

# Green Breeding





## Green breeding for a sustainable society

The Dutch Ministry of Economic Affairs (including agriculture) stimulates breeding of new, robust varieties. Therefore it has commissioned the Green Breeding research programme 2010-2020. The robust varieties developed with knowledge gained from this research will contribute to government policy to increase the sustainability of conventional as well as organic agriculture.

### Growers need robust varieties

Organic growers have only limited possibilities to control pests and diseases. Varieties with durable, broad-spectrum resistance are therefore of vital importance. However, these are scarcely available. Organic production also requires varieties that perform well with low nutrient inputs. The development of robust, low-input varieties will benefit not only the organic, but also the conventional sector: such varieties will enable conventional growers to make their production systems more sustainable, save costs, and comply with the ever stricter regulations on nutrient and pesticide use.

### Research linked to government policy

The Green Breeding programme is a good way to contribute to a sustainable society. Robust varieties increase food security, are better for the environment, reduce natural resource depletion, and save energy. This is because they need little or no pesticides, and make efficient use of available nutrients. Climate change also calls for developing robust varieties that can withstand extreme weather conditions – droughts as well as prolonged periods of rain. The Green Breeding programme is based exclusively on ‘classical’ breeding methods: crossing and selecting, with or without the use of molecular markers.

### Collaboration for sustainable agriculture

The Green Breeding programme is a collaboration between Wageningen University, the Louis Bolk Institute, the University of Groningen, and over ten commercial plant breeding companies. These companies have their own, in-house research programmes, but also value collaborative knowledge development. After all, complex problems are better solved in a consortium of research institutions and plant breeding industries. The broad consortium of this programme also provides new and useful connections between conventional and organic agriculture. The premise is that sharing knowledge and experience will help to solve complex problems better, and faster.



## The research programme

The Green Breeding research programme aims to breed varieties that are resistant to pests and diseases, and less dependent on nutrient and water inputs. The programme focuses on potato, leeks, spinach and tomato: key economic crops for both the national (Dutch) and international market.

### New forms of disease resistance

In the Green Plant Breeding programme, research institutions and commercial companies are joining forces to develop new forms of disease resistance, particularly in potato and spinach. The problem is that, time and again, the carefully bred resistances to potato blight and mildew are overcome by new strains of these pathogens within a few years. As a result organic growers risk large yield losses, while conventional growers face high costs of pesticide use. An alternative breeding strategy, aimed at achieving durable, long-term disease resistance, is therefore urgently needed.

### Resistance to insects

In addition to pathogens, insect pests are also a serious problem. Moreover, insect damage to crops is expected to increase as a result of climate change. The effects of higher temperatures are already noticeable. Thrips, which causes serious damage in leeks, in the last few years has become a growing problem also in cabbage and onion. The Green Breeding programme aims to develop varieties with improved resistance to insect damage, for example by selecting for morphological traits such as presence of a leaf wax layer.

### Varieties for sustainable, low-input production

The Green Breeding programme offers excellent opportunities to develop new varieties – for organic and conventional production – that depend less on fertilizers and pesticides and still produce good yields. Complex traits such as deep rooting, nutrient use efficiency, and interaction with beneficial soil organisms contribute to more sustainable production. All projects within the programme (potato, leeks, spinach and tomato) aim to develop varieties for low input production. For example, a key objective of both the potato and spinach breeding projects is to improve nitrogen use efficiency. The tomato project focuses on breeding rootstocks with better resistance to stress factors such as salinity, low temperature, droughts and heavy metals. The main objective of the leek project is to breed resistance to thrips.

# Green Potato Breeding



## Late blight every where

Late blight, caused by *Phytophthora infestans*, is a dreaded potato disease with potentially devastating effects. In humid weather conditions the disease spreads rapidly, causing serious foliage damage and yield losses. Organic potato growers can do little to control this aggressive disease; suitable, resistant varieties are hardly available. Conventional growers do have the possibility of using pesticides, but they, too, call for more resistant varieties. After all, chemical control is expensive and harms the environment.

## The Bioimpuls breeding programme

*Bioimpuls* is a potato breeding programme aimed specifically at the organic sector. It was launched by the *Bioconnect* organic network in 2008, and is now part of the Green Breeding research programme. The objective is to develop new genitors

from which resistant varieties can be bred. New genitors can be established by crossing wild species with modern varieties, a complex and time-consuming process. Therefore researchers are working closely together with commercial potato breeding companies and farmer-breeders. The latter assist companies in the selection of the progenies of the crossings under field conditions. This greatly increases the odds of finding a good variety. In addition to late blight, the programme also aims to improve tolerance to the potato Y virus and the fungal diseases *Alternaria*, silver scurf and *Rhizoctonia*. Additional selection criteria are nitrogen use efficiency, earliness, and long dormancy. These traits are also relevant for increasing the sustainability of conventional potato production.

## Three parallel workpackages

The GreenPotato Breeding programme consists of three parallel workpacka-

ges, each with their own objectives and time frames (short, medium and long-term, respectively). The objective for the short-term results is to cross existing, advanced genitors and make the seed available to breeding companies and farmer-breeders. As part of this objective, researchers share their knowledge and experience with farmer-breeders and get them started with selection work. Additional training and information is provided through an annual potato breeding course for farmers and a recently published manual on the subject. At the start of the project there were only two organic potato farmer-breeders in the Netherlands. The aim is to increase this number to ten within four years. This way a significantly larger amount of plant material can be screened and selected from, increasing the odds of success.

Besides, breeders crossed new resistance genes from wild potato species into modern cultivars, in order to develop new

## Jacob Eising, potato breeder at Den Hartigh:

*"This collaborative project fits in well with our own research objectives: to broaden the genetic base for potato breeding, and to develop varieties that require less pesticides and nutrients. This is also what our international clients want. By sharing knowledge and experience within this broad consortium, and increasing the genetic diversity of breeding lines, we should decrease the risk of resistance breakdown. Collaboration certainly pays off! It's an investment in the future."*

genitors. This will take many years and will only lead to useful genitors on the long term, but it will significantly broaden the genetic base for potato breeding. As many as ten different sources of resistance to *Phytophthora* are used in this project. This will allow to combine multiple resistance genes within one new variety. Such 'multiple-gene' resistance is expected to be more durable than 'single-gene' resistance.

**Partners** The Green Potato Breeding programme includes the following partners:

- Research institutes: Louis Bolk Institute, Wageningen University & Research Centre
- Potato breeding companies: Agrico, C. Meijer, Den Hartigh, Fobek, HZPC Holland, KWS Potato
- Organic farmer-breeders: Two farmers (2009), aiming for ten by the end of the project (2013).

**Duration** 2009 – 2013

**Contact** Edith Lammerts van Bueren, Louis Bolk Institute, e.lammerts@louisbolk.nl



# Green Leek Breeding

*Toon van Doormalen, leek breeder at Nunhems:*

*"The Green Leek Breeding project is truly innovative. The researchers are developing a fast and reliable method to screen leek plants for thrips resistance. In addition, they are looking for new, thrips-resistant parent lines that can be used in follow-up studies. Thrips damage is the main cause of quality loss in leek crops all throughout Europe. Therefore, as leek specialists, we are glad to participate in this study."*



## **Thrips main source of crop damage**

Thrips is a persistent, annual problem in organic and conventional leek production. Both larvae and adult insects feed on the leaf cells, leading to foliage damage in the form of silver-grey lesions. Some varieties are less susceptible than others, but none are sufficiently resistant. As a result, organic growers often end up selling their crop for a lower quality classification, while conventional growers have to spray their crop several times to produce a first-rate crop. In both cases, growers suffer a loss of income: due to reduced crop quality, or due to the costs of pesticide use.

## **Robust varieties are the solution**

The key to solving the thrips problem is to develop robust leek varieties that are less susceptible to thrips than the present varieties. It is expected that such varie-

ties will lead to a significant reduction of pesticide use in conventional production systems, and enable organic growers to produce higher quality crops. In the Green Leek Breeding project, four vegetable breeding companies are joining forces with researchers to give a new boost to thrips research, and to identify new resistance sources.

## **Conditions for successful breeding**

To successfully breed for thrips resistance, a number of conditions must be met. First, an efficient screening method is needed to select plants for thrips resistance. One available method measures resistance by placing leek plants in cylinders with thrips and assessing foliage damage after several weeks. Another (more efficient) approach is to test leaf disks in petridishes. Researchers of the Green Leek Breeding project are optimizing the latter method, so they can use it for iden-

tifying suitable resistance sources.

Secondly, while it is clear that some leek varieties are less susceptible to thrips than others, it has yet to be clarified what causes these differences. This knowledge is indispensable for breeding thrips-resistant varieties. Therefore, researchers will study a number of plant traits – including morphological features such as leaf thickness, wax layer and pigmentation – to assess whether thrips resistance is related to these traits. For example, the presence of a leaf wax layer may discourage thrips from feeding on the leaves. Finally, in the last phase of this project, a study will be initiated on the inheritance of thrips resistance. This knowledge is necessary for setting up an efficient and effective breeding programme.

**Partners** The Green Leek Breeding programme includes the following partners:

- Research institutes: Plant Research International (part of Wageningen UR)
- Breeding companies: Nunhems, Bejo Seeds, Enza Seeds Research & Development, Rijk Zwaan Vegetable Breeding and Seed production

**Duration** 2010 – 2014

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# Green Spinach Breeding

*Marcel van Diemen, crop breeder at Vitalis Organic Seeds:*

*"A few leaves with downy mildew are enough to reject an entire batch of baby leaf spinach. Resistance research is therefore crucial. In addition, we need varieties that are more efficient in their uptake and use of nutrients. This kind of plant physiological research on spinach has never been done before, and has considerable economic importance. The Netherlands is the most important exporter of spinach seed worldwide."*



## **Inefficient nitrogen use and downy mildew**

Organic spinach growers frequently observe that their crops, around harvest time, are 'wearing out' much faster than conventional spinach crops: the leaves quickly turn pale and stinky, due to inefficient uptake and use of nitrogen. As a result the production and harvest periods of organic spinach are shorter, and yields are lower. In some years more than half of the organic spinach acreage is not harvested due to poor quality.

A second problem is downy mildew. This disease – called 'wolf' by Dutch growers – can instantly render entire crops unsaleable. Resistant varieties are available, but resistance breakdown by new virulent strains is an increasingly frequent problem. Moreover, resistance sources to downy mildew are running out. Therefore, breeders want to take a new approach, and aim for 'horizontal resistance': i.e. no

absolute resistance, but robust tolerance which limits disease development. Breeding for horizontal resistance requires a sensitive assay method to quantify differences in resistance levels.

## **Netherlands market leader in spinach breeding**

Good spinach varieties are of crucial importance. In the Netherlands spinach is a major crop. The Netherlands is also a global market leader in spinach breeding, spinach seed export, and sale of deep-frozen spinach products. This applies to both conventional and organic spinach. Organic seed production, although still limited, is becoming increasingly profitable due to the growth of organic spinach production.

## **Priority for harvest security**

The Green Spinach Breeding project focuses largely on developing an efficient

selection method for breeding spinach varieties that ensure harvest security and crop quality, even with limited nitrogen inputs and little or no pesticide use. The first step is to develop a simple greenhouse assay to select varieties for nitrogen efficiency. Next, the selected varieties will be tested for vegetative vigour (which is crucial for limiting weed competition) in a 2-year field trial. A parallel study is conducted to identify alternative, more durable forms of resistance to downy mildew

**Partners** The Green Spinach Breeding programme includes the following partners:

- Research institutes: Netherlands Centre for Genetic Resources (CGN), Plant Research International (PRI), Wageningen University (all part of Wageningen UR)
- Breeding companies: Enza Seeds Research & Development, Vitalis Organic Seeds, Nunhems, Pop Vriend Seeds, Rijk Zwaan Vegetable Breeding and Seed production

**Duration** 2010 – 2014

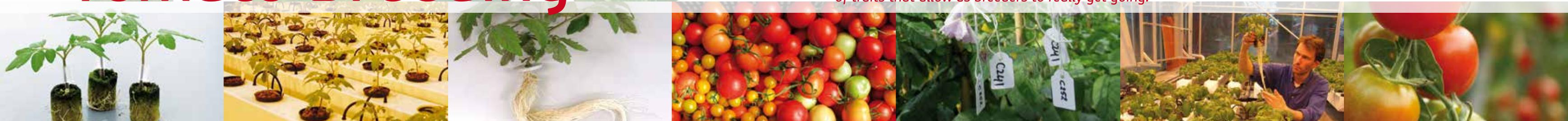
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# Green Tomato Breeding

*Gert-Jan de Boer, Manager molecular biology at Enza Seeds:*

*"We are interested in developing a more targeted approach to tomato rootstock breeding. Good rootstocks are stress tolerant and produce good yields. It would be a great leap forward if we could identify a number of traits that allow us breeders to really get going!"*



## **Rootstock determines crop performance**

The majority of conventional and organic tomato growers in the Netherlands use plants grafted on rootstock. The advantage of grafting is that it allows to combine the best traits of the shoot – such as fruit quality and yield – with the best traits of the rootstock – such as growth vigour and disease resistance. The demand for tomato rootstock is increasing worldwide; the annual market value of tomato rootstock is estimated at €30 million. The available rootstock varieties are generally good, but they do not always perform well under stress conditions. Besides disease resistance breeding is also important for lower nutrient inputs, and to increase tolerance to more variable growth conditions such as salinity and suboptimal temperatures.

## **Robust rootstock**

Breeding for stress tolerance – a highly complex trait – is a major challenge. This study aims to elucidate the physiological processes that enhance rootstock vigour, nutrient use efficiency, and salt and cold tolerance. The knowledge gained will be used to define selection criteria, and to develop assay methods that allow faster and more efficient breeding of robust tomato rootstock.

## **Desired traits from wild varieties**

Cultivated tomatoes lack the genetic diversity required for the required traits where breeding needs genetic variation. Therefore this study is conducted with wild tomato species. These species are tested under various growth conditions, and selected for the desired traits: vigour, nutrient uptake efficiency, and salt and cold tolerance. Selected species will be crossed with existing rootstock varieties. Progeny from these crosses will be analyzed to determine which physiological processes have a key influence on the desired rootstock traits. Selected progeny will form the basis for further breeding.

**Partners** The Green Tomato Breeding programme includes the following partners:

- Research institutes: University of Groningen, Wageningen University (Wageningen UR)
- Breeding companies: Enza Seeds Research & Development, Vitalis Organic Seeds, Syngenta Seeds

**Duration** 2010 – 2014

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## Project implementation and coordination

## Communication

The Green Plant Breeding research programme is carried out by Wageningen UR, the Louis Bolk Institute and the University of Groningen, in close collaboration with various commercial plant breeding companies. The latter have selected the research themes; it is thanks to their input that the most urgent crop production problems are now on the academic research agenda. The partnership between research institutions and commercial breeding companies ensures that research findings will be translated into practice.

The Dutch Ministry of Economic Affairs (including agriculture) has commissioned this research programme, and decides on the content and implementation. The programme advisory committee, which consists of representatives of both the organic and conventional sector, advises the Ministry about the implementation of the programme and its constituent projects. Once a year they discuss the progress of all projects with the programme coordination team. This team, which has an executive function and is responsible for programme management, consists of Dr Olga Scholten (Wageningen UR) and Professor dr Edith Lammerts van Bueren (Louis Bolk Institute and Wageningen UR).

For more information about the Sustainable Plant Breeding research programme please contact the programme coordination team: [olga.scholten@wur.nl](mailto:olga.scholten@wur.nl) or [e.lammerts@louisbolk.nl](mailto:e.lammerts@louisbolk.nl)

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This brochure aims to inform all those involved in the Green Breeding programme – policy makers, breeders, growers and researchers – about the programme objectives and anticipated results. Research findings will be shared through field demonstrations, lectures, trade journals, posters and the programme website. In addition, papers will be submitted to scientific journals and presented at national and international conferences. For current information please visit [www.groeneveredeling.nl](http://www.groeneveredeling.nl) , [www.biokennis.nl](http://www.biokennis.nl) and [www.kennisonline.wur.nl](http://www.kennisonline.wur.nl).

Additional target groups are non-governmental organisations, citizens, and society at large. Separate communications specifically addressing these groups will be developed as soon as research results are available. The key message will be that green breeding is of vital importance for socially responsible, sustainable agriculture.

A number of workshops on plant breeding for sustainable agriculture (in Dutch) will be organized for the Green Breeding network, inviting commercial breeders, conventional and organic growers, policy makers, and researchers. Researchers from related research programmes will be invited to give presentations, in order to promote interaction with all relevant areas of research.





# Green Breeding

Commissioned by:



Collaborative partners

Potato



Vegetables



Research institutes



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 Text: Lidwien Daniels and Ria Dubbeldam  
 Final editing: Nora de Rijk  
 English translation: Christien Ettema  
 Design: Fingerprint.nl  
 Publication number Louis Bolk Institute  
 2013-020 LbP

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