Dutch seeds

Innovation with a global reach

Netherlands

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Farming the Future

Farming the future is an international campaign which highlights how the Netherlands works with international partners to achieve global food security.
With this campaign, we showcase the knowledge and expertise of the Dutch agrifood and horticulture sectors in promoting sustainable food systems and creating social and economic opportunities worldwide.

Preface

Good, healthy seeds are fundamental for sustainable, good food production and every farmer should have access to seeds of a good quality. Access to good quality seeds is vital for reaching some of the UN Sustainable Development Goals, especially SDG 2: Zero Hunger. When it comes to seeds, there is a large diversity to choose from: from traditional landraces to newly developed varieties with improved characteristics.

A large diversity and complexity exists in the regulation in this sector; ranging from biodiversity-related regulations, such as access and benefit sharing and gene banks, quality and phytosanitary requirements that seeds have to meet, to rules about the use of genomic techniques and also legislation to promote investments in plant breeding such as plant variety protection. For this reason, governments and the seed sector need to work together.

In the Netherlands, there is a strong public-private interaction in what is commonly referred to as the “Dutch Diamond”. This approach brings together government, business, and knowledge institutions to set long term research agendas in which each actor plays a crucial role.

The Netherlands is the world’s biggest exporter of plant reproductive materials, valued at over €5 billion in 2023. The favourable business and innovation climate of the Netherlands has given rise to many globally active family-owned companies and cooperatives, strong in the development of vegetables, potatoes and ornamentals. Several international seed companies have also settled in the Netherlands. The whole ecosystem – including effective public institutions, first class services industries, and dedicated knowledge infrastructure - plays an important role in this regard.

This brochure, written in public-private cooperation, offers an overview of said infrastructure and the seed industry in the Netherlands. It also addresses topics such as new developments and state of the art innovation programs.

The Dutch Government believes that international cooperation, partnership and knowledge sharing are essential for the development of sustainable agriculture. Programmes such as SeedNL, described in this brochure, and the PVP Toolbox have been established to assist countries in the development of their own seed infrastructure. Furthermore our innovation instruments are open to international R&D cooperation.

In short, the Netherlands is open for cooperation, public interest and business!

Marten vd Berg,
Director-General Agro, Ministry of Agriculture,Nature and Food Quality

Seeds in the Netherlands: an introduction

The seed sector in the Netherlands is diverse with over 200 plant breeding companies and over 7000 propagators working in feed, arable, vegetable, fruit and ornamental crops. The sector develops new varieties and produces and markets plant reproductive materials for use in agriculture and horticulture. This includes seeds, bulbs, roots, tubers, cuttings and young plants. By continuously developing varieties with improved characteristics for farmers, processors and consumers, the sector makes a positive contribution to tackling societal challenges in the Netherlands and beyond. For example, the sustainability of crop production in value chains, food security and even human health.

The Netherlands is the world's biggest exporter of plant reproductive materials, valued at over €5 billion in 2023. Dutch breeding and propagation companies are of a significant importance not only for agriculture in general but also for the Dutch economy. The favourable investment business and innovation climate of the Netherlands has contributed to obtaining and expanding its leading position in the world, attracting several international breeding companies to settle in the Netherlands.

According to Jaap Bond, chairman of the Topsector Horticulture and Starting Materials, this position is based on three major pillars in the Netherlands. These are "international entrepreneurship, knowledge infrastructure, and effective public institutions. It is the cooperation in the "Golden Triangle" of business, government and knowledge institutions that shapes an excellent basis for the sector".

International entrepreneurship in seeds and plants started back in the 18th century, mainly focusing on vegetable seeds and flower bulbs. On horseback and through shipping routes, Dutch seeds reached many markets in Europe. They also crossed into Russia and in North America. Over the years, this active entrepreneurship has led to many globally relevant businesses. Along with this development, the knowledge infrastructure in the Netherlands with excellent plant sciences at universities and a culture of public-private cooperation in research has increasingly become the backbone of agri- and horticulture and especially the seed sector's development.

The Netherlands did not achieve such strength in seeds and young plants overnight. The first pioneering vegetable growers started selecting and trading seeds some 200 years ago, in response to the rapid urbanisation of cities like Amsterdam, Rotterdam and London. The formerly known National Agricultural College or Rijkslandbouwschool in Wageningen began conducting research into seeds in 1876. Since then, the Dutch Government has invested substantially in plant research at universities, with the industry itself always heavily involved too. Collaboration between the public and private sectors was one of the driving factors that paved the way for the Netherlands to become the first country to introduce plant breeders' rights in 1941.

Agricultural research has been stimulated vigorously from the 1950s onwards, with strong involvement of the private sector, and effective links between fundamental, industrial and applied research. Niels Louwaars, director of Plantum – the Dutch industry association for seeds and young plants - refers to seeds as "well-packed knowledge". This is because the core value of a seed lies in the genetics, along with other seed qualities. The relevance of different knowledge fields developed quickly and is still accelerating. Plant breeding, based on genetics, plant sciences and mathematical statistics in the 1960s, embraced molecular biology in the 1980s, and currently applies data sciences and artificial intelligence. Seed science and technology also made enormous strides in terms of physiology, new seed sorting and other seed enhancement technologies such as the Netherlands Plant Eco-phenotyping Centre (NPEC).

Louwaars also stresses the importance of public institutions responsible for genetic resources, seed quality and phytosanitary controls, variety registration and protection, and innovation support. Appropriate regulations are only the start of such public roles. The effectiveness of their implementation and especially the efficiency in which they operate are vital for many reasons. For example, for the development of the

Inspection services that thoroughly monitor and review seed quality are indispensable to the seed sector. “The Dutch inspection bodies are also world leaders,” says Marien Valstar, responsible for several dossiers relating to the seed sector at the Ministry for Agriculture, Nature and Food Quality. The Netherlands Food and Consumer Product Safety Authority (NVWA) has final responsibility for the phytosanitary inspection of all imports and exports of plant material. The inspections are carried out by three bodies: the Netherlands General Inspection Service for Agricultural Seed and Seed Potatoes (NAK) for field crops, the Netherlands Inspection Service for Horticulture (Naktuinbouw) for the horticultural sector, and the Flower Bulb Inspection Service (BKD) for flower bulbs. These services facilitate the worldwide trade of plant reproductive materials and also contribute to the capacity building of inspection services elsewhere in the world.

“The Netherlands has a unique system for monitoring the quality of seeds, bulbs and seed-potatoes. The inspection services have been around for almost a hundred years and have their roots in the sector. Commissioned and supervised by the government, they are responsible for monitoring compliance with the relevant regulations, but they also keep the sector on its toes. That is different from many other countries, where the inspection bodies are government agencies and only focus on carrying out the statutory checks.” says John van Ruiten, former director of the Netherlands Inspection Service for Horticulture.

sector, to create a quality label for Dutch seeds and planting materials nationally and internationally, and to facilitate production and trade.

Since seed companies need to recover their investment in the breeding of new varieties, it is important that appropriate arrangements for plant breeders’ rights are in place. The Board for Plant Varieties is responsible for the testing procedure of varieties as well as registration and the granting of national plant breeder’s rights. Next to variety testing for registration, performed by Naktuinbouw, the annually-renewed list of recommended varieties of field crops, which is the responsibility of a Committee (CSAR) consisting of farmers and breeders is also important.

The Netherlands plays a significant role in the development and promotion of plant breeders’ rights at the international level with an annual international PVP course (since 1997) and capacity building to support countries in small projects, managed by Naktuinbouw in cooperation with the Ministry of Agriculture, Nature and Food Quality, CPVO, UPOV and Plantum.

Access to genetic resources is paramount for plant breeders and scientists. After all, companies or public breeders can only develop plant diversity when they have access to genetic diversity of the crops and their wild relatives. International exchange is therefore vital, not only for the Netherlands. The global interdependence on plant genetic resources for food and agriculture was recognised already in the 1980s. “The Netherlands plays a prominent role internationally in knowledge and policy development relating to

propagating material, plant breeding and plant genetic resources for food and agriculture," says Kim van Seeters, the National Authority on Access and Benefit-Sharing for the same Ministry. The objective is to ensure the proper implementation of the international agreements that are in place and where possible improve them. As a result, breeders have access to diversity and the countries from which the genetic resources originate get a fair share of the benefits arising from their use.

The Netherlands Centre for Genetic Resources (CGN), based in Wageningen is known as a top-quality public gene bank spending a lot of effort not only in managing broad and well-designed collections, but also on documentation and facilitated access to any breeder. The Government thus funds the storage of seeds for the distant future – including in the Svalbard Global Seed Vault. The breeding companies support CGN with significant in-kind contributions.

Plantum

Plantum is the Dutch association of companies in the plant reproduction material sector, from breeding to trade, and the production of young plants. Plantum represents and promotes the interests of its members and, on behalf of the sector, acts as the discussion partner with government representatives, politics and interest groups in society, with the objective of strengthening the sector's contribution to societal needs, and its competitive position on the international stage.

Finally, innovation policies are essential for the sector to thrive. Next to a well-defined breeder's rights system and (generic) fiscal policies that stimulate private investments in research and development, there are investments in fundamental sciences managed by the Dutch Research Council (NWO), and investments in public-private pre-competitive R&D projects. These are supported by the so-called Topsectors, where the golden triangle is at the helm, and large strategic 10-year programmes under the 'Growth-Fund' of the Ministry for Economic Affairs and Climate. Substantial amounts of public money are available, which have to be supplemented by private funds in research consortia. The NWO has announced a second phase of its joint research program with CGIAR, running from 2024 to 2030, specifically for international collaborative research. This "NL-CGIAR Research Program" builds on the positively evaluated first phase (2017–2023).

On average, Dutch seed companies are estimated to spend about 15% of their turnover on their own R&D, with some companies in the vegetable seed sector even investing up to 30% of their turnover. The investments by the private breeding sector in R&D are estimated at €700 million annually in R&D. The public investments are, however, vital for the public and private knowledge infrastructure and it serves as the oil in the engine of collaboration amongst companies.

The Golden Triangle

The Netherlands' prominent position is the result of extensive consultation and coordination between the business community, inspection bodies, the research and education sector and policymakers in public institutions and research programming. Marien Valstar concludes: "In the Netherlands, we're used to taking a pragmatic approach to things – without making any compromises where the maintenance of quality standards is concerned, of course. In this cooperation it is important that everyone remains aware of each other's specific area of responsibility."

The tomato seed supply chain is a good illustration of the potential financial value of seeds and young plants; just one kilo of high-quality seed ultimately produces €10 million worth of tomatoes (see Figure 1 below).

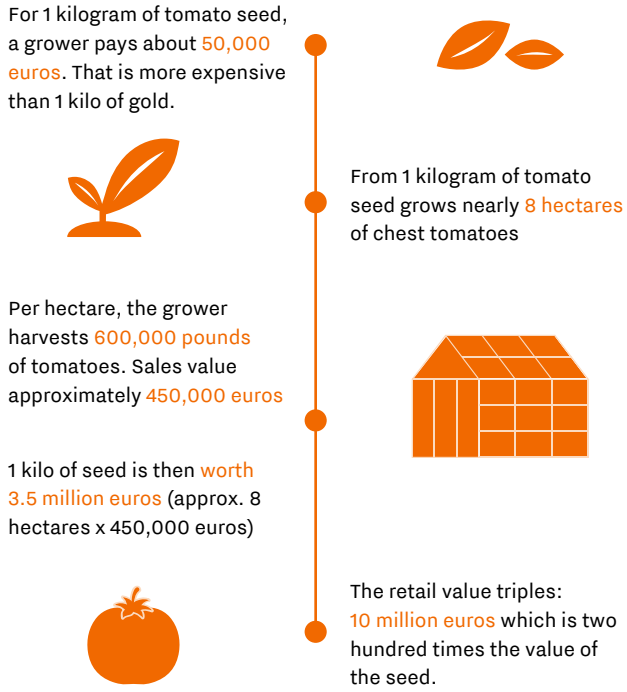


Figure 1:
The ultimate financial value of seeds and young plants is very high

Strong export position

Dutch breeding and propagation companies add value for growers all over the world, from large rose producers in Colombia to small-scale potato farmers in Kenya and organic lettuce growers in California. In 2023, Dutch companies exported an estimated €5 billion worth of plant reproductive materials, and exports are still on the rise. Those companies are active in over a hundred countries and collaborate co-operate with knowledge institutions at home and abroad. Dutch organisations and companies play a key role in seed technology and quality control too.

Exceptionally innovative

Because customers are placing increasingly high demands on seeds and young plants, innovation is of vital importance for the sector's future. Dutch companies invest a big part of their revenue in research and development, much more than pharmaceutical or electronic industries. This is underlined by the fact that more than 45% of applications for plant breeders' rights in Europe are made by Dutch breeders.

Effective policies are needed

Government policy is aimed at stimulating innovation, including:

- Effective plant variety protection systems rights in the Netherlands and beyond;
- Good access to genetic resources, based on clear rules;
- Clarity on the use of the latest breeding methods;
- Stimulation of research and innovation and the Netherlands' knowledge infrastructure;
- Facilitation of public-private partnerships;
- Well-functioning inspection bodies for seeds and young plants in the international market;
- Clear rules for plant health and seed treatments, based on scientific facts and an effective system of control.

Good-quality seeds and young plants offer financial advantages for the entire chain, from the grower to the consumer, and everyone else in between. A few examples:

- Growers benefit from healthy and strong seeds and young plants because they generate high yields and reduce crop protection costs;
- Freight forwarders and retailers reap the benefits of products with a longer shelf life; less spoilage means less lost revenue;
- Healthier lifestyles resulting in lower healthcare costs are supported by affordable healthy food and a green environment indoors and in cities.

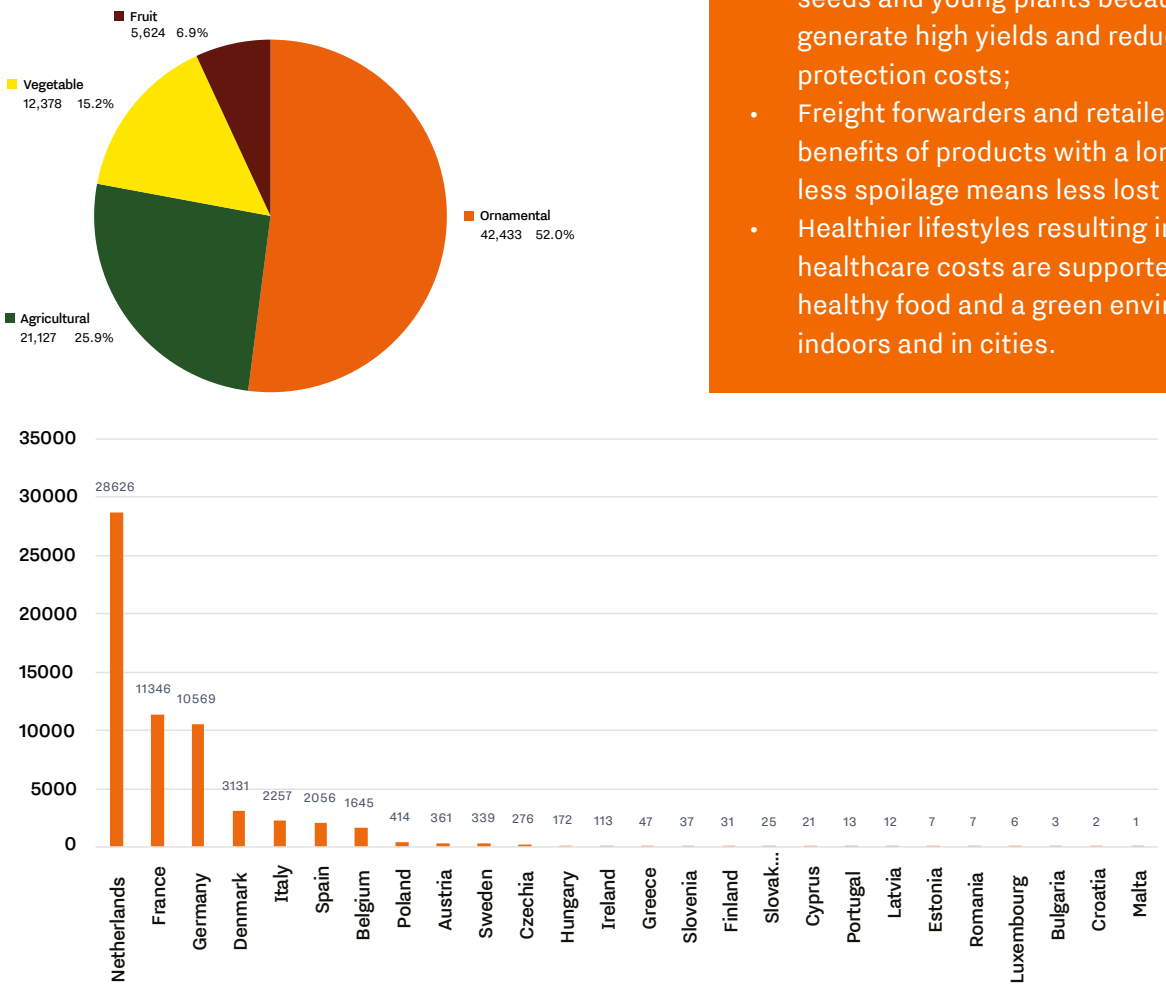


Figure 2:
Applications for plant breeders' rights in Europe over the past 20 years
Source: the Community Plant Variety Office (CPVO)

The Topsector agenda

This agenda spearheads future-proof plant materials that contribute to solutions for global societal challenges.

Plant breeding is a key technology in the new Knowledge and Innovation Agenda of the Dutch Government, as it contributes to solutions for societal challenges such as climate change, pests and diseases, and food and nutrition security for a growing global population.

The Topsector Horticulture & Starting Materials was founded in 2012 by the Dutch Government to boost innovation and to provide governmental funding for fundamental and applied research projects, co-financed by companies.

The Dutch breeding sector invested since 2012 in more than 80 projects in the public-private multiannual cooperation programme “Better Plants for New Demands”. This included projects that investigated topics like heat tolerance of crops, resistance to pests and diseases or drought, and salinity. Breeding companies and institutes are encouraged to join Topsector research in order to join forces in tackling global challenges. An analysis of the programme Better Plants for New Demands showed active involvement of companies from the USA, the UK, France, Spain, Germany and Japan.

Topsector Horticulture & Starting Materials is founded by the Dutch government to boost innovation in the horticulture and breeding sector via public-private research and development cooperation. Visit the website.

“Plant breeding is an indispensable factor in tackling current and future global challenges such as climate change and food security. Dutch companies develop solutions in co-creation with local producers of fruits, vegetables and potatoes. In our new agenda, we provide and encourage the opportunity for international multiannual R&D projects. Furthermore The Dutch Research Council (NWO) has announced a second phase of its joint research program with CGIAR, running from 2024 to 2030. The “NL-CGIAR Research Program” builds on the positively evaluated first phase (2017–2023).”

- Jaap Bond,
Chairman of the Topsector
Horticulture and Starting Materials -
Discover more about the joint program

The Netherlands has a strong business and knowledge position in green biotechnology. Internationally recognised plant propagation and biotechnology clusters are situated around Wageningen University & Research, Leiden Bio Science Park, Biotech Campus Delft and Amsterdam Green Campus. Biotechnology contributes to a transition to sustainable food systems and a biobased economy.

The key technology component ‘Biotechnology and Breeding’ of the Topsector focuses on the development of knowledge, concepts and supporting technologies to provide agriculture and horticulture with optimal starting material such as robust seeds

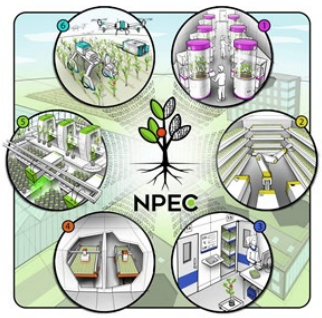
and propagating material and to accelerate the breeding of new plant varieties and make the breeding process more accurate and faster, also known as precision breeding. A growing importance of such key technologies is foreseen for applications in countries all over the world. AI, data science, image analysis and sensor technologies are being introduced to speed up breeding and production processes further.

New technologies

Current unprecedented weather and environmental conditions, caused by environmental changes, are putting an increasing pressure on crops to make them resilient or resistant to drought, salinisation, heat stress, flooding, low nutrient input, etc. Depending on the crop, it takes a minimum of 5 to over 30 years before a new variety becomes available on the market.

New technologies such as targeted genome editing (e.g. via CRISPR-Cas) are necessary in research and, when applied in breeding new varieties, can make an important contribution to confronting the global challenges.

Securing and preserving genetic resources in gene banks and making these resources available for research by knowledge institutions and use by companies contributes to food security and to market development in the long term. In order to quickly determine whether there is genetic variation for desirable traits, new methods of phenotyping need to be developed, for example to determine whether there are differences in the level of resistances or tolerances to diseases. In addition, the material in gene banks will have to be preserved and made accessible for breeders. New facilities for phenotyping have recently been opened at the universities of Utrecht and Wageningen.



The Netherlands Plant Eco-phenotyping Centre (NPEC) is an initiative from Wageningen University & Research and Utrecht University which provides scientists and companies access to a state-of-art plant phenotyping facility to unravel the genetics underneath the interactions between environment and plant performance. NPEC is designed to spearhead innovative research in plant sciences to provide data-driven insights for scientific breakthroughs. The ambitions are to help growers, breeders and farmers come up with sustainable agronomic solutions to safeguard future food security and mitigate climate change.

"NPEC is a game changer, the plant science community across the Netherlands and in Europe now have access to cutting edge measurement technologies that will push the boundaries of our knowledge in how plants function at different scales and will hasten the application of new discoveries across a broad range of crops and growing systems".

- Richard Harrison,
General Director Plant Science
Wageningen University & Research -

The research programme Green Breeding, set up in 2013 for the joint benefit of the organic and conventional sectors, uses various technologies with the exception of New Genomic Techniques as defined by the EU. The ultimate goal of these different research programmes on biotechnology and breeding contributes to the availability of sufficient genetic variation and innovative technologies for breeding. As a long-term result, after the completion of the PPP projects, companies can develop high-quality starting materials.

Sustainable Development Goals: quality seed is a basis

The UN Sustainable Development Goals (SDGs) relate to nutrition security, poverty reduction, climate change and rural development. Good seeds and planting materials provide a necessary basis for bringing these goals closer. The Netherlands is supporting the SDGs via the seed sector with its extensive international focus building on a strong home base.

Of all the international seed trade of vegetable seeds, an estimated 40% originates in the Netherlands. For seed-potatoes, this percentage is even as high as 55%. Even though the breeding efforts may be coordinated from the Netherlands, the varieties developed have to respond to local ecological conditions and culinary needs. Dutch seed companies therefore have a presence in over a hundred different countries. The number of branches of Dutch seed companies outside Europe has increased exponentially over the past few decades. These branches are not only involved in sales but increasingly also in local research, breeding and production of seeds, which contributes to quality of plant-products and earning capacity of farmers and horticulturists worldwide.

"Quality seed is essential for farmers. Wherever you talk to a farmer, globally speaking, you will soon find the conversation turning to seed, and then it is always about seed qualities, health and the performance of varieties – and also about the presence of fake seed in the market"

- Niels Louwaars,
Director of seed sector association Plantum -

When properly cultivated, good seeds from good varieties result in better harvests through resilience towards climate incidents, diseases and pests, and give farmers and consumers value for money. Varieties that have been especially bred to contain higher vitamin or mineral levels combat malnutrition while varieties that give a uniform product are preferred for better incomes.

Local and global policies are essential for achieving SDGs. "The Netherlands also plays an active and often leading role in developing the various international treaties on seed," adds Marien Valstar, Senior Policy Officer at the Ministry. This leading position is demonstrated by the Enabling the Business of Agriculture (EBA) ranking published by the World Bank, which evaluates the efficiency of countries' agribusiness policies and regulations. The Netherlands is first in seed regulations and extends this knowledge to other countries that want to develop their seed systems.

Many countries have experienced Dutch partnership projects. These projects often focus on improving the seed production chain. "Seed is not a simple input that comes from a factory, where you can adjust production to the expected demand, as with chemical fertilizers and pesticides," Schoustra (managing director of SeedNL) explains. There is a whole chain of activities, from breeding and testing to multiplication and distribution, that needs to take place before a farmer can have access to quality seeds. This applies both to international and national seed chains, and even informal farmers' seed systems. These partnership projects stimulate Dutch companies to step up their investments to widen their reach with better seeds, including smallholder farmers, thus providing a broader choice of seeds.

Diversity and inclusion

Farmers can obtain seeds from a variety of sources. In most countries in the Global South, farm-saved seed of landraces or (often old) publicly-bred varieties is the major source of seed used for the most important food crops. It is widely recognised in the Netherlands that seed system support requires a diversity of approaches. A plurality in seed systems both in system support functions and seed policies is needed. This is guided by the concept of Integrated Seed Sector Development (ISSD) which promotes integration of seed systems. ISSD aims to build the capacity of seed sector stakeholders in informal seed systems, intermediate seed systems and formal seed systems. It also aims to strengthen the capacity of regulatory service providers. Together, this represents the integrated approach.

An extensive knowledge base is available in the Netherlands through Wageningen University & Research, the Royal Tropical Institute in Amsterdam, the private sector, and civil society organisations, which supports a wide range of approaches for different crops and farmers in various countries.

"Improving plant propagating material such as seed and seed-potatoes is not only important for farmers but also contributes to securing the food supply for a growing world population. A thriving seed sector – with businesses that are supported by sound government policy on issues such as plant breeders' rights, effective inspection services and strong knowledge institutions – contribute significantly to a number of different SDGs, including SDG 2, Zero Hunger"

- Willem Schoustra,
Managing director of SeedNL -

seedNL

SeedNL is a Dutch initiative supporting the accessibility of Dutch seed knowledge and expertise for international development objectives.

Seed from different sources

Farmers often get their seed from many different sources. Take a typical smallholder in Kenya, for example. She saves her sorghum seeds from the previous year's harvest, and gets cassava sticks when her neighbour harvests some roots. She buys hybrid corn seed from a national seed company, bean or cowpea seed on the local market and vegetable seeds from an international vegetable seed company, often one from the Netherlands, through a local dealer. Wageningen University's Centre for Development Innovation has vast experience in seed sector development in countries where this mix of formal and informal seed systems is present.

A Dutch speciality: new varieties and production of high-quality seeds and plant material

The Netherlands' agriculture sector is globally renowned for introducing new varieties and top quality seeds and plant material. Seed potatoes, flower bulbs, vegetable seeds, ornamental cuttings, in vitro plants, trees and shrubs and fruit plants and rootstocks coming from the Netherlands can be found all over the world. Growers across the globe use this starting material for setting up their production systems.

The sector of seeds and plant material, and the number of companies producing this material, is significant. Registration and inspection is a legal obligation for professional operators. According to EU legislation requirements (Plant health and Identity/Quality), inspections and certification are carried out on all registered companies. Inspection services additionally offer specific certification programmes that support production and sales of high-graded material.

Over 200 companies are active in breeding and introducing new varieties. Almost 7000 companies are producing and marketing seeds, tubers, cuttings, bulbs and young plants professionally.

Inspection, production and sales of seeds/plants in numbers:

Commodity	Number of companies	Annual acreage/turnover
Seed potatoes	1600	37500 hectare
Cereals/grasses/fodder crops	1300	15500 hectare
Vegetable seeds and plants	400	€2.500.000.000
Fruit plants/rootstocks	150	3000 hectare
Flower bulbs	1200	23000 hectare
Floricultural seeds/plants	250	€750.000.000
Nursery stock and perennials	2000	9000 hectare

The Board for Plant Varieties in NL and CPVO in the EU are the responsible bodies for the registration of varieties for Plant Breeders Rights and listing in EU catalogues. Private organisations such as Floricode and KAVB hold registers with documentation of ornamental varieties marketed.Every sector has its specific sector organisation that represents their interests. Company membership is on a voluntary basis, with over 80% of companies registered as a member. For more information on sector organisations visit www.dutchhorticulture.nl

- Plantum: Breeders, multiplyers and traders of agricultural seeds, vegetable seeds/plants , soft fruit plants and Floricultural material
- Royal Anthos: Traders in flower bulbs and nursery stock, perennials
- NAO: Producers and traders Seed potatoes
- KAVB: Production and trade in Flower bulbs
- LTO Bomen: Production of nursery stock, perennials and fruit plants

Gaining knowledge, learning and sharing experience

Being able to carry out qualified jobs related to plant breeding, seed technology, quality management, controls and certification requires a human resource base with up-to-date knowledge. Various organisations and universities in the Netherlands offer possibilities for training, masterclasses, internships or other methods to develop these skills.

In many cases, education and participation in courses also offers students, trainees and professionals the opportunity to build connections with experts working in companies, organisations and governmental agencies in the Netherlands and abroad. As a result, an international network of specialists that have world leading scientific and technical expertise is fostered. Wageningen University and Research is one of the highest rated agricultural universities in the world. Utrecht, Amsterdam, and Leiden are also highly reputable universities for plant sciences, while Delft and Eindhoven are renowned for their data science programmes.

Bachelor and Master of Science programmes, as well as many possibilities for PhDs are offered to international students. Working professionals can also access masterclasses and summer- and winter school programmes to update and refresh their knowledge Those interested in continuing their learning do not always have to travel to the Netherlands to access knowledge. Many online distant-learning programmes are offered on various levels. Even MOOCs (free Massive Open Online Courses) are available on various topics, including sustainability, big data, food and nutrition.

A number of Universities of Applied Science (HAS Green Academy, InHolland and Aeres) offer excellent courses on plant physiology, plant breeding, food systems, biotechnology, molecular biology, and business courses in food and agriculture.

NUFFIC, the Dutch organisation for internationalising education, manages various scholarship and subsidy programmes, creating excellent opportunities for young professionals to access education in the Netherlands.

Wageningen Centre for Development Innovation (WCDI) offers a range of training opportunities and projects relevant to seeds. WCDI works on processes of change through facilitating innovation, brokering knowledge, and supporting capacity development. With a focus on the global challenges of food security, sustainability, healthy food, and adaptive agriculture, there are plenty of courses to choose from. Resilient and sustainable systems for a secure future, guiding sector transformations and seed sector development are just some examples.

For those who are working in the field of plant breeders' rights or inspection and certification, the institute Naktuinbouw offers practical short courses, either online at the Naktuinbouw Academy, in the Netherlands on campus, or on site. The international PVP course is known worldwide, along with courses on diagnostics, seed sampling, seed identification, disease prevention and hygiene. Internships are also possible.

All knowledge centres mentioned in this brochure participate in international projects aimed at developing legislation, system implementation, capacity building, farmer education and employee training in both governmental and commercial organisations. Financial support is also available for a number of cases, via toolbox programs, funds and scholarships.

Information regarding all possibilities stated in this brochure can also be found on the different websites of the organisations and universities mentioned.

Caring and sharing: plant genetic resources in the Netherlands

This brochure aims to highlight the importance of cultivating good seeds and plants. Equally crucial is recognising the crucial role of plant breeding in creating these good seeds. Yet, what often escapes adequate consideration is the indispensable need for raw material in the plant breeding process and crop science - the necessity of well-documented genetic diversity as a foundation for study and breeding.

Plant genetic resources have been collected, studied and exchanged since ancient times. However, the transformative shifts in agricultural practices since the 1960s and the associated replacement of traditional landraces by uniform modern varieties, caused an imminent risk of losing the fundamental building blocks of plant breeding. This threat of genetic erosion was exacerbated by ongoing changes in land use and, more recently, the climate crisis. Luckily these threats were seen and acted upon. Worldwide gene banks and the Global Seed Vault in Spitsbergen arose, creating institutions dedicated to preserve plant genetic resources and make them available for use. The Netherlands is an active actor in this global network of gene banks.

Since its inception in 1986, the Centre for Genetic Resources(CGN) in Wageningen has concentrated on creating high-quality collections of plant genetic resources, primarily vegetables, and ensuring their optimal accessibility. Key considerations for the quality of a gene bank collection include the comprehensiveness of the collection to ensure a robust representation of the gene pool, devoid of redundancy, the provision of high-quality information about the materials in the collection, and the quality of the seeds in terms of viability and phytosanitary status.

Streamlining access to gene bank collections involves enhancing the user interface for accessing information, facilitating easy searches, enabling online ordering, and ensuring prompt dispatch of quality seeds along with associated documentation. Despite its modest collection size, CGN has emerged as a significant supplier of vegetable plant genetic resources worldwide, owing to its relentless pursuit of quality over quantity.

Quality has always been the cornerstone of CGN's activities. In 2004, it became the world's first gene bank to obtain an ISO 9001 certification for its quality management system. Since then, it has been at the forefront of promoting quality management in gene banks, recognising its pivotal role in ensuring the reliability of conservation and access to plant genetic resources. This commitment to quality not only ensures the provision of plant genetic resources to current and future generations of users but also fosters effective collaboration among gene banks, underpinned by mutual trust in each other's quality standards. With this ethos in mind, CGN actively collaborates with European and global partners to establish a certification framework for gene banks worldwide.

Also within the Netherlands, CGN operates in a rich ecosystem of collaboration. It maintains close partnerships with universities, NGOs, and notably, breeding companies. There is a dynamic exchange of knowledge, advice, and support concerning the composition and maintenance of the collections. For instance, a significant portion of the regeneration of CGN material is done by breeding companies at no cost.

Integral to accessing plant genetic resources are legal considerations. As a member of the Convention on Biological Diversity (CBD) and a signatory to the Nagoya Protocol, as well as a contracting party of the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA), the Netherlands fully adheres to the principles of Access and Benefit Sharing (ABS) of plant genetic resources. While upholding these principles, it endeavours to facilitate the exchange of plant genetic resources to support scientific research and breeding efforts aimed at addressing global food security challenges. Consequently, there are no specific national Access & Benefit Sharing (ABS) obligations associated with accessing and utilising Dutch genetic resources.

CGN distributes its materials to countries worldwide under the standard material transfer agreement defined by the ITPGRFA, without imposing additional restrictions. Moreover, the Netherlands actively engages in international negotiations to promote the exchange and utilisation of plant genetic resources. In brief, the Netherlands unequivocally acknowledges the importance of plant genetic resources and actively contributes to the global endeavours to make these resources available and preserve them for future generations of users.

International cooperation in seed sector development: SeedNL

To ensure that farmers have access to the varieties and seeds of their choices, a country needs a vibrant seed sector. In 2020, SeedNL was launched with the aim to make Dutch knowledge and materials available for development programmes with the aim to support the strengthening of seed sector in low- and middle-income countries, and provide appropriate access to quality seeds for all farmers to increase productivity and farmer income. Support to countries regarding an enabling environment for a seed sector can be provided through the SeedNL Seed Laws Toolbox.

Good seed is an important fundament for food and nutrition security, sustainable agriculture and rural development. Seed companies active in the Global South have significant experience in the ecological and socio-economic environment in a wide range of countries and ways to support vegetable and potato production. Dutch knowledge institutes such as Wageningen UR and the Royal Tropical Institute have long-standing experience in seed system support.

SeedNL is a public-private partnership between the Ministry of Agriculture, Nature and Food Quality, the Ministry of Foreign Affairs, Plantum and the Dutch Potato Organisation. Together with the SeedNL community, existing of civil society organisations, knowledge institutes, companies and government institutes, SeedNL supports learning from the diversity of Dutch endeavours in seed sector development in low- and middle-income countries. Based on these experiences it supports new and innovative programs with Dutch organisations and international partners to achieve urgent changes that contribute to Sustainable Development Goals. Seed systems contribute significantly to the required food system improvement and resilience. More information on SeedNL can be found at: www.seednl.nl

Seed sector entrepreneurship

Seed sector development requires a great deal of practical knowhow. Stimulating and developing entrepreneurship in all aspects, from distributing breeding to seed production and from production and processing to distribution, also requires a long-term strategy. This is relevant both for a foreign company entering a local market, and for local entrepreneurs or farmer cooperatives investing in seed for the local market or for export. Finding the niches in the market is a key element of such entrepreneurship. Demonstrations, in special plots or in farmers' fields can be essential to create a market, and so is extending agronomic support to farmers. This allows them to translate the seed qualities into marketable product which is proven to yield positive results both for the seed supplier and the farmers.

Enabling environment

An enabling environment is crucial for seed sector development in order to support a diversity in seed system initiatives, facilitate farmers' choice in seeds and varieties, promote innovation, and encourage investment. In low- and middle-income countries seed regulatory frameworks can be a key bottleneck for seed sector development. There may be limitations relating to rapid variety introduction, quality assurance, or coherency with regional and international standards, but also generic issues relating to business licensing and currency limitations. An often seen effect of poor implementation of rules is the existence of fraudulent or fake seed in the market. A well-functioning, transparent and enabling business environment benefits all seed sector stakeholders, including local seed businesses, domestic enterprises and international seed companies. Farmers will benefit by improving their access to quality seed of improved and locally adapted varieties.

Partnerships

SeedNL has been involved in the development of partnerships between the Netherlands and Ethiopia and Nigeria. These partnerships are based on the Integrated Seed Sector Development (ISSD) approach, aiming at a plurality of seed systems and joint learning of farmers and formal sector actors. This includes the

strengthening of the private sectors, improvements of in the informal and intermediate seed systems, and support for public tasks in the implementation of seed regulations. Capacity building on variety testing, seed production, seed business management and quality control is critical in these endeavours". is critical in these endeavours.

Widely different seed systems operate side by side. A Ugandan farmer may buy maize seeds from a national company, obtain bean seeds through a cooperative, get cassava cuttings from a neighbour and buy tomato seeds from an international vegetable seed company. Improvement of these systems that operate alongside each other needs tailor-made interventions, as each system has its unique dynamic. A solid analysis of sector performance should lead to the joint design of a national seed road map, requiring multi stakeholder consultations. Recognising that the partner country develops and owns their own ambitions and objectives, SeedNL identifies fields where expertise, experience or knowledge can support these objectives. Currently over 15 countries are supported through our community of practice and knowledge hub.

Dutch investments

Both the Dutch public and private sectors are investing significantly in seed system transformation in low- and middle-income countries. The Dutch Government has invested over €210 million between 2018-2022 through global programmes, public private partnerships, knowledge programmes, etc. In addition, the Dutch vegetable and potato seed sectors continue to expand their activities, which initially started with variety testing, trade, and building-up of local distribution networks, but increasingly also includes investing in multiplying seeds locally and breeding, including local crops.

With the launch of SeedNL, public and private investments can be better aligned and allow for a more coordinated learning. Joining the unique expertise in the public-private network, the Netherlands creates value for partners in seed sector development.

Resistance to pests and diseases

Pest, diseases and invasive species are a major concern for farmers globally. Physical barriers may suffice for cattle and birds, who know exactly when certain crops are at their tastiest. But other mechanisms are also needed for many insects, fungi, bacteria, and viruses that attack crop plants.

Besides chemical control or biological agents to control such pests and diseases, crop level resistance has proven to be a major solution. Breeders have put disease resistances high on their agenda, especially for breeding fresh produce crops, where it is common to encounter strict residue limits. Reducing crop losses and lowering the costs of crop protection are also important goals for farmers. Environmental sustainability concerns and regulations are limiting chemical control options, resulting in an increased priority for resistance breeding.

Diseases in crops can have devastating effects, not just on the plant, but on whole communities of people. One of the most illustrative examples is the Phytophthora (potato disease) outbreak in Ireland in the mid-19th century, which led to massive emigration, many of which fleeing to the USA.

Significant gains in disease resistance can be made through plant breeding. Some genetic resistances remain effective for decades, such as mildew resistance in barley, but for other crop-disease combinations new resistances have to be regularly introduced. Notorious in this respect are mildews in lettuce and spinach. When resistances depend on single genes, it is often imperative to continue breeding until different resistance genes or alleles have been combined.

Despite plant breeding being a powerful tool in making crop production less dependent on chemical controls, a major setback is the time it takes to develop resistant varieties. In traditional breeding programmes, backcrossing commonly takes anywhere between eight to forty years depending on the source of the resistance and the complexity of the breeding cycles. An example of the latter is clubroot in cabbage, which was found in a species related to cabbages and which could be transferred only through bridge crosses to bypass the species-barriers. This breeding programme started back in the 1970s and took decades. Scab resistance in apple has been introduced from a wild apple the size of a cherry. It took 5 generations, some 50 years (from the 1940s to the 1990s), to obtain the first resistance variety with sufficient fruit quality to be introduced in the market.

Advanced knowledge of plant-microbe interactions, both above and below ground (soil microbiome), in combination with the quickly developing genetic knowledge at the molecular level, is increasingly used in resistance breeding. New genomic techniques provide huge promise to accelerate the breeding processes, notably for disease resistances based on single genes, either by knocking-out susceptibility genes or by modifying or activating existing resistance genes to create new alleles that give renewed resistance to a pathogen.

Why Plant Breeders' Rights matter for agricultural development

Plant Breeders' Rights (PBR) are important for increasing the quantity and quality of production by farmers and growers. For more than 50 years, new varieties have resulted in an average annual growth of 1% of the cereal production capacity in Europe, based on genetics. Only with PBR protecting these new varieties, breeders can generate income that can continue to finance their efforts in future breeding programs.

The development of new varieties requires significant investments in time, knowledge and money, especially in crops with an already wide range of varieties. Without PBR, the incentive for companies and institutes to invest for 5-15 years in developing new varieties would be much lower. It is thanks to this system, which already exists in the Netherlands for over 80 years, that farmers and growers can see new varieties with better properties regularly entering the market.

Countries that want to implement a PBR system normally join UPOV, the international Union for the Protection Of Varieties of plants. This Union currently has 80 member countries, with an additional 20 states having initiated the procedure to join. In the last years, many countries in Africa have started to implement the UPOV convention.

In the Netherlands, applications for PBR can be done at the Board for Plant Varieties; for EU-wide PBR this application can be filed at CPVO (the Community Plant Variety Office). Via the recently developed online UPOV e-PVP portal, applications for PBR can now be done simultaneously in over 70 countries that are participating in the UPOV system. In the Netherlands, the Minister of Agriculture appointed Naktuinbouw as the responsible variety testing institute.

DUS examinations for PBR are carried out in the EU by CPVO entrusted examination offices. Such offices exist in many EU member states. Naktuinbouw is entrusted by CPVO for a wide range of crops. Annually, more than 2000 new varieties in agricultural and horticultural crops are DUS-examined in the facilities of Naktuinbouw. Around 90-95% of the applications successfully pass the tests and PBR can be granted. The Netherlands' breeding companies hold plant variety rights for almost 45% of the protected varieties in the EU, showing the importance of breeding in this country.

It should be emphasised that protecting varieties is an option, not an obligation. The restriction on multiplication and sales only applies to PBR-protected varieties. In addition, the use of protected varieties in breeding programmes is allowed without the consent of the owner of the PBR (this is the so-called breeders exemption). Countries that have implemented UPOV can identify food crops that allow farmers to reuse farm-saved seeds for private and non-commercial use without further licenses.

Developments in breeding in the 1990s, notably based on biotechnologies, have led to the introduction of patents as a form of protecting certain specific characteristics of plants. Plant varieties as such are not patentable in the EU. An important drawback of patents is that plants containing patented traits cannot be freely used for creating new varieties. For

Having PBR on a (new) variety gives a breeder the exclusive right to multiply and sell this variety for around 20 to 30 years. To apply for PBR, a variety must be considered new, distinct, uniform, and stable. The criteria assessment of the variety linked to a PBR application is done through a so called DUS (Distinct, Uniform, Stable) testing procedure.

the marketing of such varieties, a license from the patent holder may be required. There is a societal debate ongoing around whether patents on plant traits are useful and desired or whether they should be abandoned as they do not support breeding.
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Qualified personnel, solid application and testing procedures and good testing facilities are equally important to good legislation. A well-functioning authority is a prerequisite that can use nationally prepared DUS tests or take over DUS reports from other UPOV member countries. The Netherlands is in the position to support countries by providing advice and capacity building related to laws and rules. Support can also take place through technical cooperation, training, internships, supplying protocols and reference materials. Through courses in Wageningen (CDI) or Roelofarendsveen (Naktuinbouw), professional expertise can be built-up quickly.

nak tuinbouw

Support from Naktuinbouw: using the PVP toolbox.

Naktuinbouw offers support to policymakers, technical officers, and administrative personnel in countries worldwide towards the development and implementation of a PBR system. As an independent service, Naktuinbouw is accredited by the Netherlands government and CPVO as an Examination Office. Naktuinbouw as a service and colleague organisation has gained vast knowledge and insight in PVP legislation and procedures in many countries.

Naktuinbouw also helps DUS examination offices and inspection services through advice and training. Manuals and certification as well as test protocols can be supplied to participants. An international helpdesk for questions on PVP is also in operation.

Plant health and phytosanitary policy are key issues

No country wants to bring harmful diseases and pest upon itself by importing infected seeds and plant material. That is why exporting countries like the Netherlands perform a strict control regime involving testing, inspection and certification. For internal EU trade, a solid plant passport system is in operation since 1993. An International Phytosanitary Certificate (IFC) is necessary for every shipment of seed and plant material going to countries outside the EU.

Countries can set their own plant health rules for the importation of materials. They need to comply with international principles set out by IPPC and WTO on this subject. The most important one is that import regulations must be in line with internal phytosanitary measures in the country itself and they must not conflict with state of the art scientific knowledge.

In the Netherlands, the responsibility for the execution of the phytosanitary policy is with the National Plant Protection Office at the Netherlands Food Safety Authority (NVWA) as the coordinating competent authority. Together with the Ministry of Agriculture (LNV), international phytosanitary issues are handled. Good trade relations and appropriate phytosanitary agreements are very important for Dutch exporters.

Clear and uniform phytosanitary regulations and (technical) requirements are important for both exporting and importing countries. Establishing import regulations in a country begins by conducting risk analyses. Risks can be determined, and the resulting rules make clear which protocols, tests and inspections need to be carried out by or under the responsibility of the authorities of the exporting country. By issuing an IFC, the NVWA takes responsibility to declare that all necessary tests and inspections have been carried out and no signs of relevant harmful organisms have been found.

Phytosanitary issues can be quite complicated, not only for authorities but also for companies. In certain crops (vegetable seeds, floricultural cuttings) many companies produce much of their propagating material in countries all over the world. The companies normally send said material first back to the Netherlands, where the material is cleaned, tested, processed and/or rooted. In many cases, it is already necessary to know the final country of destination in order to be able to have all the necessary certificates available for certification.

BKD
UW SCHAKEL IN KWALITEIT

Located in Lisse in the heart of the bulb growing area, the **BKD (Flowerbulb Inspection Service)** has set up home with an office and laboratory. Professional inspectors annually visit production fields multiple times and certify Dutch tulip bulbs, lilies bulbs and hyacinths to be marketed globally.

NAK

The Dutch General Inspection Service (NAK) is located in Emmeloord, in the middle of one of the largest areas for seed potato production. NAK keeps a close eye on the produce of more than 2,500 Dutch producers of seed potatoes and agricultural seeds. An intensive inspection and testing regime guaranties that certified potatoes find their way to potato growers worldwide.

Knowledge about pathogens and especially the availability of proper inspection and state of the art detection and test protocols is very important. Special attention is paid to the development and validation of these techniques by NVWA, inspection agencies, university institutes and the laboratories of seed companies (e.g. in ISHI/ISF cooperation). Every year, a number of very sensitive (improved) protocols become available. In many cases, PCR and DNA techniques replace ELISA tests, although the latter are still important in big scale screening and testing.

Considering the amount of inspections and tests, a number of companies have developed their own programs for continuously safeguarding the identity and health of the seeds and plants they produce.

Provided that these programmes follow prescribed protocols, are solid, fulfil technical requirements and have skilled personnel responsible for the examinations, the competent authorities in the Netherlands can use test results in certification procedures (also known as certification under official supervision). NAL and Elite systems of Naktuinbouw are a good example. This even further improves the reliability of the health and quality of the propagation material.

In the Netherlands, a world-class inspection system with three independent agricultural inspection agencies in seeds and plants carries out regular company and field inspections. It also samples and tests control laboratories, and markets reliable products. If seed is not fulfilling norms and standards, material cannot be approved for marketing.

naktuinbouw

In Roelofarendsveen, in the western part of the country, Naktuinbouw (the Inspection Service for Horticulture) runs a number of laboratories for health testing, seed analysis (ISTA accredited) and identity analysis (DNA services, Variety Tracer). Their offices also boast a trial garden. The organisation employs 90 inspectors responsible for regular audits and inspections, as well as import and export inspections.

Nederlandse Voedsel- en Warenautoriteit
Ministerie van Landbouw, Natuur en Voedselkwaliteit

The NVWA, with head offices in Utrecht, is the national NPPO (National Plant Protection Organisation) and responsible for the integrity and proper functioning of the Netherlands phytosanitary system. It supervises and audits the appointed inspection agencies. It has a specialist back -up laboratory (NIVIP) for diagnostics. International communication on phytosanitary issues is a primary responsibility of NVWA.

State-of-the-art seed technology

The seeds that farmers use have to be in optimal condition. Next to the genetic quality (identity and varietal purity and adaptation), three other seed quality determinants are important: physiology, analytical purity and health. Additional seed-applied technologies can support the seeds and the crop that grows from them.

The most basic way to improve the quality of seeds involves sorting and cleaning. The high-throughput air-screen cleaners, indented cylinders and gravity separators are commonplace all over the world for the major crops. These do not suffice for most horticultural seeds. Notably, the diversity of small flower seed species require very special seed sorting equipment. Since the Netherlands is home to a wide variety of horticultural seeds, it is an excellent source of special seed sorting machines for these diverse uses. More recent developments in seed sorting include the use of X-ray, combined with AI-supported image analysis to identify off-type embryos in individual seeds.

Seed physiology has received a lot of attention in the country, particularly over the past 50 years. Originating in public-private scientific cooperation, a variety of seed priming processes are applied by seed companies when uniform germination and seedling vigour are essential. The demand for these traits is highest in high-tech greenhouse horticulture, where crop uniformity is highly valued.

There is also a wide range of additional technologies available, from pelleting to facilitating machine seeding, and those that add important compounds to enhance seed health and protect the emerging plants systemically. Attention is given to adding non-chemical agents to perform these functions to replace chemical alternatives, support the microbiome and provide micronutrients and plant hormones that support the seedling to grow into a strong and resilient plant.

Non-chemical methods, biological alternatives and biodegradable stickers are important developments to make seed treatment as environmentally sustainable as possible. All these technologies provide value for the seed user; the development and application of these technologies is becoming a decisive part of the success of the seed companies, next to their breeding effort.

New crops: public then private

Crop diversity in most advanced farming systems is rather low. Arable crop production in many parts of the Netherlands have a standard rotation mainly including potato, cereal and sugar beet. In any locality, field vegetables like onion and cabbage and grass seed production can be included. Protein crops such as field beans are emerging and may take up minor acreages as well.

Plant breeding serves an important purpose in the search for new crops. Crops that are new to the Netherlands arable crop areas have to be adapted to Dutch growing conditions, and need to serve a market and fit into current or future farming systems. Potato was a new crop in the Netherlands in the 19th century and became the major staple for Dutch consumers. Maize (Zea mais) has been adapted to the short growing season in North-western Europe since the early 20th century through subsequent selection cycles. It is now the major feed crop for the dairy industry in the country. The great diversity of flowers and pot-plants that the Netherlands is famous for also originally derives from various regions. However, there are also several indigenous crops that have been 'forgotten', mainly because the yield potential was insufficient compared to alternatives. An example is field bean (Vicia sp.), which was outcompeted by imported soy for protein production.

The more recent research for increasing diversity in farming systems has focused on a wide range of crops, such as Jerusalem artichoke, Crambe, Tagetes, Quinoa, Miscanthus, fibre hemp, oil flax, soybean, lupin and others. Such developments require a combination of agronomy, market and breeding. Crops need to be mechanically planted, tended and harvested if they are to be adopted at any scale in a Dutch farming system. Breeders can facilitate this by working on plant architecture and other characteristics in the new varieties. They also need to make such a crop economically viable by increasing yield potential and, in some cases modify the levels of preferred compounds such as protein content and composition.

The business and marketing concerns should not be ignored either. The Dutch seed sector has successfully invested in breeding cover crops and catch crops for some time, which due to their importance in sustainable cropping systems in major parts of Europe, is now proving to yield significant demand.

Private sector breeders are commonly not the first to jump into such novel developments where success cannot be predicted. It is also an important task for public research to show that a commercial future exists. This could take up to decades, but in the case of quinoa and Miscanthus, the private sector follow-up proves to be possible.

Taste and other consumer qualities

Breeders have for a long time focused on improving yield in actual farmers' conditions. This includes yield components such as disease and pest resistance, water- and nutrient use efficiency, and plant architecture affecting light interception and increased plant population. Increasingly though, yield for the farmer also needs to be calculated in monetary terms. Product qualities for consumers are increasingly included in the breeding goals. In vegetables, this translates to taste (less bitterness in brussels sprouts), texture (tomatoes), shelf life (slow browning lettuce), and size (cauliflower), which can contribute to food waste reduction. There are also initiatives to increase heath compounds, which is internationally done for iron, zinc and provitamin A in basic food crops, fighting malnutrition. However, legal limitations to making specific health claims in most countries results in a decrease of appetite for breeders.

Taste panels

Taste can be increasingly identified chemically, which allows breeders to select promising lines. Sugar and acid levels are the major determining factors that can be measured, next to 'mealiness' or juiciness levels. However, "Breeders also still commonly enlist the help of taste panels", says Wouter Verkerke, researcher at the taste lab of the Greenhouse Horticulture centre of Wageningen University & Research. These panels are made up of a large number of experienced tasters. They give extensive feedback on the texture, taste and scent. The only drawback is that tasting 24 varieties takes at least a few days. Breeding companies now employ both laboratory and test panels at their own premises as well.

Example: fine-tuning new tomato varieties

Dutch seed companies are improving an increasing range of plant traits, including flavour. The new vine tomato is aromatic, sweet and slightly tart, with a firm, juicy bite.

Until 25 years ago, vegetable seed companies barely paid any attention to the flavour of their new varieties, eventually causing a bad reputation for their varieties. Luckily, the current approach to plant breeding is completely different. Nowadays, whether a variety ends up on supermarket shelves strongly depends on the taste of the produce. Tomatoes are a great example. Dutch vegetable seed companies develop hundreds of new tomato varieties every year. They differ from one another in type, but also in traits such as resistance to fungi, bacteria, and viruses, crop yields and production levels.

Crunchy and firm

The score depends on the desired taste. Verkerke says “Companies want vine tomatoes to be sweet and fragrant, with a tangy kick and a firm, juicy bite. But snack tomatoes need to have a crunchy and firm texture, and may be slightly less fragrant, so that you keep eating them.” The desired taste can also differ from one country to another. The Japanese, for example, want a soft, sweet tomato without any tanginess.

Wageningen University & Research has identified some of the many genes responsible for producing certain flavours. This enables seed companies to improve their tomato plants in an more targeted way moving forward, combining other desired qualities, such as disease resistance and salt tolerance, with a specific taste.

Organic seed

Increasing the cropping area under organic production is seen as a major tool to improve ecological sustainability in farming. Organic products are valued by consumers who are willing to pay a higher price compared to conventionally-produced alternatives. Several Dutch seed suppliers identified this trend early and have a ready market for their organically produced seed in Europe and beyond.

The areas under organic production, notably for vegetable crops, have increased substantially over the past three decades. Initially, organic producers mainly used conventional seed that was not treated with chemical crop protection products or, mainly in the biodynamic sub-sector, home-grown seed. The call for quality seed that is produced organically inspired conventional seed companies to set up specific business groups to produce seed for this target group separately and select their varieties for their performance under organic conditions. Others professionalised their organic seed production and started to breed, developing fully organic seed companies.

Organic seed production requires additional knowledge and care compared to conventional seed production. The reason is that chemical options cannot be used when a seed transmitted disease appears in the seed production field. This not only demands quality, but also freedom from diseases on or in the seed, which is extra important for organic growers as they cannot afford to start a crop with an inoculum of harmful disease agents. Organic seed production is therefore very knowledge-intensive and has a higher risk of failure. This means that organically-produced seed is commonly more expensive than conventionally-produced seed.

Plantum has organic seed companies as members, conventional companies that have invested in producing seed under certified organic conditions, and also companies that sell untreated seed to the organic sector. Together they provide an estimated 95% of the seed used by organic growers.

Currently, rules in Europe prescribe that organic producers have to use organically-grown seed unless such suitable seeds are not available in the market. Only in that latter case can they use non-treated conventionally-grown seed. Since conventional seed is normally cheaper than organically-produced seed, some farmers see the use of organic seed as a dilemma. An annually updated list of varieties of which organic seed is available can be found on the website of Organicxseeds.

New propagation systems

Propagation of crops and varieties thereof is normally done based on an long tradition and practice, developed by growers during centuries. Using seeds, taking cuttings, growing side shoots, harvesting bulbs or grafting on rootstocks are well known techniques to multiply material. The biggest difference is between vegetative propagation ("cloning") and generative propagation (true seeds).

When applying vegetative propagation the genetic makeup of a young plant does not change and one makes multiple copies of the same mother plant. So it leads to a uniform progeny. Generative reproduction of normally vegetatively propagated crops commonly leads to recombination of DNA and can result in a very diverse progeny. Of course, producing homogeneous seed lots of DUS tested varieties is necessary.

Multiplication through seeds commonly produces larger numbers of offspring in several crops. Also, diseases and pests are less frequently infecting the propagation material compared to roots or cuttings. In most cases, seeds can be stored longer and transported easier. Vegetative propagation, on the contrary, can be preferred because of the quick and uniform growth of the young plant, and because of the uniformity of the crop.

Since the 1980s, a new vegetative propagation technique, known as tissue culturing, has become an important way of propagation. Many ornamentals nowadays are propagated "in the tube", such as Orchids, Gerbera, Anthurium and lilies. Over the last ten years, fruit plants (banana, strawberry, apple rootstocks) are more often propagated also in vitro culture. Tissue culturing improves the speed of multiplication. Disease pressure is also much lower than conventional vegetative multiplication techniques with often reduced phytosanitary hurdles for international trade of plantlets.

Very interesting is the creation of new seed propagated varieties in crops that traditionally are propagated vegetatively. Some companies in the Netherlands are the source of that development. Around 20 years ago, commercial seed propagated F1 shallot hybrids were introduced in the market. Shallots are traditionally propagated through bulbs, which is very slow. It took some time until a uniform product was created. A new discussion then arose: Where is the distinction between onions, echalions and shallot species? Nowadays the seed shallots cover a significant part of the global shallots production.

Since the introduction of the potato crop in Europe in the 17th century, propagation has been carried out through tubers. Ten years ago, two Dutch companies presented their first seed propagated potato varieties (so called TPS; true potato seeds). It may still take some time until the seed-propagated varieties can be regarded as comparable to tuber-propagated potatoes in all potato growing areas, and reach the same production quantity, uniformity and size of tubers. But transporting true seeds is much cheaper and disease risks are much lower compared to conventional seed potatoes. For specific growing conditions (mainly more tropical climates), true potato seeds can provide new solutions for farmers who currently have little access to quality tubers of good varieties, and who re-use locally produced tubers as seed potato with all associated disease risks. Potato breeders now also increasingly use this technology in their breeding; whether true seeds will be used directly by farmers, or whether specialised producers of young plants, mini-tubers or conventional seed will emerge who supply ware potato growers with 'conventional' seed tubers grown from true seed, remains to be seen in the wide diversity of potato-growing areas of the world.

Another example of a change of propagation mode can be seen in strawberry propagation, which traditionally is through vegetative means with so-called runners. Seed-propagated varieties have been around for some time but mainly for ornamental use and hobby market purposes. Recently, several companies are introducing F1 true seed hybrids for professional strawberry production. More seed companies have announced investing in breeding of seed-propagated strawberry (and other soft fruit) varieties. It can be expected that a shift in other crops towards seed multiplication might follow.

CropXR: making crops more resilient, sustainable and climate adaptive

Throughout history, plant breeding has successfully resulted in crop varieties with ever-increasing levels of yield and quality. Today's crops perform well under stable conditions. High yields and quality can only be achieved if plants are supported and protected against a wide array of biotic and abiotic stresses by control measures. Challenges like climate change, new limits on the use of agrochemicals and a growing world population put pressure on the current agricultural system worldwide. Therefore, growers need more resilient crops that must overcome increasingly common and intense heat waves, droughts, floods, nutrient shortages and higher salinity. Furthermore, resilient crops should be able to cope with diseases and pests, while the use of fertilizers and pesticides are being reduced. As the pace of climate change accelerates, speeding up the development of resilient crops and resilient cropping systems is urgent.

Current plant breeding techniques cannot effectively enhance highly complex traits like resilience. To breed a new generation of robust varieties, new smart interventions are needed. A new generation of smarter technologies and breeding tools should be capable of improving complex plant characteristics. That is where the new initiative CropXR comes in. By combining plant biology, simulation modelling, and artificial intelligence, CropXR aims to develop, optimise and utilise a revolutionary smart-data breeding methodology. Thus, breeding for complex resilience traits in different growing systems for several crops can be speeded up. This enables breeders to develop 'extra-resilient' (XR), more sustainable crops.

CropXR

The CropXR institute

CropXR is a 10-year Dutch initiative, that started in 2024. It is a collaborative effort involving four universities (Utrecht University, Wageningen University and Research, University of Amsterdam & Technical University Delft), Plantum and a number of industrial partners. These include leading plant breeding companies in the vegetable, potato and ornamental

sector, processing companies and biotech companies. In addition to scientific research and data collection and sharing, human capital development and practical research projects in agriculture and plant breeding are important subjects. The institute works on these topics in close collaboration with Universities of Applied Sciences. CropXR is financially supported by the Dutch Research Council, the National Growth Funds, and the Foundation for Food & Agricultural Research. Learn more about CropXR at www.cropxr.org.

The sense of urgency to develop more resilient and climate adaptive crops is a crucial pillar of the CropXR endeavour. All partners work together to contribute to developing a sustainable agricultural ecosystem. The need for increased food security fuels the positive energy of the CropXR coalition towards achieving its mission: “In 2033, we have resilient crops developed through data-driven design”.

CropXR has defined four success strategies that will pave the path towards achieving this mission:

1. The heart and fundament of CropXR is its Data-Driven Design. CropXR studies and unravels crop resilience. This creates the ability to accurately predict for resilience in crops through the combination of biology, data, modelling, simulations, and artificial intelligence.

2. On top of the research, experiments, data, and knowledge generated by the CropXR community itself, CropXR will develop the Resilience Hub. The aim is to create the world’s most extensive collection of knowledge, data, tools, and experts around the topic of crop resilience.

3. A unique characteristic of the CropXR coalition is the intensive collaboration between academia and industry. The various (industrial) partners, even competitors, work closely together on a common mission. A group of people is brought together who are different in many ways but share an urgency to create societal impact. Diversity is embraced and the many different talents of all those who participate are cherished as a unique competence.

4. In the fourth strategy, Accelerators, CropXR continuously identifies ways to speed up the progress towards the mission. Accelerators can be: improving collaboration, smarter experimentation, innovative data approaches, or access to new resources, partners, and knowledge.

Potatoes: contributing to food and nutrition security

Potato is a staple food in the Netherlands, and exporting seed potatoes is seen as an important contribution to a number of SDGs.

After rice and wheat, potato is the third most important food crop globally, with 380 millions of tons produced annually, consumed by over 1 billion people. Potato is considered by the United Nations as a major contributor to future food security, especially where water shortages create limitations to cereals and year-round rice growing. Potato has a positive resource use efficiency in many aspects (energy, land, water) compared to other major food crops and can be adapted to a wide range of ago-ecological conditions.

Based on dry weight, the protein content of potato is comparable to maize and rice. Potatoes have a much better protein-to-carbohydrates ratio (1 to 9) than other roots like yams (1 to 18) and cassava (1 to 25). Potatoes are also a source of minerals, vitamins and fibres. They are rich in vitamin C, which also promotes iron absorption, and contain vitamins like B1, B3 and B6, as well as minerals like potassium, phosphorus and magnesium.

The quantity of potato production in different potato-growing regions of the developing world is generally far below potential, even though the demand for potato is rapidly increasing for its consideration as an affordable part of a healthy diet, particularly in quickly-expanding urban areas. This creates a range of business and employment opportunities along the value chain. It is becoming an income-generating crop for many small-scale farmers. Rapid, quantum leaps in potato yield can be achieved using quality seed and advanced cultivation practices, including rotation.

A critical element of potato production is the planting material. As a vegetatively propagated crop, storage of seed potatoes has its technical challenges, and tuber-transmitted diseases are multiple and difficult to manage. Just as with other crops, genetics are in many ways a determining factor for a successful crop.

Active breeding of potato started in the Netherlands some 150 years ago. Over the years, this has resulted in our internationally recognised leading position in breeding and seed production. In fact, the Netherlands is the world's largest exporter of seed potatoes, covering approximately 55% of the globally exported certified seed potatoes (800,000 tonnes per year). Varieties are bred for the specific needs of different ago-ecologies and user preferences. That includes the consumer, with distinct preferences for texture, colour and taste, but also the processing industry, requiring specific traits for chips, crisps or starch and protein production. The Dutch national list of varieties has over a hundred varieties of which seed potatoes are grown for different regions and uses. An essential element of the global position in seed potatoes is the quality control system applied in the Netherlands, providing the seed potatoes with a widely recognised NAK quality label.

The Dutch potato sector is a typical example of the golden triangle where companies, government, and knowledge and educational organisations collaborate with each other, respecting their own goals and responsibilities. Official quality controls were initiated 90 years ago. Public-private collaboration in research has a history of over 70 years. The combination of innovation and entrepreneurship has led to a diversity of approaches to seed production and exports. The use of modern breeding methods reduce the time to arrive at a new variety. Storing and exporting seed potatoes, being bulky, wet and easily spoiled by heat, has several logistical bottlenecks. Rapid multiplication through tissue culture, mini-tubers, and controlled systems for further multiplication in the target countries offer important strategies to guarantee healthy material for the farmers. The recent development of true potato seeds offers new possibilities both in breeding and logistics. Breeding at the diploid level and the subsequent development of hybrid potato seed is a Dutch development that is now gaining momentum.

Ornamentals: Dutch companies produce top-class planting material

The Netherlands has a globally recognised name as a country of production and sales of flowers and plants. Tulips are iconic but many other bulbous crops, cut flowers, pot-plants, perennials and nursery stock are equally important.

The total annual value of ornamentals production and sales (including re-export) in the Netherlands exceeds €12 billion, of which more than €10 billion is exported. Ornamental produce belongs to the top 10 export sectors in the Dutch economy. More than 3500 companies in Floriculture, Bulb production and Nursery stock are active. An estimated 60-70% of the planting material is exported.

Most of the ornamental crops grown in the Netherlands are not native to the lowlands. Tulips and other bulb crops like hyacinth were introduced in the late 16th century. Arboriculture production became more important with the growing interest in gardening in the 17th century, and many new species of shrubs and trees were introduced, initially especially from Asia. Botanical gardens at that time played an important role in the introduction of those new species. Boskoop as a centre of production really started to grow in the 19th century when the German market became more important. In the Westland area, glasshouses for grape production were erected since the mid-19th century. The typical warehouses with huge glass constructions started to be used in the early 20th century.

Floriculture in Aalsmeer (nowadays regarded as the traditional heart of the cut-flower business in the Netherlands) emerged at the end of the 19th century, but in fact it was only since 1960s that ornamental production exploded in acreage in the Netherlands. In a connection with the presence of a strong auctioning system for marketing the produce, and supported by practical research and advisory services, many growers made the step from growing vegetables to ornamentals. The Netherlands became a world market leader, not only in production, but also in trade of flowers.

Since the 1980s also in several other countries (mainly in Israel, Africa and Latin America) professional ornamental production emerged. Often a “Dutch connection” was and still is visible. The production of carnations, roses, alstroemeria’s and chrysanthemums exploded.

The Netherlands houses probably the largest number of ornamentals breeders worldwide. The vast majority of applications for plant breeders' rights for new varieties of ornamentals comes from Dutch companies.

Around 45% of EU applications for PBR (in 2022) is done for new ornamental varieties. In the top 10 companies applying for PBR, 6 of them are from the Netherlands. The most important crops include Roses, Chrysanthemum, Phalaenopsis, Petunia/Calibrachoa, Impatiens, Lilium, Gerbera, Dianthus, Anthurium and Hydrangea.

Seed and planting material of those varieties have to fulfil high standards to be marketed. All companies are registered and regularly inspected. Not only is the material fulfilling EU requirements and standards for quality and phytosanitary status, but in many cases it can be inspected and classified as high-graded material by authorities as Naktuinbouw and BKD in quality plus systems like Elite, Select Plant or Classes I and II .

Colophon

This brochure is a co-production of the following organisations:

Ministry of Agriculture, Nature and Food Quality
URL: https://www.government.nl/ministries/ministry-of-agriculture-nature-and-food-quality

Plantum
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Topsector Horticulture and Starting Materials
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