

Prophyta



Autumn 2026

Gene banks essential
for future innovation
16

The missing layer:
precision reproduction
30

How seeds prepare
for life without water
40



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In this edition

4-9

In short

5

Editorial

10

Federico Pisani

**"Plant breeding is a holistic practice.
That supports ecological balance"**

12

Agriculture in Spain

From local production to global relevance

13

Antonio Villarroel, ANOVE

Spain: natural laboratory

15

Spain Feeds Europe, but

Challenges everywhere

16

Why gene banks are racing to
protect the future of food

"Time is starting to run out"

19

Making space for diversity

Farmers' varieties and landraces

20

Access to genetic resources at a turning point



22

Interview John-Pieter Schipper:

Plenty of opportunity for breeding

25

Consortium for Food Plants gene conservation

25

Column Niels Louwaars

Diversity at every level

26

Biodiversity in Tropical Fruit Cultivation

From threat to opportunity



28

**What public data can reveal about
genetic strategy**

30

The Missing Layer

Precision Reproduction

32

The Nardocott UK Case

Lessons to learn on EDVs

34

UPOV and young people

Cultivating the next generation

36

CropMix Living Labs

To support sustainable arable farming

37

Enza Zaden explores mixed cropping

Cultivating Resilience through Diversity

39

New assay for the detection of LMV in lettuce

40

New insights into the biology of seed maturation

When drying drives development

42

At the intersection of sustainability and commerce

**Echinacea secures a permanent place
as premium product**



45

**Transmission of 'Candidatus Liberibacter
solanacearum' via carrot seeds**

46

Vegetable seed sector development

A diversity of approaches



47

One hundred years Laboratory of Entomology

48

**Online plant breeding education
supports professional development**

49

Knowledge transfer in plant breeding

"Mutual exchange is even more important"

50

Spotlight on a herbal book

ON THE COVER

Diversity in aubergine
(Source CGN, image edited)

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After a period of more than 13 years of discussion, it now looks as if the EU seed and plant material sector is indeed going to get new legislation for safeguarding identity and quality of marketed plant reproductive material. Also, registration of varieties and certification will be newly regulated. The basis is a Commission proposal from 2023, in which 11 old council directives were merged into two regulations.

In June, a new regulation 2026/1392 was published specifically for forestry material, replacing the 1999 Directive. Also in June, an EU trilogue agreement was reached for agricultural and horticultural PRM. It is expected that the final text, which needs to be approved by both the Parliament and the Council, can be published by the end

of the year/beginning 2027. Also, new delegated and implementing acts have to be formulated. After final adoption, it will take another 4 years to enter into force (so presumably 2031). Main elements of the new Regulation are sustainable VCU for new agricultural varieties and voluntary for the introduction of vegetable and fruit varieties, equivalency requirements for imported seeds and plants that are ready to be marketed, specific requirements (derogations) for seeds marketed to non-professionals (amateur gardeners) and for conservation varieties, and the introduction of possibilities for exchange of seeds between farmers (under strict rules). The fundamental aspects for certification and inspection are going to be unchanged.

Tomato: fruit or vegetable?

Today, the tariffs the USA imposes on imports makes the front pages of newspapers worldwide, but discussions about it are nothing new.

In the late 19th century, tariffs led to a lawsuit that ended in the federal Supreme Court. The case: is a tomato a fruit or a vegetable? According to John Nix & Company, one of the largest sellers of produce in New York City, the tomato is a fruit and thus should be exempt from taxes. The Customs Authority of New York, however, considered tomatoes as a vegetable and thus taxable. The court unanimously decided in

favour of Edward L. Hedden, collector of the Port of New York. Justice Horace Gray stated that tomatoes should be classified under the customs regulations as a vegetable, based on the ways in which it is used, and the popular perception to this end. While the tomato is botanically a fruit, legally it should therefore be regarded as a vegetable. Consequently, the tariff of 10% should apply. The case *Nix v Hedden* had a remarkable consequence in 2005 when the New Jersey State Legislature designated the tomato as the official state vegetable based on this ruling.

Source: supreme.justia.com

Inserting full-length genes without breaks

Researchers have developed a new method that allows large pieces of genetic information to be inserted into plants with precision. Published in *Nature Biotechnology*, the study overcomes a long-standing hurdle in plant science, where adding full-length genes has proven far more difficult than simple gene editing. The scientists at King Abdullah University of Science and Technology (KAUST), Saudi Arabia, have successfully tested the method in both tobacco and rice crops. It gives plant breeders precise control over where foreign genetic material is placed within a genome. Unlike traditional genome editing tools like CRISPR, that typically rely on breaking DNA strands to make alterations, the new KAUST approach inserts large genetic sequences without causing structural breaks. This safer, cleaner insertion method is vital for introducing multi-gene traits that require multiple genetic instructions working in harmony.



GMO Panel positive about new canola

The GMO Panel of the European Food and Safety Authority (EFSA) has published a positive scientific opinion evaluating the safety of genetically modified RF3 Canola Quality Brassica juncea.

Conducted by EFSA's Panel on Genetically Modified Organisms, the assessment evaluated application EFSA-GMO-NL-2019-158, submitted by BASF Agricultural Solutions, which seeks authorisation to import and process the crop for use in food and animal feed across the European Union and does not include cultivation. Developed through conventional breeding by crossing a GM CQ B. napus line with B. napus RF3, the resulting plant carries traits engineered to improve crop management. The variety expresses the barstar gene to restore male fertility as part of a pollination control system, along with the bar gene, which confers tolerance to glufosinate-ammonium herbicides. In its comprehensive risk evaluation, the EFSA GMO Panel concluded that RF3 Canola Quality B. juncea is as safe and nutritionally equivalent to non-GM counterparts, posing no additional health risks to humans or animals. The scientific opinion also determined that environmental risks from accidental spillage during import and processing would be negligible, marking a pivotal milestone as the application moves toward European Commission authorisation for market access.

Source: elsa.onlinelibrary.wiley.com

'Speed breeding' facility for pepper and tomato

The World Vegetable Center has opened a new speed breeding facility for pepper and tomato at its headquarters in Shanhua, Taiwan. Funded by Taiwan's Ministry of Agriculture, the facility is designed to accelerate the development of improved vegetable varieties for smallholder farmers worldwide. Speed breeding shortens crop breeding cycles by optimising light, temperature and humidity, enabling plants to grow faster and produce seed earlier. Instead of the usual 1–2 generations per year, researchers can produce up to 4–6 generations. The facility's advanced lighting and precision climate control will support rapid breeding of heat-tolerant and disease-resistant pepper and tomato lines. By speeding up testing and selection, WorldVeg can respond more quickly to climate change, pests and diseases, and deliver resilient varieties that help farmers improve productivity, incomes and food security.

Source: World Vegetable Center



Multi-target RNAi for mite control

Researchers at Southwest University in Chongqing, China, have developed an RNA interference strategy that knocks down several target genes at once to control spider mites more consistently.

The approach uses double-stranded RNA (dsRNA) directed at the Rpt2, Rpt3 and Rpt5 subunits of the 26S proteasome. RNA interference can selectively silence genes in pest insects and mites, but the effectiveness of a single target can vary between mite

species and host plants. By targeting several conserved Rpt subunits simultaneously, the researchers observed a more consistent effect across different mite-crop combinations. The study suggests that carefully designed dsRNA constructs could improve the reliability and cross-species performance of RNAi-based biopesticides. The technology could become a complementary tool within integrated pest management programmes.

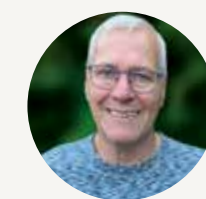
Source: *Entomologia Generalis*.

Sharing genetic variation is also a societal responsibility

The challenges facing global food supply are familiar, but no less urgent. Climate change, biodiversity loss, heat, drought, flooding, salinisation and erosion are putting cropping systems under severe pressure. At the same time, population growth and improving public health keeps driving demand for sufficient, safe and nutritious agricultural products. For plant breeders and the seed sector, the food chain begins in using the broad genetic potential. That is where our strength lies – and our responsibility. Variety development is no longer merely a commercial endeavour; it is a societal prerequisite for resilient agriculture, stable yields and responsible use of natural resources.

This edition of *Prophyta* focuses on genetic variation, with particular attention to collections and gene banks. Far from static archives, they are dynamic infrastructures for future food security. Public and private collections, and cooperation between them, provide the building blocks breeders all over the world need to develop crops better equipped for growing in changing conditions and new cultivation techniques. Yet access to usable genetics is not self-evident. Regional interests, differing perspectives and bureaucratic (border) barriers can slow the storage, exchange and use of genetic material. That is why the sector must keep investing in a shared societal vision, open dialogue, international cooperation and research across the value chain.

The question is not whether sufficient genetic diversity exists, but how quickly and carefully we can put it to use together. Those at the start of the food chain help determine what becomes possible later. This calls for genetic knowledge, use of new breeding techniques, entrepreneurship and a shared conviction: seed quality and diversity is safeguarding future perspectives.



Steven van Paassen, editor-in-chief

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reshape breeding priorities

Digital transformation of seed distribution

Policy support for smallholder-centric seed systems

Polish cooperation in genomic techniques

Four Polish plant-breeding companies within the Krajowa Grupa Spozywcza (KGS) are joining forces with the University of Silesia to assess whether new genomic techniques can accelerate the development of improved crop varieties. The three-year pilot project will initially focus on winter wheat and sugar beet.

Conventional breeding can take many years before desirable traits, such as drought tolerance, disease resistance or yield stability, are reliably fixed in a new variety.

The partners will test whether targeted genetic changes can shorten that timeline and strengthen Poland's domestic breeding expertise.

The initiative is explicitly designed as a pilot phase, with no immediate move toward large-scale application. First, the collaboration will determine whether techniques developed under laboratory conditions can be translated into breeding material used by Polish companies.

Source: CEO Magazyn.



Dual gene drought tolerance and blast resistance

Researchers have identified a naturally occurring variant of the rice gene NLR8 that helps plants cope with both drought and rice blast, one of the crop's most damaging fungal diseases. Such combined protection is uncommon, but it is becoming increasingly important as crops face multiple stresses at the same time.

The variant, known as NLR8-Hap2, is caused by a small deletion in the DNA sequence that removes part of the protein's LRR domain. According to the study, the shortened protein stabilises two transcription factors involved in drought response and defence against rice blast.

When the researchers introduced NLR8-Hap2 into elite indica and japonica rice lines, resistance to both stresses increased without a measurable yield penalty under normal field conditions. The allele could therefore provide a valuable building block for the development of more climate-resilient rice varieties.

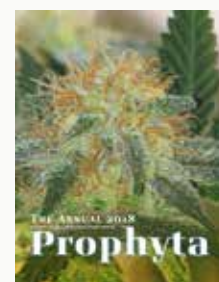
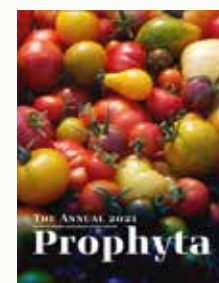
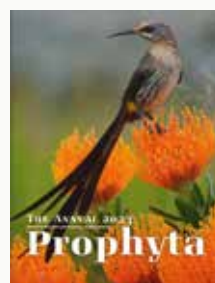
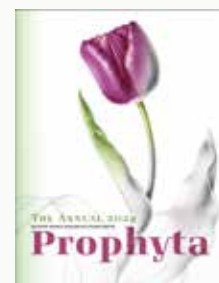
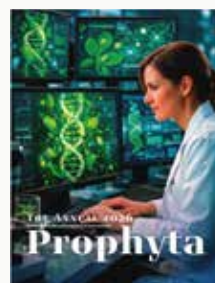
Source: Nature Communications.

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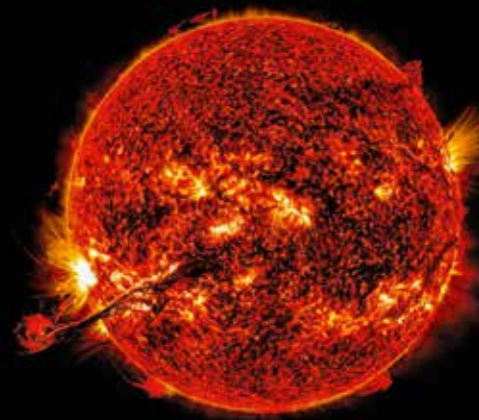
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Heat and disease resistance

In early 2026, the World Vegetable Center reported on new tomato varieties being deployed in Paraguay to make production more resilient to high temperatures and disease pressure. The varieties combine heat tolerance with improved disease resistance, traits that are becoming increasingly important as periods of extreme heat intensify in many production regions. According to WorldVeg, the varieties may also extend the production season and improve tomato availability during warmer periods. The World Vegetable Center (WorldVeg) is an international non-profit research-for-development organisation with regional offices in Africa, Asia and, more recently, Latin America.

Source: World Vegetable Center. Image: Javid Naderi.



Provisional deal for plant reproductive material

The Council of the European Union and the European Parliament have reached a provisional agreement on a major overhaul of EU rules governing plant reproductive material, including seeds, cuttings, roots and tubers. The deal brings Europe closer to reforming legislation that, in some sectors, has changed little since the 1960s.

The proposed regulation is intended to make EU rules simpler, more consistent and easier to apply across member states. It also aims to create more room for innovation, digital tools and modern breeding techniques, while improving support

for conservation varieties, locally adapted varieties and plant material used in organic production. According to the Council, the reform should help strengthen agro-biodiversity, improve traceability and ensure access to reliable planting material that can withstand climate change, pests and diseases. The agreement would replace several sector-specific directives with a single harmonised regulation, although it must still be formally adopted before the new rules take effect.

Source: Council of the European Union.



Peanut allergies tackled

Scientists at Clemson University, Florence, USA, have identified key genetic regions that control production of the major allergenic proteins in peanuts (*Arachis hypogaea*).

The discovery could help plant breeders develop peanut varieties that reduce the risk of accidental allergic exposure. Peanuts contain several proteins that can sometimes trigger deadly allergic reactions. Four of these proteins - Ara h1, Ara h2, Ara h3 and Ara h6 - cause the most severe responses. Published in Functional & Integrative Genomics, the study analysed 92 genetically diverse peanut lines and found significant differences in allergen levels. The team also identified chromosomal regions associated with allergen production.

Molecular plant breeder Sachin Rustgi and his team strive to equip plant breeders with genetic markers to accelerate the development of safer peanut varieties without sacrificing yield or nutritional value. Researchers hope these future low-allergen peanut lines will lower the risk of severe accidental exposure, make oral immunotherapy more accessible and give peace of mind to millions of families managing food allergies. Further testing is currently underway to confirm how the identified genes perform in real-world agricultural conditions and to ensure taste and crop resilience remain uncompromised.

Source: www.isaaa.org



Plant Variety Rights point to China's growing innovation

China's latest round of granted Plant Variety Rights highlights the rapid development of its breeding sector and the growing importance of early intellectual property protection. For scientists and breeding researchers, the announcement underlines both the opportunities for international collaboration and the need to safeguard innovation in high-value ornamental crops. Dutch expertise continues to be recognized, particularly in roses, as China becomes a breeding innovator.

Source: Ministry of Foreign Affairs, the Netherlands

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Federico Pisani, Manager Development Cooperation and Genetic Resources at Euroseeds

“Plant breeding is a holistic practice that supports ecological balance”

Plant breeding is no longer only about higher yields. In a warming world, it has become a race to keep crops resilient, food systems secure and biodiversity alive. Federico Pisani, Manager Development Cooperation and Genetic Resources at Euroseeds, works at precisely that intersection: where genetics, sustainability, international policy and development cooperation meet.

Steven van Paassen
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At the forefront
His role, Pisani says, is to bring the European seed sector’s voice into international forums, coordinate Europe-wide policy positions and work with partners on seed-related development projects. “Ultimately, the aim is to keep the European seed sector at the forefront of development cooperation policies and initiatives, while helping to ensure that genetic resources are conserved, accessed and used in ways that are equitable, sustainable and beneficial to all.”

Better take care
For Euroseeds, biodiversity is both the foundation of plant breeding and a condition for life on Earth. “They are both sides of the same commitment,” Pisani says.

Biodiversity supports ecosystem stability, human survival and economic prosperity. It provides pollination, clean air and water, and climate regulation. Diverse ecosystems are also more resilient to shocks, both biotic and abiotic. “So we had better take care of them.”

Underappreciated position
That same diversity is the raw material for breeding innovation: resistance to new pests, adaptation to climate change, improvements in yield or nutritional quality and responses to changing market preferences. “Plant genetic resources are the indispensable raw material for breeding,” Pisani says. That places the seed sector in a unique, often underappreciated position between biodiversity conservation and agricultural innovation. Plant breeding delivers crops with higher yields, better disease resistance and greater climate adaptability. But, Pisani stresses, to see breeding only through the lens of productivity is to miss its deeper role: preserving the genetic diversity on which resilient food systems depend.

Cultural and economic
By introducing new genetic combinations, breeders help crops cope with drought, heat and emerging pests, reducing the vulnerability of agricultural systems. The effect is broader than yield protection. Diverse crops can support soil fertility and pollinators and reduce the need for inputs. Traits from crop wild relatives keep the genetic pool rich enough to absorb future shocks. There is also a cultural and economic dimension. Traditional crop varieties are often bound up with local identity, customs and cuisine. “As an Italian national, tomatoes come to my mind,” Pisani says. At the same time, neglected and underutilized crops can create new opportunities for farmers, strengthen food security and respond better to specific regional conditions. “In this way,” he says, “plant breeding is not just a scientific endeavour but a holistic practice that supports ecological balance, cultural continuity and economic vitality, ensuring that agriculture remains both productive and sustainable for generations to come.”

Advocating
Euroseeds’ contribution to preserving and creating biodiversity rests on three pillars: supporting access to plant genetic resources, promoting breeding innovation that generates new diversity and engaging in the policy processes that determine how genetic resources are conserved and used.

“To see breeding only through the lens of productivity is to miss its deeper role.”



“The strategy is about growing the pipeline of usable diversity for the future and protecting what already exists today.”

In practice, that means advocating for fair, functional and predictable access and benefit-sharing frameworks under the International Treaty on Plant Genetic Resources for Food and Agriculture, the Convention on Biological Diversity and EU and national laws. It also means supporting modern gene banks, digital germplasm information and genomic tools that help identify useful traits in existing collections. Alongside this, Pisani points to pre-breeding programmes that widen the genetic base of commercial crops, and to in-situ conservation that keeps wild populations and traditional varieties evolving in natural or farm environments. “The strategy is as much about growing the pipeline of usable diversity for the future as it is about protecting what already exists today.”

It remains uneven
Euroseeds works with its members, EU institutions, international bodies such as FAO, the secretariats of the International Treaty and the Convention on Biological Diversity, national gene banks and research institutes. Cooperation has improved over recent decades, especially through the Treaty’s multilateral system and European research initiatives, but it remains uneven. “Some gene banks are under-resourced and struggle to keep pace with digitalisation or regeneration needs, and negotiations on sensitive issues have at times stalled. So there is still room, and need, for closer collaboration and more consistent engagement,” Pisani says.

Pace and predictability
Within the European seed sector, the urgency around biodiversity and climate change is real. It shows in investment choices: breeding programmes increasingly target resilience traits, not yield alone. Companies are broadening the crops and traits they work on and revisiting neglected species and traditional varieties that may fit new climatic conditions. The constraint, Pisani says, is often not ambition but the pace and predictability of regulation and policy: access to genetic resources, approval pathways for new breeding techniques and the market signals farmers receive. Breeding cycles are long, often a decade or more from first cross to commercial variety, so stable, forward-looking frameworks are needed now if crops for the 2040s and 2050s are to be ready in time. “The honest answer is twofold: the sector itself is moving with a real sense of urgency, but the broader ecosystem it operates in - funding, regulation and market incentives - needs to move with equal urgency for that innovation to reach fields at the scale and speed the climate and biodiversity challenges demand.”

Steadily broaden
Progress is already visible, Pisani emphasises. Breeders have brought varieties to market with improved drought and heat tolerance, stronger resistance to emerging pests and diseases and, in several crops, reduced dependency on chemical inputs. “Over the past 20 years, plant breeding has achieved about 1.16% annual yield growth in the EU, which translates into a

compound increase of over a quarter of total yield over that period,” he says. On the conservation side, European gene banks have expanded and digitalised significant parts of their collections, making germplasm easier to find and use. Multilateral access mechanisms under the International Treaty have supported a steady flow of material between countries and institutions for research and breeding. Genetic diversity is also becoming more central to pre-breeding. More programmes now screen crop wild relatives and landraces for useful traits, while genomic tools make it faster and cheaper to identify which parts of that diversity are worth incorporating into elite material. These steps may not always make headlines, Pisani says, but they steadily broaden the genetic base available to commercial breeding.

Accelerate
Looking ahead, he expects this trajectory to continue and, in some areas, accelerate. Wider use of new genomic techniques could shorten breeding cycles for climate-resilient traits; further digitalisation and characterisation of gene-bank material should make underused diversity easier to deploy; and continued engagement in international policy processes and development initiatives may improve regulatory environments. “The results can take time, but the direction of travel is well established.” •

From local production to global relevance

Spain is one of the EU's leading agricultural producers. It ranks second in agricultural area, with around 20 million hectares in production and 800,000 farms, and second in production value, at about €65 billion. The wider agri-food industry is valued at approximately €170 billion. Cereals, livestock, citrus and other fruit crops, olives and wine are the main pillars of Spanish agriculture. Spain accounts for around 50% of total EU olive production, mainly for oil, and is the world's largest producer of this commodity. For many years, Spain was also the world's leading producer and exporter of oranges and mandarins, although China has now assumed that position.



Bad shape

This leading position was not always self-evident. Before the Spanish Civil War (1936–1939), Spanish agriculture was in poor condition and had long been regarded as backward. Farms were often very small, modernisation was limited and agricultural policies were inefficient, resulting in low average output. Cheap labour, relatively high energy costs and access mainly to local markets further slowed development. In addition, large areas of land belonged to the Church or to municipalities, while soil quality in many regions was relatively poor. As a result, the incentive to innovate, improve and increase productivity remained extremely limited.

Depending on immigrants

Real change began in the 1950s, when active land reform policies created larger plots and farms, and provided a strong incentive for mechanisation. Productivity tripled between 1950 and 1970, although production per hectare initially remained relatively low and below the EU average. In the 1960s and 1970s, many people left rural areas and moved to cities. In 1960, 42% of the working population earned its main income from agriculture; by 1985 this had fallen to 15%, and today it is

about 3.5%. As a result, most agricultural and horticultural sectors are now heavily dependent on migrant agricultural workers from Morocco, sub-Saharan Africa and Eastern Europe. They are estimated to make up around 70% of the agricultural labour force. In general, wages are low, the work is physically demanding, and living and housing conditions are poor.

Irrigation crucial

Still, especially in northern Spain, many small farms, known as minifundiums, remain. These farms often depend heavily on EU subsidies and rely largely on rainfall for water. Larger farms, or latifundios, are mainly found in the southern part of the country. In the hot and dry climate of many Spanish provinces, irrigation is now crucial for high-value crops. Key production areas include Andalusia, with olives, grapes and vegetables; Valencia and Murcia, with citrus and fruit crops, such as strawberries, and the rapidly expanding avocado sector; Rioja and La Mancha, with wine; and Jerez, with sherry.

Local and domestic

The history of Spanish agriculture is long and diverse. Around 5000 BC, Neolithic farmers from the east, particularly the Anatolian region, arrived by maritime

routes and cultivated cereals such as wheat, barley and emmer, as well as legumes. The Phoenicians, from around 1100 BC, and later the Romans, introduced and expanded wine and olive production. During the Moorish period, from roughly 700 to 1500 AD, irrigation techniques advanced significantly, and crops such as rice, cotton, citrus and sugarcane were introduced. For a very long time, agriculture remained mainly local and domestic in orientation. Spain's entry into the EU in 1986 gave a major impulse to the development of a more market-oriented agri-sector.

Most vulnerable country

For today's Spanish agriculture, the consequences of climate change are critical. Spain, especially the south and east, where around four-fifths of the country's agricultural land is located, is probably one of the EU's most vulnerable countries to drought, extreme heat and desertification. At the same time, heavy rainfall can cause sudden water damage, partly because erosion and limited water-retention capacity make it difficult to contain large volumes of water. Finding effective ways to adapt to these changes will be crucial if Spain is to maintain the strong position of its agricultural sector. •

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Interview Antonio Villarroel, ANOVE

Spain: natural laboratory for adaptation

As climate change reshapes food production, plant breeding is becoming one of agriculture's most practical tools for resilience. "For Spain, with its water scarcity, heat extremes and diverse cropping systems, genetic diversity is no longer only a conservation issue. It is an innovation imperative," says Antonio Villarroel, Secretary General of the Spanish National Association of Plant Breeders (ANOVE).



Modern plant breeding rests on a clear principle: identify or create genetic variation, then select the combinations that perform best under specific conditions. But its significance goes beyond individual varieties. "A resilient food system cannot depend on a single genetic solution," Villarroel says. "It needs a broad portfolio of crops, varieties and traits that can respond to conditions we cannot fully predict." He points to tomato as an example. Over seven decades, breeding has expanded the genetic diversity available in commercial tomatoes, while delivering varieties tailored for flavour, shelf life, disease resistance and market needs. The lesson, he argues, is that conservation and innovation are not competing goals. Plant genetic resources must be preserved, understood, used and responsibly expanded.



“Genetic diversity is not simply about safeguarding the past. It is agriculture’s capacity to choose, innovate and adapt.”

Antonio Villarroel, ANOVE

Breed for adaptation

The link between agriculture, genetic diversity and climate change is direct. Water availability, temperature patterns, extreme weather events and pest and disease pressure are all shifting. In some regions, established crops are already being tested. Spain is a particularly clear case. Farmers in many regions must produce with less water, while facing longer and more intense periods of heat and drought. Genetic adaptation is therefore essential, alongside better water management, soil stewardship, agronomic practice and digital tools. "A variety that maintains yield under water stress can determine whether a farm remains profitable. A crop that tolerates high temperatures during flowering or resists a disease moving into new territory can protect both production

and livelihoods. The task is not simply to breed for resistance, but for adaptation: reliable performance under new climatic scenarios," Villarroel emphasises. **Evidence from Spain** Spain's breeding sector has already built substantial innovation capacity. It invests more than €100 million annually in R&D&I, operates 78 research centres and includes many companies with in-house research capabilities. That capacity is producing measurable results. In maize, wheat, tomato and blueberry, genetic improvement is estimated to have generated an additional cumulative production of 62 to 76 million tonnes over the past 30 years. In 2020 alone, almost 700 new plant varieties were registered for commercialisation in Spain. "These figures show that breeding is not a distant scientific promise; it is already shaping farm productivity," Villarroel says. The environmental implications are equally important. Studies cited by ANOVE point to potential annual savings of up to 22 million cubic metres of water and 345,400 tonnes of CO₂, alongside productivity gains.

Climate-smart plant breeding

Spain's agricultural diversity gives it a distinctive role in European adaptation. Its production systems range from arable crops and horticulture to fruit, citrus, vineyards and specialised sectors, each with different genetic requirements. Its regions also span contrasting pressures: water scarcity, high temperatures, extreme weather and shifting disease landscapes. "This makes Spain a natural laboratory for climate-smart plant breeding. Progress will be especially important in four areas:

drought and heat tolerance; resistance to emerging pests and diseases; improved water and nutrient-use efficiency; and better nutritional and sensory quality. Together, these traits can help agriculture produce more value with fewer inputs, while maintaining quality for consumers."

Raise awareness

Climate adaptation cannot be delivered by breeders alone. It requires farmers, seed companies, research centres, universities, public authorities and European sector organisations to work in close alignment. An example of this collaborative approach is the 'Farmers Against Climate Change' (Agricultores contra el Cambio Climático) initiative, founded by ANOVE together with Spain's leading farmers' organisations and agri-food cooperatives. Its aim is to raise awareness and disseminate the extensive work being carried out in plant breeding specifically to combat the effects of climate change. The initiative is a good example of how different actors across the agricultural value chain can work together to communicate the value of innovation and new varieties as tools for adaptation.

First link

Genetic diversity is not simply about safeguarding the past. It is agriculture's capacity to choose, innovate and adapt. In a changing climate, that capacity may prove to be one of its most valuable resources. "Seed should therefore be placed at the centre of agriculture's adaptation strategy," Villarroel concludes. "It is the first link in the food chain and one of the most effective tools available to maintain productivity, protect farmers' profitability and reduce pressure on natural resources." •

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Spain Feeds Europe, but challenges everywhere

From the shimmering “sea of plastic” near Almería to the fertile fields of Huelva and Murcia, southern Spain has become one of Europe’s most important food baskets. Once dry and economically fragile, these regions now export vast volumes of fruit and vegetables. Their mild winter climate gives them a decisive advantage: while northern Europe produces little in the colder months, produce from Andalusia and Murcia fills shelves in Germany, France, the United Kingdom and the Netherlands.



Greenhouse complexes around El Ejido and Almería. © Google Earth Pro, 2003-2026.

When demand is high

The clearest example is Campo de Dalías, southwest of Almería. Protected cultivation began here in 1963 with simple plastic coverings; today greenhouses cover about 33,000 hectares. Peppers, tomatoes, cucumbers, watermelons and courgettes grow beneath the white canopy in two seasons a year. The main period, November to April, coincides with peak European demand. Annual output reaches around three million tonnes, worth €3.5 to €4 billion, while organic farming now accounts for roughly 15% of the area.

Technical solutions

Behind this success lies a harsher reality. Farming in a semi-desert demands constant technical solutions. Extreme temperatures, strong winds and unreliable water supplies put growers under pressure, intensified by climate change. Pumping groundwater is increasingly undesirable, so desalination is becoming essential. In Balanegra, a large plant can produce up to 120,000 cubic metres of water a day. Without such interventions, Spain’s winter production would be far more fragile.

Sustainability and certification

The plastic is also one of the model’s darker sides. Greenhouse film must be replaced every three years, creating a vast waste stream. An estimated 85%-90% is recycled, but illegal dumping and pollution remain controversial. There is also a social dimension: more than 70,000 migrant workers carry out much of the production, processing and packaging. Their housing and working conditions are regularly criticised. As sustainability and certification become increasingly important to buyers, these issues directly affect the future of growers and cooperatives.

Nothing for granted

Further west, Huelva is the heart of Spanish strawberry production. The province produces around 350,000 tonnes a year and supplies a large share of Europe’s market from January to June, peaking in March and April. Yet nothing can be taken for granted. Over the past decade, output has declined by about 2% annually. Competition from local production elsewhere is growing, while older imported varieties such as Oso Grande and Camarosa were not always appreciated because of their flat flavour. Breeders have responded with varieties combining better flavour, shelf life and longer production. Calinda, Fortuna, Rociera and Marisma are now established, while Red Sayra, presented in 2026, is expected to strengthen Huelva’s position. Growers still face a shortage of suitable plots, because fields can generally be used for strawberries for only three consecutive years. Water remains another critical constraint.

Major investments needed

In the southeast, Murcia is another focal point of Spain’s export sector. Citrus groves of lemons, grapefruits, oranges and mandarins dominate the landscape; more than half of Spanish citrus exports come from this region. Apricots, peaches, table grapes, melons, watermelons and winter crops such as lettuce and broccoli are also important. Limited and unpredictable water supplies require major investment in storage, treated wastewater reuse and drip irrigation. New varieties are arriving quickly, but plant health is the main concern: keeping pests out while reducing pesticide use. Spain continues to feed Europe, but the real test is whether it can keep doing so sustainably. •

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Why gene banks are racing to protect the future of food

“Time is starting to run out”

Gene banks are racing against time to protect the genetic diversity needed to secure future food production. As climate change, biodiversity loss and legal barriers accelerate, Theo van Hintum of the Centre for Genetic Resources (CGN), the Netherlands, warns that vital crop traits are disappearing just when breeders need them most. In this interview, he explains why wild crop relatives, traditional landraces and international cooperation are essential to feeding a changing world.

Collection mission in the Pyrenees. CGN organizes annual collection missions where seeds from wild populations are collected for inclusion in the gene bank.

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“Time is starting to run out,” van Hintum says. “Climate change and shifting agricultural systems are causing diversity to disappear in the field faster than it can be captured. At the same time, the very changes that threaten diversity are increasing demand for new traits adapted to those conditions. Add international legal barriers, and there is a great deal of work to do.”

Not from every species

Broadly, van Hintum explains, gene banks draw from two sources: wild relatives of crops and landraces that have been cultivated by farmers over many generations. “Biodiversity is everything that lives,” he says. “It exists at the level of ecosystems, between species and within species. The crops we eat are only a very small part of that biodiversity. As a gene bank, we focus on the genetic variation within that limited group of agricultural and horticultural crops.”

Van Hintum cannot conserve, document and make available all wild material from every species that might be relevant to food. Van Hintum says. “In the Netherlands, we have used climate-change models to identify crops most at risk over the next decades. Those are the priority species we try to sample and store as a backup. Some of the material is included in the CGN collection for active management. That gives breeders direct access to interesting genetic material. We call these Crop Wild Relatives.”

“There is still substantial diversity in nature.”

Diversity left to collect

Despite global biodiversity loss, van Hintum says there is still substantial diversity in nature. “As far as I know, we are one of the few national gene banks that still collect internationally. We organise about 5 collecting missions abroad each year. Obtaining permits, however, is a major obstacle.” Commercial breeders also organise collecting missions, he adds, although the most valuable material is often retained for private use. “I have no problem with that,” he says. “Make sure you get the material you need. I hope that can happen through public gene banks, but if you use other channels, fine - as long as you comply with the law.”

New technologies help

Modern sequencing allows researchers to look beyond what is visible in the field. A wild lettuce, for example, may not have the soft, attractive head consumers expect, but it may carry genes that could help create one.

“We can now sequence material to see whether a trait is really there,” van Hintum says. “Eventually, we will be able to predict useful traits in wild relatives that we would never have found in the past. That greatly expands the domain in which we can search for new genetics. And that is crucial in the race to produce enough food with the right varieties in the future.”

Dr. ir. T.L.J. van Hintum
Head of Plant Genetic Resources at the Centre for Genetic Resources, the Netherlands (CGN), part of Wageningen University & Research. CGN safeguards, documents and distributes plant genetic resources for food and agricultural crops.

“Eventually, we will be able to predict useful traits in wild relatives.”

Gone is gone

Landraces tell a different story. Over generations, small-scale farmers domesticated wild species into crops adapted to local conditions. These landraces were often heterogeneous, giving them a built-in capacity to withstand stresses such as drought or disease.

“About a century ago, we learned to breed progressively better, more homogeneous varieties with traits such as yield, uniformity and, later, taste,” van Hintum says. “But those varieties had to be pampered with fertiliser and chemical crop protection. Intensive agriculture arrived, with all its positive outcomes, but also with less sustainable consequences.” More old varieties are vanishing or being replaced by modern ones. With that trend, an important source of genetic variation is vanishing. “Once it is gone, it is truly gone,” van Hintum says. “And precisely now, because of climate change and other pressures, we need those robust traits again. Gene banks must conserve, document and make available the landraces that still exist, at high speed.”

Cooperation could be better

Many landraces are already held in national gene banks, van Hintum says, and large collections have been established with international support, particularly in the Global South. But cooperation between gene banks could be better. “National and institutional gene banks depend on different funding streams,” he says. “Some rely on national money, some on institutional money, and others have to survive on project funding.” >



Theo van Hintum: “If we can conserve the parts of the diversity that feed us, then at least we are doing what we can.”



Staff, working in the CGN gene bank, where thousands of seed samples are stored at -20 °C in vacuum-packed aluminum bags in order to preserve the seeds long-term.

He points to CGIAR (formerly Consultative Group on International Agricultural Research) as an example of a more coordinated system. Its gene banks conserve more than 700,000 accessions from 150 countries and make crop diversity available to researchers, breeders, farmers and communities. “That works because it is under one form of management,” van Hintum says. “But many national gene banks lack the funding, staff and infrastructure to do their work properly. If we cooperated better, with less bureaucracy, we might be able to keep more of that diversity where it is.”

Feed the world

The ultimate goal, van Hintum says, is to give future generations access to the diversity needed to breed the crops that can feed the world. However, genetic resources of agricultural crops are subject to the sovereignty of the countries in which they occur. “When it comes to food, we are so dependent on one another that if we start building walls, we will starve,” he says. “Another effect of putting a wall around a country is that the country may not have the capacity to conserve the material properly, and the diversity behind that wall may disappear. We must keep applying pressure to ensure that genetic resources can be exchanged as freely as possible, especially given the pace of change in agriculture, sustainability and climate.” Van Hintum values close cooperation with the breeding sector. “They are the ones who turn genetic diversity into good varieties that farmers and growers around the world want to buy,” he says. “We feel strongly supported by them to feed the world.”

“

The breeding sector turns genetic diversity into good varieties to feed the world.”

Seed packets from CGN. The seeds are carefully labelled and packaged in aluminum bags for long-term storage in the gene bank.



Huge task

Despite the decline in biodiversity, van Hintum remains cautiously optimistic. “I fear the loss of biodiversity in general, but if we can conserve the parts of the diversity that feed us, then at least we are doing what we can,” he says. “Ideally, I would become unnecessary. Maintaining a valuable and useful collection of genetic diversity is a huge task. Perhaps one day computers will predict which genes we need, and we will make them synthetically, without physical material. But for now, that is science fiction. Until then, gene banks must continue to collect, conserve, document and make available the genetic diversity within crops and their wild relatives. For everybody.” ●

Making space for diversity

Farmers’ Varieties and Landraces need room in seed law

Plant genetic resources can be conserved in gene banks, in farmers’ fields and in natural habitats through crop wild relatives. On farms, farmers’ varieties and landraces (FVLs) survive because farmers keep cultivating, selecting, exchanging and using them. But seed laws often struggle to accommodate these living, changing populations. Many legal systems were built for varieties that are distinct, uniform and stable. FVLs are different: genetically diverse, continuously evolving and closely tied to local agro-ecological and cultural conditions.

In many countries, varieties must be officially registered and, for some crops, seed must be certified before it can be marketed. Depending on how these rules are written and enforced, handling, selling or sharing FVL seed may become illegal. That creates friction between seed regulation and wider policy goals: conserving agrobiodiversity, adapting to climate change and keeping locally adapted diversity in use.

More flexible rules

Countries have taken different routes. One is direct accommodation: seed policies, laws and regulations explicitly recognize FVLs, or equivalent categories, and give them tailored registration pathways. The EU uses the concept of the ‘conservation variety’; Switzerland has ‘niche varieties’; Peru recognizes ‘native varieties’; Mexico refers to ‘common-use plant varieties’; and countries including Indonesia, Nepal and Uganda use terms such as ‘local varieties’ or ‘local seeds’. These categories usually come with more flexible rules, reflecting the heterogeneous nature of FVLs. They may include adapted registration procedures, exemptions from ordinary testing requirements and, in some cases, limits on where or how much seed may be marketed.

Also heritage varieties

A second route is indirect accommodation. Some laws do not name farmers’ varieties, but create space through exemptions or derogations from registration, certification, labelling or marketing rules. In the United States, registration and certification are voluntary, enabling a broad commercial market that also includes heritage varieties. Other countries recognize farmers’ seed systems and exempt certain local exchanges or sales. Ethiopia’s Seed Proclamation excludes ‘the exchange or sale of farm-saved seed among smallholder farmers or agro-pastoralists’. Zimbabwe exempts seed grown by a farmer and sold by that farmer to another person for sowing. Some countries also restrict seed laws to a defined list of crops, leaving other crops outside regulation. Such openings matter because FVLs are often most valued by farmers in niche ecologies that formal public and private breeding programmes rarely target.

Registration can help

Which strategy best supports on-farm diversity is hard to prove. Existing evidence shows how these legal mechanisms are implemented, but says far less about their impact on farmer access, commercialisation or biodiversity.

Registration figures may exist, but data on the cultivated area of each variety are often missing, and evidence of biodiversity impact is rarer still. Where local exchange and sales are merely tolerated or implicitly allowed, documentation is even thinner. Registration can help seed companies add FVLs to their portfolios, especially where formal seed systems dominate. Yet in many low- and middle-income countries, farmer-managed seed systems still supply most seed for many crops. There, the key question is whether registering a limited number of FVLs does more for diversity than simply allowing farmers’ seed systems to function and grow.

Support value chains

Law is only one factor shaping the use of FVLs. Farmers choose them for cultural, agronomic and economic reasons. Still, regulation can open or close doors for organisations that support farmers’ seed systems through seed fairs, community seed banks and the reintroduction of gene bank materials through farmer-field schools. Better legal frameworks can also support value chains built around locally adapted varieties and underutilised crops.

Unnecessary barriers

Managing FVLs on farms keeps plant populations evolving and can offer options for farmers, crops and regions overlooked by formal breeding. But farmers’ varieties alone cannot answer every pressure linked to climate change. Plant breeding remains essential, as does the conservation and continued use of locally adapted diversity. The challenge for seed regulation is clear: make room for diversity without putting unnecessary barriers in its path. ●

*The article is written by and based on a study conducted by **Niels Louwaars** (independent specialist Seed Systems), **Claudio Chiarolla** (Bioversity International) and **Barbara Pick** (independent expert on intellectual property) on behalf of **Bioversity International**.*



Global tensioning of access to genetic resources and the effect on NGT development

Access to genetic resources is at a turning point

In the fields of plant breeding and propagation, exciting innovations are taking place, but the geopolitical landscape is also changing. Some, such as new genomic techniques (NGTs) are the result of years of research and hard work, others are the results of global economic shifts. In the latter, the most discussed are the geopolitical tensions and the recent conflicts. These have a tremendous impact on the whole value chain and additionally affect trust in general. Other important shifts are the tensioning of international frameworks and agreements.



Image: Ian Talmacs

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Ever since the first farmers, there have been continuous efforts to create better varieties. In the last decades, genetic techniques, such as the well-known CRISPR-Cas system, have enabled targeted genetic changes. Until recently, NGTs fell under strict GMO legislation, but a new legal framework has now been proposed that differentiates between various types of NGT applications.

EU approval of NGTs

The proposed EU legislation introduces categories, with Category 1 products being treated similarly to conventionally bred varieties and Category 2 products being regulated more in line with conventional GMO rules, though with a case-by-case approach to the approval procedure. This could accelerate approval and stimulate innovation. At the same time, discussions continue regarding labelling, traceability and intellectual property.

Fair and equitable benefit-sharing

Internationally, access to physical genetic resources is regulated mainly, but not exclusively, through the Convention on Biological Diversity (CBD) with its Nagoya Protocol and the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA, here 'Plant Treaty'). With the Nagoya Protocol, bilateral agreements are established between the user and provider of the material, whereas with the Plant Treaty a standard material transfer agreement (SMTA) is used. Apart from ensuring biodiversity conservation, an important part of these frameworks is that they aim to ensure fair and equitable benefit-sharing (Access and Benefit Sharing, ABS) from the use of genetic material with the provider of that material.

Under pressure

While these systems support biodiversity-rich countries, breeders often experience them as complex and time-consuming. There is a high administrative burden and often also legal uncertainty, which can limit access to materials. Especially for smaller breeding companies, which may lack the experience or access to legal expertise, they need to rely on other sources, such as commercially available material. Currently, both frameworks are under pressure, since the expected benefits have not yet been fully realised, which has resulted in increased discussions about expansion and funding.

The rise of DSI

One of the most significant recent developments in the context of ABS is the emergence of the concept of digital sequence information (DSI). It is an umbrella term often associated with genomic data, most often DNA sequences, available in digital form from public databases. This information is often used in modern breeding and plays an important role in the development of NGT varieties.

Both within the CBD and the Plant Treaty, mechanisms are being developed to ensure fair sharing of benefits derived from the use of DSI. In 2024, at the Conference of Parties 16 (COP16), this

resulted within the CBD in a multilateral mechanism on DSI and its so-called Cali Fund. Users of DSI are encouraged to make a financial contribution to the fund.

The developments have a substantial impact on the sector. The access to physical material is already difficult and is getting increasingly difficult. DSI is adding an additional layer, resulting in increased complexity and costs. The resulting higher threshold might discourage the use of these materials by breeding companies.

The future of breeding under pressure

The discussion around the use of DSI and the expected monetary benefits is not often directly linked to the development and application of NGTs. However, NGTs rely on genetic information, whether this is found in private collections or in public international databases. In breeding, the use of DSI is increasingly becoming a tool to accelerate the development of new varieties, for both conventional breeding and the development of NGTs. If the use of this information becomes tightly regulated, it could negatively impact the development of new varieties. Additionally, it can also affect the balance between breeding companies and public research institutes. Often, breeding companies are part of public-private partnerships which enable the sequencing and annotation of genomes. The generated DSI from these combined efforts often becomes publicly available. For a well-functioning innovation system, it is crucial that access to genetic resources, both physical and digital, remains safeguarded. At the same time, recognition of origin and fair benefit-sharing are essential for international cooperation.

Impact of regulation on innovation

The accumulation of regulations, from seed legislation to NGT policies and ABS obligations, has an impact on innovation. On the one hand, clear rules provide certainty and can stimulate investment. On the other hand, overly complex and overlapping systems can slow innovation. Smaller companies and public breeding programmes are particularly affected by administrative burdens. Large multi-nationals often have greater capacity to navigate regulations, which may lead to further concentration in the sector. The challenge for policymakers is to strike a balance between protecting biodiversity, ensuring fair benefit-sharing and stimulating innovation. This requires coherence between European and international frameworks, as well as practical feasibility for users.

A way forward

Access to genetic resources is at a turning point. New developments surrounding DSI and NGTs demonstrate that traditional boundaries between physical material and digital information are becoming less distinct. Regulation will need to adapt accordingly. For the breeding sector, it is essential that access to genetic variation, in the broadest sense, is preserved. Only then can conventional and new breeding techniques, such as NGTs, reach their full potential and contribute to sustainable agriculture and food security. •

Interview with John-Pieter Schipper, CEO of Bejo

Genetic diversity and plenty of opportunities

Agriculture is changing dramatically and rapidly. Growers must adapt their production systems to climate change, stricter environmental requirements and a society which demands more sustainable food production. In order to achieve that, they need varieties which can withstand drought, soil salinization, new diseases and a lower input of resources. Will those genetics be available in time? John-Pieter Schipper, CEO of Bejo and active within ISF and Plantum, remains optimistic: “Breeders may not always be quick and regulations are tough, but I see plenty of opportunities.”

In recent decades, the international commercial breeding companies specialising in agricultural and horticultural crops have focused mainly on resistances, higher yields, logistical quality and consumer preferences. With success: varieties became hardier, more uniform and better adapted to the market and supply chain. However, the challenge has become greater and more urgent. Climate change is bringing drought, lack of irrigation water, flooding, soil salinization, and new diseases and pests one step closer. At the same time, environmental protection demands greater biodiversity, the preservation of natural pollinators and reduced - or sometimes no - use of chemical crop protection and fertilizers.

Partly dependent

Growers are seeking ways to manage this new reality, each at their own scale and speed. Sometimes out of conviction, sometimes under pressure from legislation, they invest in technology, alternative cultivation systems and a modified means of production. In doing so, they are partly dependent on innovations in the supply industry, including breeding companies. New varieties can help make that change possible. The only question is whether they will become available soon enough.

Strong awareness

“Let me start by saying that there is strong awareness of climate and environmental issues among breeding companies. The pressure of innovation, so on new genetics, is intense.

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and active within ISF and Plantum

biotechnology: for breeding



This applies to the large international companies, but certainly also to smaller, local breeders; worldwide,” says John-Pieter Schipper. He is at the head of Bejo, an international vegetable breeding company in Warmenhuizen, and serves on the boards of ISF and Plantum. This means he is not afraid to speak on behalf of the broader breeding sector.

“Farmers and growers are our customers. We aim to build and maintain good and long-lasting relationships with them. We talk to them in many parts of the world, every single day. Consequently, we fully recognise their extensive wish list.”

Significant investment

Schipper acknowledges that there is sometimes doubt about the commitment of the large international breeding companies in particular. Is their focus too much on their own interests in the short term, and not enough on the public interest or that of the customer? “Fortunately, the majority of our customers recognise that the sector is highly active,” he says. “Substantial investment has been made - and continues to be made - in discovering, developing and preserving new genetics, in breeding techniques, seed quality, logistics and in crops and markets. These investments are not always successful and returns often take many years to materialise. Sometimes progress is not fast enough. However, breeding remains a relatively slow process. We have managed to shave years off the cycle from wish list to new commercial variety over the past two decades, but it remains a natural process.”

“The pressure of innovation, so on new genetics, is intense”.

Natural pollinators

In this sense, Schipper looks beyond commercial genetics alone. “Preserving biodiversity is of great importance to society, but is also crucial for the future of the sector and for the success of our customers. The sector is also aware of this. Consider natural pollinators, such as bees and hoverflies, and the natural enemies of insects that attack our crops. We will continue to really need them in the future.” That is why the sector supports local beekeepers and research is being conducted into bee health. How do bees enter their winter dormancy in good condition, and how do they emerge from it fit and healthy again? In addition, the breeding sector is developing new production systems for its own seed production, such as strip cultivation and an optimal mix of flowering field margins.

Not 100%

Schipper also points to the sector’s many years of investment in organic cultivation, both in seed production and the crops grown by customers. “Seeds and vegetables are now being grown organically in a very professional manner. And we continue to make significant strides in this field. Moreover, you can see

Carrot seed production with flower border by Bejo in France



“No matter how hard gene banks try, the quality of and access to genetics remain inadequate in many places.”

John-Pieter Schipper

that organic cultivation is inspiring conventional cultivation. By means of an integrated approach, conventional cultivation is also gradually moving towards an almost organic level. However, I do not expect us to ever see a fully organic sector worldwide. Uncertainties and thereby costs are higher in many regions, and the grower remains an entrepreneur and the consumer often remains cost-conscious. Ultimately, this may call for a little less 'more and faster', but instead an efficient food chain with great attention to biodiversity.”

Limited pool

According to Schipper, that focus on biodiversity is also reflected in the relationship with local and international gene banks. “That relationship needs to be as strong as possible,” he says. “As breeders, we have our own gene banks and can benefit from each other’s genetics thanks to the breeders’ exemption. But ultimately, that is a limited pool. If we don’t continually replenish it with new, wild genetics, innovation will die. We therefore depend on biodiversity.” In the past, breeders would regularly go on collection missions or take a good look around during trips abroad. International legislation has severely restricted this opportunity. Local and international gene banks must now take over that role to a large extent.

“Well-functioning gene banks and access to their collections are crucial. This is well-organised in the Netherlands, and I am very pleased about that. As a sector, we are keen to contribute to and help fund this,” Schipper states. The situation is less straightforward globally. “No matter how hard gene banks try, the quality of and access to genetics remain inadequate in many places.

Often there is lack of funding, capacity and knowledge. Local legislation and tough discussions are also still creating too many obstacles. Those discussions are often not about the collection, preservation and provision of genetics, but rather about entirely different concerns. And those vary by country, whereby the debate quickly becomes too broad and too complex.”

Coalition of the willing

That is why a group of breeding companies formed a ‘coalition of the willing’ during the recent ISF congress. They want to, for example, provide concrete assistance to local gene banks by helping them to refresh their collections. The Dutch government has also launched initiatives to support gene banks worldwide in partnership with the private sector. “We are seeking a fair, simple and affordable way of working to make genetic material available to as many stakeholders as possible. This not only benefits the large international breeding companies, but especially the smaller, local breeders.”

More unknown

Despite the rapidly mounting challenges, Schipper views the future of the breeding sector with confidence. “Fortunately, there is still ample biodiversity for new, wild genetic material. In addition, with new technologies we are constantly able to better understand and utilise known genetics. There is still far more that remains unknown than known. There are also new techniques and tools that allow for faster and more targeted breeding. And the world population continues to grow, so the demand for food is rising. If only the decision-making could move a little more swiftly...” •

Consortium for food plants gene conservation

Since 2004, the International Treaty on Plant Genetic Resources for Food and Agriculture has been in place. Over 150 countries have signed this FAO Treaty and agreed to cooperate in the protection of genetic material of important (64) species for food. Through so-called Standard Material Transfer Agreements (contracts), material can be exchanged between countries.



Although very much under discussion, a system of benefit sharing is in operation. Most professional and official gene banks that collect and maintain seeds of these species are connected to the ITPGRFA, but that is not the case for many botanic gardens in the world up until now. A new initiative from FAO and the Global Crop Diversity Trust was launched in 2025 to improve connections with international botanic gardens. Their international organization BGCI (Botanic Gardens Conservation International) is now partner in programmes to safeguard global food diversity and specialists from these botanic gardens can be included in the network. “Botanic gardens can play an essential role, as they are key to conserving the diversity of food plants needed for farmers and breeders, and are vital for achieving the Four Betters: better production, better nutrition, a better environment and a better life, leaving no one behind,” as FAO director Dongyu says. The global system needs, according to the 2030 strategy of the Trust, to grow stronger. It is not yet fully functional nor sustainable and many gene banks still face capacity challenges, placing important crop diversity at risk and limiting its use. Also therefore, broader partnerships are welcome. •

Diversity at every level

Diversity is essential – not only the genetic diversity breeders use to create varied portfolios of varieties from which farmers can choose. Breeders are especially well placed to explain why diversity matters in all its forms: in laboratories and trial fields, in farming systems, in the seed industry and in society at large. Beyond the value of genetic diversity for breeders, diversity in farmers’ varietal choices and diversity within the field are equally relevant. The recently dubbed ‘opportunity crops’ can strengthen resilience in farming systems, just as multilines in monocropped fields can help manage pests and diseases – an approach that may soon become practical again through genome editing.

Diversity is also a management tool: it can bring out the best in teams of breeders and allied specialists. The same principle applies to the seed sector. Diversity in corporate cultures and competition in the market force companies to make strategic choices – which crops and markets to serve, which competitors to engage with and how to behave in the market. Together, these companies meet the varied needs of farmers, value chains and consumers.

Finally, diversity matters in society. Democracy depends on nurturing difference and on turning opposing interests, world views and beliefs into debate that can produce better solutions. Breeders understand the importance of diversity in their work. They also know its value elsewhere: at every level, diversity creates the options and resilience needed to succeed now and in the future.



Niels Louwaars, Seed Systems Specialist, the Netherlands, nlouwaars@gmail.com

Biodiversity in Tropical Fruit Cultivation

From threat to opportunity

Tropical fruit cultivation faces a paradox. Genetic diversity in crops such as banana and papaya offers opportunities for innovation and resilience, while the commercial focus on uniform varieties has made plantations more vulnerable to pests and diseases. The challenge is to turn biodiversity into a strategic asset by using new varieties and technologies to strengthen resilience and sustainability.

A hybrid approach at Papaya of micropropagation combined with grafting onto seedling rootstocks.

Tradition Meets Innovation

Brazil ranks among the world's largest producers and consumers of bananas, cultivating a wide spectrum of varieties – from the globally dominant Cavendish to regional favourites like Prata, and niche products such as the 'Princess Apple'. This diversity reflects consumer habits and market segmentation, yet it also exposes weaknesses. Diseases such as Sigatoka and Black Sigatoka already consume about 20% of production costs, while the looming threat of Tropical Race 4 (TR4) – a devastating Fusarium fungus – casts a long shadow. Though not yet officially present in Brazil, TR4 poses a serious risk to Cavendish-dominated plantations worldwide.

“From bananas to papayas, biotechnology is reshaping how growers respond to disease, climate pressure and market demand.”

Tropic Biosciences: biotechnology against disease and waste

Internationally, Tropic Biosciences is among the companies working on banana innovation. The company recently introduced new banana varieties, including the non-browning banana, which stays fresh longer after slicing, and an extended shelf life variant that improves transport and export efficiency. Tropic is also developing TR4-resistant Cavendish bananas, expected to reach commercial markets around 2027. These developments show how biotechnology can help reduce food waste, improve resilience, and support the future of banana cultivation.

Pomona: a premium banana for Brazil

In Brazil, the new Pomona variety is attracting attention. Marketed as a premium banana, Pomona is positioned around its superior post-harvest shelf life and distinctive flavour profile. Trial plantations are underway in Vale do Ribeira

“Genetic diversity is emerging as a practical tool to make tropical fruit cultivation more resilient.”

(São Paulo), Delfinópolis (Minas Gerais) and Bom Jesus da Lapa (Bahia), covering about 40 hectares. Early feedback from growers and retailers has been positive, suggesting potential in a market where consumers are willing to pay more for differentiated fruit. Pomona shows how biodiversity can be used to add value and reduce risk.

Papaya: biotechnology as a game-changer

While banana innovation focuses on varietal diversity, papaya advances depend heavily on biotechnology. Traditional micropropagation through tissue culture faces challenges such as poor rooting and the absence of a taproot. To overcome these limitations, SBW do Brasil has developed a hybrid approach: micropropagation combined with grafting onto seedling rootstocks. This method produces stronger, more uniform and more productive plants, while ensuring 100% hermaphroditic plants and higher-quality fruit for export. Beyond propagation, gene-editing technologies open new horizons. Non-transgenic approaches such as CRISPR/Cas9 RNP (SDN-1) aim to create papaya lines resistant to papaya ringspot virus (PRSV) and the meleira complex (PMeV/PMeV2), without integrating foreign DNA. This strategy could accelerate regulatory approval and sidestep consumer concerns about transgenics. Climate change adds urgency: extreme heat increasingly causes flower drop, making virus- and heat-resistant varieties essential for future resilience.

Biodiversity as a strategic vision

The common thread between banana and papaya is unmistakable: biodiversity, when strategically harnessed, becomes an opportunity rather than a liability. In bananas, varietal diversity supports premium products and disease-resistant cultivars. In papaya, genetic diversity combined with biotechnology enables stronger, more adaptable plants tailored to global market demands. Realizing this vision requires long-term commitment. Field trials, scientific validation and institutional collaboration are indispensable. The benefits extend beyond productivity: they encompass food security, reduced disease-control costs and higher-quality fruit for consumers worldwide.

Turning point

Tropical fruit cultivation stands at a turning point. Where genetic uniformity once symbolized efficiency, it now signals vulnerability. The path forward lies in embracing biodiversity through innovative banana varieties such as Pomona and advanced propagation and gene-editing techniques in papaya. Initiatives from global companies such as Tropic Biosciences, alongside local innovation from MultiCropsPlus, show how diversity can be transformed into resilience. Together, these developments could strengthen Brazil's position in tropical fruit innovation. •



Alewijn Broere

Managing Director of MultiCrops Plus (MCP), an organization specializing in the development and application of tissue culture protocols and techniques in fruit and bioenergy crops, with Holambra, Brazil, as the main location.

What Public Data Can Reveal About Genetic Strategy

Reading the Signals

Although proprietary genetic variation is core to vegetable breeding, companies closely guard their strategic pipelines. Germplasm pool composition is rarely disclosed, and with New Genomic Techniques (NGTs), breeders have even more reason to protect proprietary lines, trait targets, and breeding strategies. But is all information really as invisible as breeders would like?

Despite a high degree of confidentiality, breeders leave behind a trail of observable, public signals – including R&D investment, plant-variety-right (PVR) applications, crop portfolios, resistance launches and technology partnerships – which provide insight to their genetic strategies. These signals can be triangulated and mapped over time to show how breeders are translating genetic resources into commercial varieties to aid growth. Despite this, breeders generate a range of observable, public signals - including R&D investment, plant variety right (PVR) applications, crop portfolios, resistance launches and technology partnerships - that provide insight into their genetic strategies. Triangulating these signals over time can reveal how breeders are translating genetic resources and R&D priorities into commercial varieties.

R&D shows the scale

R&D intensity in the market is exceptionally high (Figure 1). Among the biggest investors are Rijk Zwaan, at around 30% of turnover, and Enza Zaden, which invested 27% of turnover in R&D in 2025. Nunhems reports reinvesting around 20–25% of annual revenue in R&D. Direct comparisons are challenging, as diversified groups such as Bayer and Syngenta report R&D at the Crop Science or group level. While this provides an indication of overall R&D intensity, it does not reveal which specific crops, traits or genetic resources are being prioritized. Few companies provide this level of insight. One example is Rijk Zwaan, which reported more than €200 million in global R&D investment in 2025, including €130 million in the Netherlands, alongside the introduction of around 200 new commercial varieties during the year. Given the limited comparability of reported R&D spending, public Community Plant Variety Office (CPVO) applications provide a more systematic proxy for protected breeding output.

Changing crop priorities

In 2025, CPVO received 2,897 applications across all crop sections, representing an 11.4% decrease from 2024. However, vegetable applications proved comparatively resilient, declining by only 3.2%, from 747 to 723. As a result, vegetables increased their share of total applications from 22.9% to 25%. Lettuce and tomato accounted for the highest CPVO activity, with 185 and 182 applications respectively, indicating where breeders submitted the largest number of candidate varieties for EU protection.

Looking at historical filing patterns at the company level provides an indication of where protected breeding activity is becoming more concentrated over time. Comparison of average annual applications from 2016–2020 with 2021–2024 reveals distinct patterns among breeders (Figure 2). Rijk Zwaan’s tomato applications doubled from 19.0 to 38.0 per year, alongside increases in cucumber from 5.2 to 11.5 and pepper from 9.4 to 14.3. Enza Zaden showed a different pattern, with tomato applications rising from 6.8 to 17.3 per year, while lettuce declined from 46.0 to 32.0. Other breeders show different crop signatures again, suggesting that changes in protected output are not moving uniformly across the industry. The top 15 vegetable applicants accounted for roughly 86–91% of applications between 2017 and 2023, meaning competitor-level monitoring can capture a substantial share of observable protected-variety activity while still revealing distinct crop priorities.

Resistance launches

These shifts in protected varietal activity are also reflected in recent company announcements, which provide further insight into the traits breeders are prioritising. Rijk Zwaan continued breeding for Bremia and Fusarium resistance in lettuce, while also launching two Galuna melon varieties resistant to Px races 6 and 7. Syngenta launched the tomato rootstocks Armour, Honor and Kronosor with intermediate ToBRFV resistance, while Enza Zaden continued to showcase its HREZ high-resistance tomato portfolio in 2026. Resistance breeding is also evident across the wider competitive set: Hazera is breeding specifically for onion sets while addressing challenges including Fusarium, East-West Seed positions built-in disease resistance as a core feature of its tropical vegetable portfolio, and both Bejo Zaden and Sakata identify disease resistance as a central breeding priority.

Geography changes

Regional breeding investments add another layer, showing how genetics are being adapted to different climates, disease pressures and production systems. Rijk Zwaan’s Mogi Mirim facility in Brazil focuses on breeding for tropical conditions,

while Syngenta’s US\$10 million Almería R&D centre brings selection closer to Mediterranean growing environments. Geography therefore provides an additional lens on breeding strategy, influencing both the traits breeders prioritise and the speed at which selections can be tested, validated and advanced.

Into view earlier

A third emerging signal is how breeders are positioning themselves around New Genomic Techniques (NGTs), which can indicate who is building the capabilities to deploy useful genetic variation more efficiently. Rijk Zwaan publicly advocated for CRISPR-edited tomato and lettuce to be exempt from GMO rules as early as 2023, several years before the EU’s new NGT framework was adopted in 2026. Technology development and partnerships are also becoming increasingly visible: Bayer commercialised a gene-edited leafy green in North America through a licence with Pairwise, while Syngenta opened selected proprietary CRISPR-Cas12a and gene-editing technologies through its Shoots by Syngenta out-licensing platform. More recently, Limagrain’s July 2026 agreement with Qi Biodesign provided access to a differentiated CRISPR nuclease for vegetable crops. Together, these moves offer an early indication of which breeders are securing the tools and technical capabilities needed to incorporate useful variation into commercial varieties more rapidly

Connecting the signals

While no single data point or source is conclusive, genetic strategies and priorities can be inferred by tracking and triangulating multiple indicators over time. At Valona, we monitor not only public filings and company announcements, but also breeding investments, partnerships, trial activity, patents and technology access. Together, these indicators can reveal where competitors are concentrating resources, and which traits and technologies are gaining strategic importance. This provides a deeper, more forward-looking view of competitor direction in a market where genetic strategy is increasingly visible through fragmented public evidence. •



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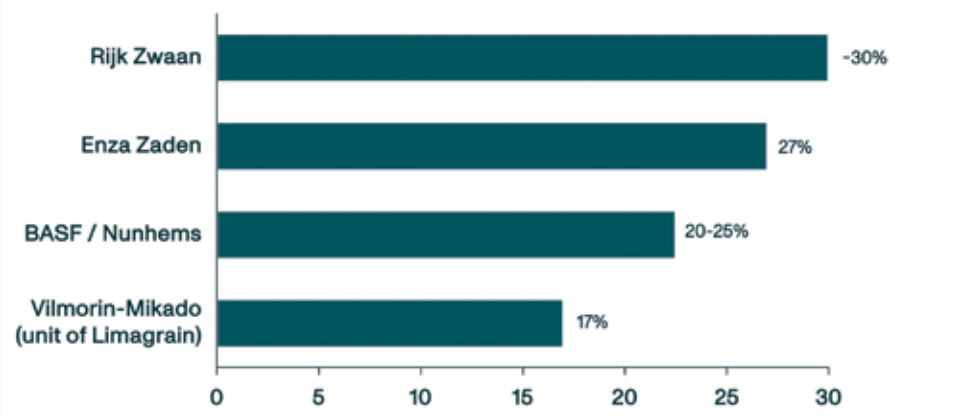


Figure 1
Selected disclosed R&D expenditure as a share of turnover/revenue, latest available figure.
Source: Annual reports and public disclosures; Valona analysis.

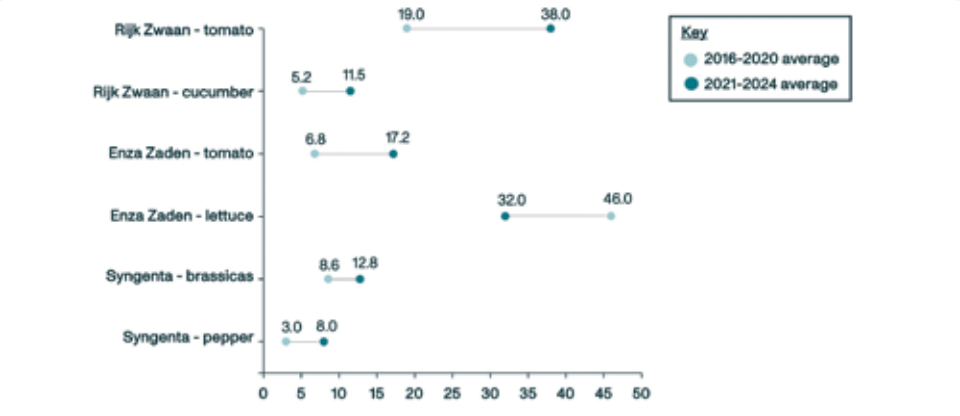


Figure 2
Average annual CPVO vegetable applications by selected breeder and crop, 2016-2020 vs. 2021-2024.
Source: Community Plant Variety Office (CPVO); Valona analysis.

Precision Reproduction

Plant breeding and seed production have changed significantly in recent decades, but the objective remains the same: developing productive crops and securing food supply under changing conditions. New breeding techniques, genomics, molecular markers, automated imaging, sensors and data-driven selection allow breeders to characterise plants in ever greater detail. We measure plant height, biomass, root architecture, disease resistance, canopy temperature and many other traits. But what ultimately determines whether a plant will produce seed or fruit?

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Successful reproduction
A plant may perform well during vegetative growth, yet if pollen development, pollination or fertilisation is impaired, its genetic potential cannot be translated into the next generation. Pollen carries the male half of the genetic information. Its quality and quantity directly influence fertilisation, seed set, fruit development and yield. Knowing how much pollen a plant produces, whether it is viable, dead or aberrant, and how it responds to environmental conditions provides valuable information for breeding and seed production. Systematic pollen phenotyping brings this information into a quantitative, actionable framework.

It is an important part of *precision reproduction*: measuring, understanding and optimising reproductive performance.

Why pollen quality matters
For breeders, pollen quality indicates the reproductive potential of breeding material. A line may have desirable characteristics, but if it is a poor pollinator, advancing it can create problems in later breeding stages or seed multiplication. For seed producers, the link is even more direct. Seed production depends on enough viable pollen reaching female flowers at the right time. Poor pollen quality or too few pollen grains can lead to incomplete fertilisation, low seed set and reduced yield. Routine pollen phenotyping changes how reproductive performance is evaluated. Instead of investigating pollen only after failure, reproductive properties can be characterised before key breeding or production decisions are made.

The limitations of conventional pollen analysis
Traditional staining or germination assays followed by microscopic evaluation provide useful information, but they are labour-intensive, relatively slow and may depend on operator experience. Staining methods do not work equally well for every crop, while germination assays require suitable crop-specific media and conditions.

Conventional assays reduce the result to a simple distinction: pollen is viable or non-viable. But reproductive performance is more complex. Successful fertilisation depends on a sufficient number of functional pollen grains reaching the stigma. A meaningful reproductive phenotype should therefore include both quality and quantity.

Moving from microscopes to quantitative data
Impedance flow cytometry measures pollen grains in suspension as they pass individually through a microfluidic channel and records their electrical properties. These signals differentiate viable, dead and aberrant pollen populations while counting each cell. The automated measurement analyses thousands of cells within seconds, creating an objective, statistically relevant basis for comparing lines by viable and aberrant pollen percentages and production volume. Large numbers of lines can be compared systematically. Pollen analysis becomes a tool for line characterisation, breeding and seed production, rather than only a diagnostic assay after problems occur. This shift is central to precision reproduction: generating comparative information that reveals reproductive properties of different lines and how they interact with the environment.

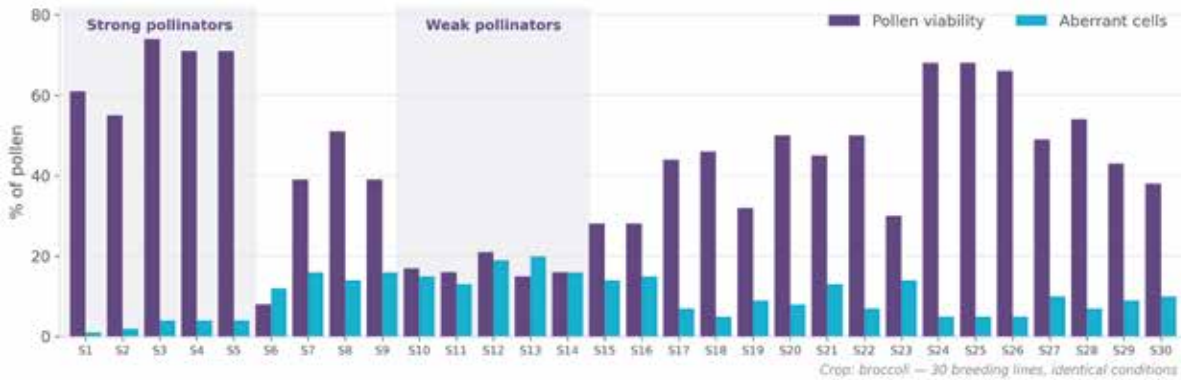


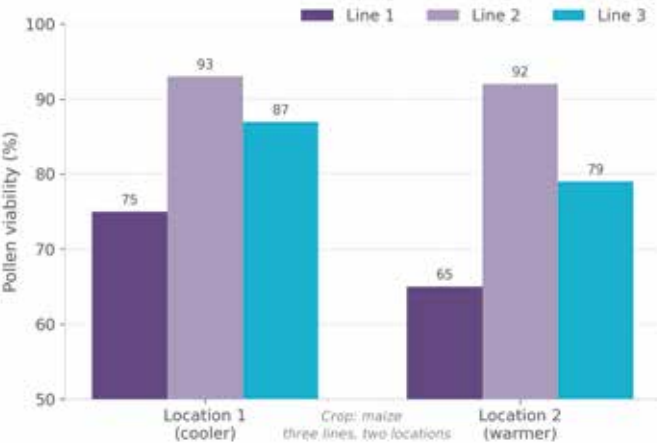
Figure 1
Screening of a broccoli line.



Broccoli: identifying good and poor pollinator lines

A screening of 30 broccoli lines shows the value of systematic pollen phenotyping. All lines were grown under the same conditions, and viable and aberrant pollen proportions were determined. The results showed considerable variation. Some lines produced a high proportion of viable pollen and very few aberrant cells. These good pollinators developed pollen normally and carried a comparatively low reproductive risk. Other lines showed a different profile: in some cases, aberrant pollen was similar to, or even higher than, viable pollen. Such lines represent a reproductive risk, even with favourable vegetative traits. Aberrant pollen grains are cells that were aborted during development. Their presence can indicate developmental instability or susceptibility to unfavourable environmental conditions.

Hidden property
If a poor pollinator line is advanced, its reproductive weakness may appear only later, after significant time, labour and money have been invested. It may perform well for conventional traits but repeatedly create difficulties during crossing or seed multiplication. Early pollen phenotyping uncovers this hidden property. Breeders can compare reproductive performance and add information for a more complete line selection assessment. The value lies in systematic comparison: screening many lines under the same conditions reveals reproductive variation within breeding material. Good and poor pollinators can be identified before weaknesses create delays or costs.



Corn: finding the right production location
A line's reproductive properties are not determined by genetics alone. Environmental conditions during pollen development and flowering can strongly influence pollen quality, so the same line may perform differently across locations. A crop-placement example with three corn lines illustrates this interaction. The lines were grown at two production locations, one colder and one warmer. Corn normally shows high pollen viability, but lines react differently to environmental conditions. Line 1 had strongly reduced viable pollen at the warmer location. Line 2 remained relatively stable and appeared more tolerant, while Line 3 showed moderate temperature sensitivity. These results show that a line cannot always be classified simply as having good or poor pollen. Reproductive performance may depend strongly on the production environment, and even smaller reductions in pollen viability can lower seed set and yield.

Each parent line
This is where pollen phenotyping provides direct value for seed production. Choosing the right production location is essential for commercial success. Even a good parent line can deliver a poor result if it is grown in the wrong environment. Production locations are commonly selected based on climate data, experience, field availability and historical yield. Pollen measurements add direct biological information by showing how a specific line's reproductive system responds to each location. By comparing pollen performance across locations and seasons, seed producers can identify stable lines and lines requiring specific production environments. Crop placement can then reflect the reproductive response of each parent line, not only general regional assumptions.

Figure 2
Corn crop placement.

From reactive testing to better decisions
The broccoli and corn examples show two complementary applications of pollen phenotyping. In broccoli, lines grown simultaneously under the same greenhouse conditions showed large differences in pollen quality. This information helps identify good and poor pollinators and supports more efficient line selection. In corn, the lines reacted differently to two environments. This information supports crop-placement decisions and helps match each genotype with a suitable production location. In both cases, pollen phenotyping helps move from reactive testing to predictive decision-making. Problems can be detected earlier and decisions can be based on quantitative information. Combining pollen data with field observations, seed-set results, environmental data and other agronomic characteristics can improve outcomes.

Precision reproduction as the next step
Plant breeders have made great progress in genotyping and phenotyping. The next challenge is to characterise reproduction with the same systematic approach. Impedance flow cytometry makes it possible to analyse pollen rapidly, objectively and quantitatively. It provides information about viability, aberrant cells and pollen quantity, enabling large numbers of lines or production conditions to be compared. This is the idea behind precision reproduction. It is not simply measuring whether pollen is viable, but understanding how reproductive characteristics differ between genotypes, how they respond to the environment, and how this knowledge can improve breeding and seed production. Modern agriculture measures almost everything that happens above and below the ground. It is now time to pay equal attention to the process that determines whether a plant successfully produces the next generation. •

The Nardocott UK Case

Lessons to learn on EDVs

The recent UK court decision on EDV has raised questions about essential characteristics and the (continuous) interpretation of EDVs.

On March 12, 2026, the High Court of England and Wales issued a significant judgment concerning the interpretation of Essentially Derived Varieties (EDVs) under the UK Plant Variety Act. This was the very first case in the UK on EDVs. The Nardocott Protection SAS v Asda Stores Ltd & Anor case concerned the commercialization in the UK of a mandarin variety (Tan Gold), which is claimed to be essentially derived from Nardocott.

Not retained

At the heart of the dispute was the question: when should a new variety remain dependent if it is predominantly derived from the Initial Variety but does not retain its essential characteristics? The Court accepted that the variety in question was predominantly derived from Nardocott and was clearly distinguishable from it. However, it concluded that the requirements for dependency under the UK Plant Varieties Act 1997 were not met because certain characteristics considered essential to Nardocott were not retained. The court decision reflects a reality that the breeding sector has been advocating against: the danger of a narrow interpretation of the EDV concept.

Why EDV-concept?

Plant variety protection allows breeders to use protected varieties to create new ones, through the so-called “Breeders Exemption. The breeder’s exemption, while fundamental to enabling further breeding (as plant breeding can only build on existing genetic material), is not an absolute term.

The EDV concept was introduced into the 1991 Act of the UPOV Convention to maintain a balance. It preserves the freedom to breed while establishing dependency when a new variety remains predominantly derived from an initial variety. An EDV must be distinct from the Initial Variety and can be protected in its own right. However, its commercial exploitation requires authorization from the titleholder of the initial variety.

The issue is not whether further breeding should be permitted, but whether the resulting variety should be commercially independent of the variety that provided its principal genetic foundation.

The case

The proceeding arose from Nardocott Protection SAS seeking to enforce its UK PBR in relation to the commercialization of the mandarin variety Tan Gold (Tango). The Court considered pollen viability and seed formation essential characteristics of Nardocott. These characteristics were not retained in Tan Gold, as it has reduced pollen viability and remains essentially seedless. Because their expression was not retained in Tango, it concluded that was not a dependent variety under the UK Plant Varieties Act 1997. The infringement claim against Asda was dismissed.

Why this matters

The Nardocott judgment highlights a particular challenge in applying the EDV concept, especially in modern breeding and the increasing use of new breeding techniques.

For CIOPORA, changing one or several important characteristics should not automatically erase predominant derivation. A breeder may select an elite variety because it already combines valuable agronomic performance, adaptation, fruit quality and consumer appeal. A targeted act of derivation can preserve that successful genetic foundation while introducing (a) specific improvement(s). We, at CIOPORA, support that EDV assessment should focus primarily on predominant derivation and genetic conformity. Phenotypic differences are relevant to establishing distinctness but should not by themselves determine dependency.

This approach recognizes both stages of innovation: the long-term development of the initial variety and the subsequent improvement introduced into its genetic foundation.

By the time an EDV reaches the supermarket shelf, both contributions may be present in the same mandarin. The purpose of the EDV concept is to ensure that the plant variety protection system can recognize them both.

For CIOPORA, and the breeding-sector, clear and predictable rules on EDV status of new varieties resulting from mono-parental derivation are essential. A broad interpretation of EDV is key to incentivizing further breeding, keeping the system up-to-date with latest technology developments, and ensuring that rules can be applied effectively and consistently in practice. •

“

Phenotypic differences are relevant to establishing distinctness but should not by themselves determine dependency.”

“

Clear and predictable rules on EDV status of new varieties resulting from mono-parental derivation are essential.”

UPOV and young people in plant variety protection

Cultivating the next generation



Plant variety protection is a long game. The new varieties being developed today may take years to reach a farmer’s field, and many future breeders, PVP specialists and agricultural innovators are currently still students. UPOV’s activities increasingly reflect that the future of the PVP system depends on engaging young people early and making room for their perspectives.

Plant variety protection is a long game. The new varieties being developed today may take years to reach a farmer’s field, and many of the people who will be engaged in plant breeding, bringing quality, diverse foods to our plates and beautiful flowers to our homes, are currently probably still students. Increasingly, UPOV’s activities reflect an awareness that the future of the PVP system depends on drawing young people into it early, and on making room for the perspectives they bring.

Bootcamp inspired
Nowhere was that clearer earlier this year than in Abuja, where thirty young Nigerian plant breeders, lawyers and agricultural professionals joined the second Plant Variety Protection and Intellectual Property Boot Camp. Over five days, the

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For all the latest updates from UPOV and global Plant Variety Protection (PVP) figures, subscribe to the UPOV newsletter: upov.int/en/about-upov/news/newsletter.

bootcamp explored how variety protection can help build climate-resilient food systems and drive agricultural innovation in Nigeria, UPOV’s 80th member, making the UPOV PVP system applicable in 99 states.

Increasing part of conversation
The younger generation will feel the pressures of climate stress and food security more directly than any before it. Capacity building and training are not just about handing down rules and standards, but about giving young professionals the tools and confidence to shape how those rules are applied and developed. Their questions and priorities, from sustainability to access, are increasingly part of the conversation about where the UPOV system goes next.

Meaningful role
One of the lessons growing from younger participation in the UPOV system is how many disciplines plant variety protection now touches. For a young person weighing a path into the field, this breadth is an opportunity: there is no longer one route in. A background in coding, communications, molecular biology, intellectual property law, agronomy, business or international cooperation can all lead to a meaningful role in developing the UPOV PVP system.

Need young entrepreneurs
That widening field needs people and UPOV has been building the pathways to bring them in. This year UPOV opened its international certification programme on plant variety protection to private sector professionals for the first time, giving those outside national PVP offices a way to earn an internationally recognized credential. UPOV also partnered with Seed World Europe to give all finalists in the ‘20 Most Promising Plant Breeders in Europe Competition’ free access to online courses on Plant Variety Protection (PVP).

These training and capacity building initiatives carried out under UPOV’s Training and Assistance Strategy offer concrete entry points into PVP careers. National PVP offices, breeding companies, IP firms and international organizations all need the next cohort of plant variety examiners, variety protection specialists, breeders and legal experts. Above all, agricultural value chains need young entrepreneurs to leverage plant variety protection for business and sustainable rural development. For young people, that translates into a real and growing set of options in a sector that rewards curiosity across boundaries.

Bringing experience
What that pathway looks like in practice can be seen in UPOV’s own team. In May 2026, the UPOV office welcomed Kaho Terayama as an Associate Programme Officer, bringing experience in supporting the implementation of Japan’s Plant Variety Protection and Seed Act, together with a working knowledge of the East Asian PVP landscape. In her role, she

supports the delivery of UPOV’s Strategic Business Plan, including the Communication Strategy and Training & Assistance Strategy, identifying and analyzing the cases and practices that show the impact of the UPOV PVP system.

Value
“While working at Japan’s Ministry of Agriculture, Forestry and Fisheries, I saw how successful Japanese plant varieties created value for farmers, delighted consumers and opened opportunities for exports and international licensing. Those experiences inspired me to work in plant variety protection. As agriculture faces growing challenges, I believe new plant varieties are the foundation of agricultural success and a source of hope for the future,” Kaho Terayama says. A recurrent thread running through all of this is evolution, and the need for the young generation to be part of the conversation. When UPOV convenes its 2026 sessions in Geneva in October 2026, the discussions will shape a PVP system that today’s youth will inherit. •



UPOV VSG Yolanda Huerta (in the middle) and two young leaders from the NextGen Ag Impact Network (NGIN) on the sidelines of the 2026 ISF World Seed Congress.

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Whole Chain is Exploring in CropMix Living Labs

Enhancing crop diversity to support sustainable arable farming

Increasing crop diversity is recognized as an important step towards more resilient and sustainable arable farming systems. Yet moving from uniform cropping systems to more diverse cropping systems raises many practical, economic, ecological and organisational questions. The CropMix-project was established to address these challenges and to accelerate the transition towards ecology-based agriculture through research and co-creation with stakeholders across the agricultural chain.

One of the strengths of CropMix is its highly interdisciplinary and practice-oriented consortium. It consists of more than 130 members, including 25 arable farms, researchers from multiple disciplines, commercial partners, governmental organisations and societal stakeholders throughout the food chain. Universities, applied research institutes, seed companies, farmers, nature organisations, financial institutions and food chain partners work together to develop knowledge that is both scientifically robust and applicable in practice.

Collaboration is at the heart of the project. Throughout the programme, researchers work closely with farmers and industry partners to ensure that research questions remain relevant and that results can be applied under real farming conditions.

A key role in this collaboration is played by the CropMix Living Labs, where farmers, researchers, supply chain partners and other stakeholders jointly explore solutions to practical challenges associated with crop-diverse farming systems. These Living Labs provide a space for experimentation, reflection and mutual learning, helping to translate scientific insights into workable innovations while also bringing practical experiences and stakeholder perspectives back into the research process.

In addition, CropMix organises two consortium meetings each year. These meetings provide an opportunity to present recent research findings, discuss emerging insights and collect feedback from partners. This continuous exchange of knowledge helps align scientific research with the needs and experiences of practitioners and other stakeholders.

Now more than halfway through the programme, CropMix is progressing well. Many researchers have completed their data collection, analyses are underway and the first scientific publications, reports and practical outputs are becoming available. These early results already provide valuable insights into the opportunities and challenges associated with crop-diverse farming systems and offer a strong foundation for the remaining years of the project.

For plant breeders and seed sector professionals, CropMix provides an important platform for understanding the role that crop diversity may play in future production systems. By bringing together expertise from research, practice and industry, the project contributes to the knowledge and innovations needed to support the transition towards resilient agricultural systems that can meet both environmental and production goals. •

CROP MIX

CropMix is a five-year Dutch research programme (2023-2027), that focuses on crop diversity, with strip cropping as one of its key examples. The project investigates how crop-diverse systems can contribute to ecological resilience, while remaining economically viable and practically feasible for farmers. Research activities cover ecological interactions above and below ground, economic and logistical challenges, and the institutional and societal changes needed to support adoption at scale. More information about the results on [linkedin.com/company/cropmix](https://www.linkedin.com/company/cropmix) or visit the website [cropmix.nl](https://www.cropmix.nl).



View on
LinkedIn



View on
cropmix.nl

Jessica Spaan
Project Manager at CropMix
project led by Wageningen
University & Research
<https://cropmix.nl>

Yvonne Florissen, meeting of CropMix growers at Bio Vitalis

Enza Zaden and CropMix explore mixed cropping systems for the future of sustainable vegetable production

Cultivating resilience through diversity

This document outlines Enza Zaden’s involvement in the CropMix project and highlights how diversified cropping systems can contribute to more resilient, sustainable vegetable production.

Biodiversity is closely connected to Enza Zaden’s work as a vegetable breeding company. Genetic diversity underpins the search for new traits, including resistance to emerging diseases and pests, and is supported through the maintenance of our genebank and contributions to seed conservation. Through the CropMix project, Enza Zaden is also exploring how diversity at the species and cropping system level can contribute to more resilient agricultural systems.

Interactions

For Enza Zaden, CropMix offers an opportunity to better understand how vegetable crops and varieties perform in different production systems. A breeding company normally evaluates varieties in relatively controlled trial settings, but mixed cropping systems introduce additional interactions between neighbouring crops, soil biology, insects, wildlife and management practices. Studying these interactions helps us consider how future varieties might be developed for performance. The project also provides a valuable opportunity to collaborate with public-sector researchers working at the forefront of alternative cropping systems and contribute practical trial experience to the broader scientific community.

Core tenets

Since 2021, Enza Zaden has participated as a consortium partner by conducting annual strip-cropping trials with six crop species: pumpkin, fennel, leek, lettuce, cauliflower and a grass-clover mix. The trials are designed to evaluate both crop performance and the effects of neighbouring crops. In consultation with researchers from the plant breeding programme at Wageningen University &

Research (WUR), an additional layer of complexity was added to the experimental design to also test variety differences within each vegetable crop. The trial was performed at Enza Zaden’s organic research station in Voorst, the Netherlands. The station is certified organic and managed with intensive crop rotations, beneficial insectary strips and organic fertility sources. These conditions, which reflect core tenets of organic agriculture, make this location well-suited for studying diversified production systems and for testing new models that may be relevant to both organic and conventional growers.

Students

One key benefit of this project is that it has supported multiple years of student research in collaboration with WUR. Interns have used the CropMix trial at Voorst for thesis topics that include studying below-ground interactions between species and varieties, the effects of neighbouring crops on quality traits, insect biocontrol and herbivory responses, and statistical approaches for analysing complex trial designs.

Drone-based data

Some of the results were quite unexpected. For example, two complementary projects found that neighbouring crop species had a significant effect on sensory evaluations of sweetness and anise flavour intensity in fennel. The trial has also provided an opportunity to assess how new technologies can support phenotypic evaluations in these complex cropping systems. Drone-based data revealed a strong correlation between early leaf cover in cauliflower and final days to maturity when paired with pumpkin.



Trials of strips to evaluate both crop performance and the effects of neighbouring crops.

Which functional traits

The 2026 season marks the sixth and final year of the strip-cropping trial at Voorst. Although formal conclusions are still being developed, the trial has already provided insights and areas for further exploration. For example, some varieties have performed consistently across different neighbouring crops and growing seasons, while others have been less consistent for key traits, such as yield and quality. For a breeding company, this raises important questions: which functional traits and underlying genetic factors contribute to this resilience, and how can these components be incorporated into new varieties?

Real challenges

For growers, mixed cropping systems may offer additional options for managing crops under variable weather conditions and increasing resource constraints. At the same time, these systems present real challenges for practical considerations, such as equipment use, labour management and harvest coordination. With continued collaboration between breeders, researchers, students and growers, projects like CropMix may help turn the complexity of diversified systems into new opportunities for sustainable vegetable production. •

Adrienne Shelton
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ENZA ZADEN



A faster and highly Sensitive Method New assay for the detection of **LMV** in lettuce



Lettuce seed productions are screened using fast and sensitive methods such as the new seed extract (SE)-qPCR.

Lettuce mosaic virus (LMV), now called *Potyvirus lactucae*, is detected worldwide and can infect lettuce (*Lactuca sativa*) and other species of the Asteraceae family. Symptom severity depends on the LMV strain and the lettuce variety and may include dwarfism, mosaic symptoms, leaf distortion and chlorosis. This can lead to reduced lettuce heads and ultimately to severe crop losses. LMV is seedborne and aphid transmitted in lettuce and is generally more problematic for field crops than greenhouse productions. As no seed treatments are available, the main control measure is to evaluate seed productions using immunological (e.g., Enzyme-Linked Immunosorbent Assay (ELISA)), as well as Polymerase Chain Reaction (PCR)-based techniques for detecting LMV.

Faster and more sensitive

The International Seed Health Initiative (ISHI) protocol described an indirect ELISA-based assay detecting LMV on lettuce seeds and seedlings. To provide a faster and more sensitive detection method, a seed extract (SE)-qPCR assay was developed that can be used as a pre-screening step before the existing ISHI seedling ELISA assay. The assay includes seed grinding, RNA extraction, and a qPCR with two primer and probe sets, targeting gene sequences of the LMV coat and P3 protein and a set targeting an internal amplification control.

Validation study

In silico analysis and testing of the LMV SE-qPCR, using RNA from LMV and non-target virus isolates (ArMV, TBRV and TSWV), demonstrated the analytical specificity of the LMV SE-qPCR. The analytical sensitivity of the LMV qPCR was high, with detection of as little as 30 synthetic oligonucleotides resembling LMV sequences per PCR reaction with >95% confidence. Moreover, the SE-qPCR was able to detect an LMV infection equivalent to a single infected seed in a subsample of 1,000 seeds. Analysis of different lettuce SEs containing equal amounts of LMV revealed that the seed matrix minimally affected (<3 Cq difference) the SE-qPCR results. LMV-spiked SEs consistently produced the same qualitative (positive or negative) outcome, demonstrating high repeatability.

Interlaboratory study

Reproducibility was confirmed in an interlaboratory study involving eight laboratories from the Netherlands, France, Spain and Japan. All laboratories identified subsamples of a high LMV infected seed lot as positive and a healthy lettuce seed lot as negative. The concordance for medium LMV infected samples was lower (96.9%), but meeting the set requirements. Comparison with the LMV seed and seedling ELISAs showed that all assays identified the

same lots as positive, demonstrating 100% diagnostic sensitivity. The diagnostic specificity of the LMV SE-qPCR was lower (66.7%), due to some false positive results in the SE-qPCR in relation to the seed and seedling ELISA. As the LMV SE-qPCR is used as a pre-screening assay for the seedling ELISA, it is considered as fit for purpose.

Conclusion

The validation study showed that the LMV targeted SE-qPCR assay is suitable as optional pre-screening assay in the ISHI LMV detection method for the detection of LMV. The seed and seedling ELISAs remain an integral part of the LMV detection method, where the seed ELISA is regarded as a screening step, potentially following the proposed LMV SE-qPCR, and the seedling ELISA is used as a confirmatory test for suspect seed lots. The validated LMV SE-qPCR assay offers the seed industry a faster and highly sensitive approach for LMV detection in seed lots, thereby strengthening testing workflows, improving disease prevention and supporting the continued supply of high-quality lettuce seed to growers worldwide. •

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New insights into the biology of seed maturation

When drying drives development

At the Seed Maturation & Desiccation Group from the Laboratory of Plant Physiology, we aim to understand how seeds prepare for life without water. By integrating plant physiology, molecular and evolutionary biology and bioinformatics, our research explores how drying shapes gene regulation and enables long-term survival. Three recent studies from our group provide complementary pieces of this puzzle, while also delivering new resources and concepts for the seed research community.

Seeds are remarkable biological systems. They can survive months, years or even decades in a dry state, preserving both biodiversity and the foundation of global agriculture. This extraordinary ability depends on a relatively short developmental window known as seed maturation, during which seeds acquire key quality traits, such as desiccation tolerance, longevity and dormancy. Yet, despite its importance, the molecular regulation of this phase has remained surprisingly difficult to unravel.

SeedMatExplorer

A new resource for discovering genes underlying seed quality. One of the major challenges in seed biology is identifying which genes control complex traits, such as longevity and desiccation tolerance. To address this, we developed SeedMatExplorer, an open-access platform that combines high-resolution transcriptomic and physiological data throughout seed maturation in *Arabidopsis thaliana*.

Community resource

Rather than providing only a large dataset, SeedMatExplorer links changes in gene expression directly to the acquisition of seed quality traits, such as dormancy, germination, desiccation tolerance, longevity and chlorophyll content. Researchers can explore gene expression patterns, identify co-expressed gene networks and rapidly generate hypotheses about candidate regulators involved in seed development and seed quality. Although developed using *Arabidopsis*, the platform provides a valuable framework for identifying molecular regulators of seed quality that can subsequently be investigated in crop species. We hope it will become a community resource that accelerates discoveries across seed science, breeding and conservation.

Fundamental difference

Large datasets become particularly powerful when they are

used to answer new biological questions. Using SeedMatExplorer together with publicly available transcriptomic datasets, we recently investigated how the seed maturation transcriptome evolved. Surprisingly, we found that seed maturation differs fundamentally from embryogenesis and germination. Whereas these developmental stages predominantly express evolutionarily older and highly conserved genes, seed maturation is characterized by increased expression of younger, rapidly evolving genes. This pattern was consistently observed across both monocot and dicot species.

'Innovation hub'

These findings suggest that seed maturation has acted as an evolutionary 'innovation hub', providing an opportunity for newly evolved genes to acquire specialised functions associated with seed quality traits. We propose the 'out of the seed' hypothesis, in which seed maturation serves as a landscape for evolutionary innovation, helping explain how new molecular functions arise while contributing to the remarkable diversity of seed characteristics observed across flowering plants. Beyond advancing our understanding of plant evolution, this work also highlights seed maturation as an attractive developmental stage for discovering novel genes with potential applications in seed technology and crop improvement.

Far more dynamic picture

Our latest work extends this concept further by showing that drying itself is an active developmental signal. During seed maturation, water content gradually decreases as seeds prepare for storage. This drying phase has traditionally been viewed as the final step before seeds enter a quiescent state. However, our recent physiological and molecular analyses reveal a far more dynamic picture. By exposing developing *Arabidopsis* seeds to different drying regimes, we found that seeds actively perceive and respond to the

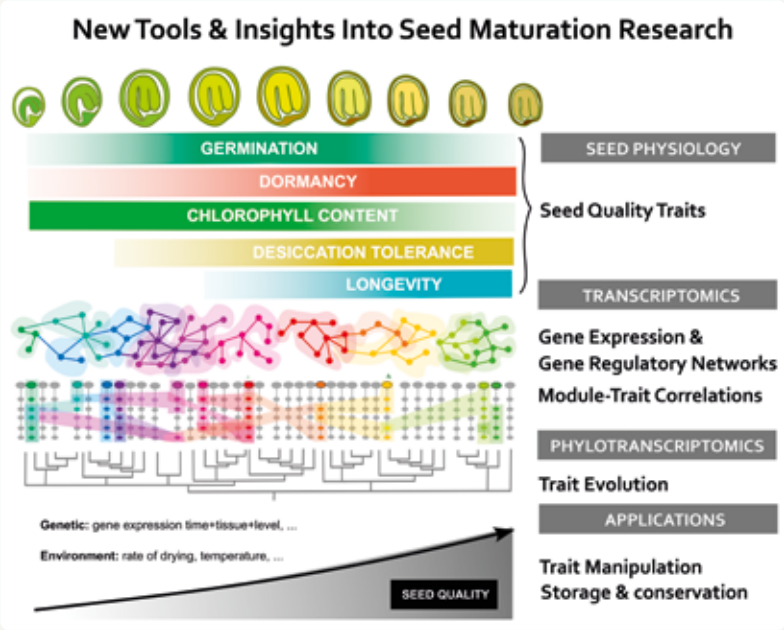


Figure: Novel research integrates data, evolution and physiology to uncover how seeds mature and prepare for drying. SeedMatExplorer enables discovery of genes associated with seed maturation and quality traits; comparative phylotranscriptomics reveals how maturation has shaped gene and trait evolution; and physiological studies demonstrate that drying itself acts as a developmental signal, influencing molecular regulation and the acquisition of longevity and desiccation tolerance. Together, these approaches reveal seed maturation as a dynamic, evolutionary important process with implications for seed improvement, storage and the conservation of plant biodiversity. Figure by Dr. Mariana A. Silva Artur (Wageningen University & Research).

Further read

Artur, M.A.S., Koetsier, R.A., Willems, L.A.J. et al. SeedMatExplorer: the transcriptome atlas of *Arabidopsis* seed maturation. *BMC Plant Biology* (2026). doi.org/10.1186/s12870-026-09313-z

Sami, A. A., Bentsink, L., Artur, M. A. S.; The phylotranscriptomic profile of angiosperm seed development follows a reverse hourglass pattern, *The Plant Cell*, Volume 37, Issue 12, December 2025, koaf266, doi.org/10.1093/plcell/koaf266

Sami, A. A., Willems, L. A., Abdulroheem, L., Carpentier, M. C., Merret, R., Bentsink, L., & Artur, M. A. (2026). Drying kinetics govern transcriptional and post-transcriptional reprogramming during seed maturation. *bioRxiv*, 2026-04.

rate at which they lose water. Slow drying accelerated the acquisition of desiccation tolerance while triggering extensive transcriptional and post-transcriptional reprogramming, including changes in co-translational mRNA decay. In contrast, rapid drying activated stress responses associated with reduced seed longevity. These findings demonstrate that drying is not simply a passive consequence of seed maturation. Instead, it acts alongside hormonal regulation as a developmental signal that helps coordinate the molecular programmes required for long-term survival in the dry state.

Practical applications

Together, these studies illustrate how combining physiology, bioinformatics and evolutionary biology can reveal new principles governing seed development. They also demonstrate the value of integrating multiple layers of biological information, from gene

expression and RNA regulation to evolutionary history, to better understand the mechanisms underlying seed quality. As agriculture and biodiversity conservation face increasing challenges under climate change, improving our understanding of how seeds acquire longevity and survive drying is becoming ever more important. Resources such as SeedMatExplorer, together with new insights into the evolutionary and molecular biology of seed maturation, provide valuable foundations for identifying new targets for crop improvement, optimizing seed production and storage, and conserving plant genetic resources for future generations.

Safeguard

Ultimately, understanding how seeds prepare for life without water is not only a fascinating biological question, but it may also help safeguard the diversity and resilience of plants on which agriculture and natural ecosystems depend. •

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At the intersection of sustainability and commerce

Echinacea secures a permanent place as premium product

Delicious Candy is suitable for landscaping, borders and seed mixtures.

In the breeding of the perennial Echinacea purpurea, two forces meet: the market's demand for compact, floriferous plants with plenty of colour at the point of sale, and the ambition to develop varieties that remain strong for years in gardens, borders and public green spaces. Independent breeder Marco van Noort emphatically opts for sustainable quality in Echinacea purpurea. Yet he, too, cannot ignore retail. Floris Tas, commercial director at Selecta-one, a customer of Van Noort's genetics, sees every day how that tension plays out across the chain.

Steven van Paassen
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According to Tas, the way a plant is presented in retail plays an important role in the purchasing decision. Consumers mainly respond to visible features, such as colour and a full appearance. Less immediately visible characteristics, such as winter hardiness or suitability for a particular position in the garden, generally carry less weight at the point of sale. "We take that into account when selecting saleable plants," says Tas, managing director of the sales subsidiary Selecta one Netherlands and global Group Director Sales.

Van Noort places the emphasis differently. Not the fastest flowering, the most compact growth or the brightest colour comes first, but a sustainable, robust plant. "My varieties must grow and flower beautifully for at least five years. I am principled about that. Customers must be able to rely on the quality of my varieties," he says.

Beautiful collections

Van Noort Breeding in Warmond stands in a family tradition spanning three generations of seed production and perennials as cut flowers. Van Noort still grows starting material, but his true interest lies in genetics, especially

Echinacea. In the 1990s, he began collecting plants, mainly in the Netherlands, Germany and the United Kingdom. "Back then, there were still older plant collectors with beautiful collections. I was able to buy them. Royalties hardly played a role. That is how I built up my own basic collection."

“My varieties must grow and flower beautifully for at least five years.”

Marco van Noort



Being strong

From those collectors he learned a lasting lesson: a plant must first be naturally strong; only then does ornamental value come into play. That principle still guides his work. In cultivation, he pays close attention to the mineral balance in the soil, because healthy soil produces resilient plants. For pest control, he chooses natural predators wherever possible, such as predatory insects and parasites. He also applies crop rotation. In trial fields, he deliberately leaves virus-susceptible seedlings in place to see which plants offer resistance.

Traditional

As a one-man company, Van Noort largely keeps crosses and selections in his own hands. His genetics come from his own collection or from wild species. He works traditionally: pollinating in the field or greenhouse, selecting and crossing again. Marker techniques and gene editing are too expensive for him – and, he says honestly, "not fun to do". He outsources the propagation of his selections via tissue culture to his Polish partner Tuszyński. Between weeks 17 and 25, Tuszyński supplies plug plants to a select group of plant growers. They cultivate the plants under licence in 1.5 to 3-litre pots. After 12 to 14 weeks, the plants are ready for the market.



ECHINACEA

Echinacea originates from North America and Canada. Echinacea purpurea in particular has long been known for its anti-inflammatory properties. Today, there is an active global trade in health supplements containing extracts of dried Echinacea leaves or roots. North America is the largest market, followed by Europe and Asia.

SELECTA GROUP

The Selecta Group is active worldwide in breeding, growing and marketing ornamental plants. Its breeding activities include bedding and balcony plants, houseplants, perennials and cut flowers. The company is headquartered in Stuttgart. With production sites and sales offices in Europe, Africa, Asia and the Americas, the company serves the relevant markets.

Suitable for patios

Van Noort now offers a range of around 40 Echinacea varieties, in various shapes and colours and with trendy names. These range from the classic variety 'Hot Summer' to new selections, such as the Meditation series. The catalogue describes it as: "Sturdy, compact plant with many orange flowers. The compact shape is well suited as a patio plant or for a sunny border." It is exactly the type of plant consumers and retailers are looking for.

Dead within a year

That is precisely where things start to grate. As a plant enthusiast, Van Noort takes a critical view of a retail market that mainly asks for compact plants full of flowers at the time of purchase. "Consumers often do not really know how to handle perennials. Often such a plant is dead within a year. Instead of sustainability, more and more genetics are focused on that short-term experience. As a result, the commercial market power of retail unfortunately puts pressure on the quality of Echinacea."

Own growing-on location

On the commercial side, one of the parties involved is Selecta-one. Tas is Group Director Sales at the German group. Selecta purchases Van Noort's selections via Tuszyński as tissue-culture plants. At its own growing-on location in Stuttgart, these are further cultivated into starting material for growers. After around 10 weeks, the Echinacea plants are supplied to retail chains as saleable plants.

“Consumers mainly respond to visible features.”

Floris Tas



Van Noort works traditionally: pollinating in the field or greenhouse, selecting and crossing again.

Tissue culture

"I do understand Van Noort's view," Tas responds. "Echinacea is originally a perennial, capable of growing in the same spot in the garden for several years. In the past, the plant was propagated from seed. It first had to be vernalised before it could be grown on and sold the following spring. With the introduction of tissue culture around 10 years ago, that step disappeared for Echinacea. The quality of plants from tissue culture is also considerably better than that of seed-grown plants. In addition, cultivation can be planned very well. That is how Echinacea secured a permanent place in our summer and autumn range."

Commercial premium product

The plant has now also been selected more strongly for compactness. This allows for a higher loading rate on sales trolleys and increases its suitability as a single-variety product or as part of mixed plantings in pots and hanging baskets on balconies or terraces. "With its abundant and colourful flowering, Echinacea has grown into a popular garden plant over the past decades. From a product for enthusiasts, it has become a true commercial premium product," says Tas. "Sales volumes have risen rapidly in recent years. As a result, several large breeders have also started working with it, targeting the public through retail. And consumers are very price-conscious..."

Serious collaboration

Still, the principled Van Noort and the commercially driven Selecta-one have found common ground. "I was very sceptical about the large commercial breeders, but to survive as an independent breeder, you need sustainable partners across the entire chain. With Selecta-one, I eventually felt there was a connection. They take my vision of sustainable quality very seriously." "We certainly do," Tas confirms. "Sustainability is one of our core values. Through genetics, at the beginning of the chain, you can lay a solid foundation for it. Van Noort supplies those genetics. Several times a year, our breeder and product manager from Stuttgart visit him to view and discuss his selections: which ones fit best at the intersection of sustainability and commerce? We both learn a great deal from that."

“

Through genetics, the beginning of the chain, you can lay a solid foundation for sustainability.”



In the Selecta-location in Stuttgart, Echinacea are further cultivated into starting material for growers.

Performing for years

Meanwhile, Van Noort is also turning his attention to public green spaces, landscaping and a new generation of garden designers. "You can see a trend towards naturalisation in verges, parks and gardens. People want to see chicory, thistles, bees and butterflies again. More sowing, less mowing. That creates more nature and saves labour." For designers looking for natural, organic and resilient plant material, he believes his selections are a good fit. As an example, he mentions the Delicious series, with semi-double flowers that are frequently visited by bees and butterflies. The plants are robust, winter-hardy down to -12 °C and flower after 12 to 14 weeks. They are suitable for landscaping, borders and seed mixtures. For Van Noort, that is where the future lies: strong plants that are not only attractive at the point of sale, but continue to perform for years. "There are always new challenges in creating something new: better, more beautiful, stronger. It never stops." •

Insufficient evidence to support transmission of ‘*Candidatus Liberibacter solanacearum*’ via carrot seeds

CLso has been detected in both historical and recent carrot seed lots from several countries.

‘*Candidatus Liberibacter solanacearum*’ (CLso) is a phloem-limited bacterium of significant phytosanitary concern due to its association with economically important diseases in solanaceous and apiaceous crops. In potato, the pathogen causes zebra chip disease, while in carrot it is associated with leaf discoloration, stunting and proliferation of secondary roots.

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CLso is primarily transmitted by psyllid vectors, which efficiently spread the bacterium between host plants. Its host range is largely confined to Apiaceae and Solanaceae, including carrot, celery, eggplant, parsley, pepper, potato and tomato, as well as some weed species that may act as reservoirs. The pathogen occurs in North, Central and South America, Europe, North Africa and New Zealand.

Raising questions

CLso has been detected in both historical and recent carrot seed lots from several countries, raising questions about its potential for seed transmission. Studies have shown that the bacterium can be present on the seed coat. However, it has not been detected in the embryo, which is essential for vertical transmission. Although relatively high levels of carrot seed infestation have occasionally been reported, early indications of possible seed transmission could not be reproduced in subsequent investigations.

No evidence

Consequently, there is currently no definite evidence that CLso is transmitted through carrot seed. This conclusion aligns with the EPPO datasheet, which considers seed transmission in carrot to remain unproven (gd.eppo.int/taxon/LIBEPS/datasheet). The RPLI entry for CLso on carrot seed has therefore been revised to reflect the current state of knowledge (worldseed.org). Earlier uncertainty regarding seed transmissibility led some countries to introduce phytosanitary restrictions on apiaceous seed movement. However, as additional studies failed to demonstrate vertical transmission, many of these measures were reviewed and, in several cases, withdrawn, in favour of a more evidence-based regulatory approach. •



View the
EPPO
datasheet



View the
The RPLI entry
for CLso

A diversity of approaches

Quality vegetable seeds have the potential to significantly improve nutrition security in sub-Saharan Africa, the region with the world’s lowest per capita production and consumption of vegetables. International seed companies have an important role to play, as they have done in Asia, where they improved access to quality seeds and knowledge of good agricultural practices. As a result, vegetable production and consumption have increased significantly since the turn of the century.

Wide variety of actors

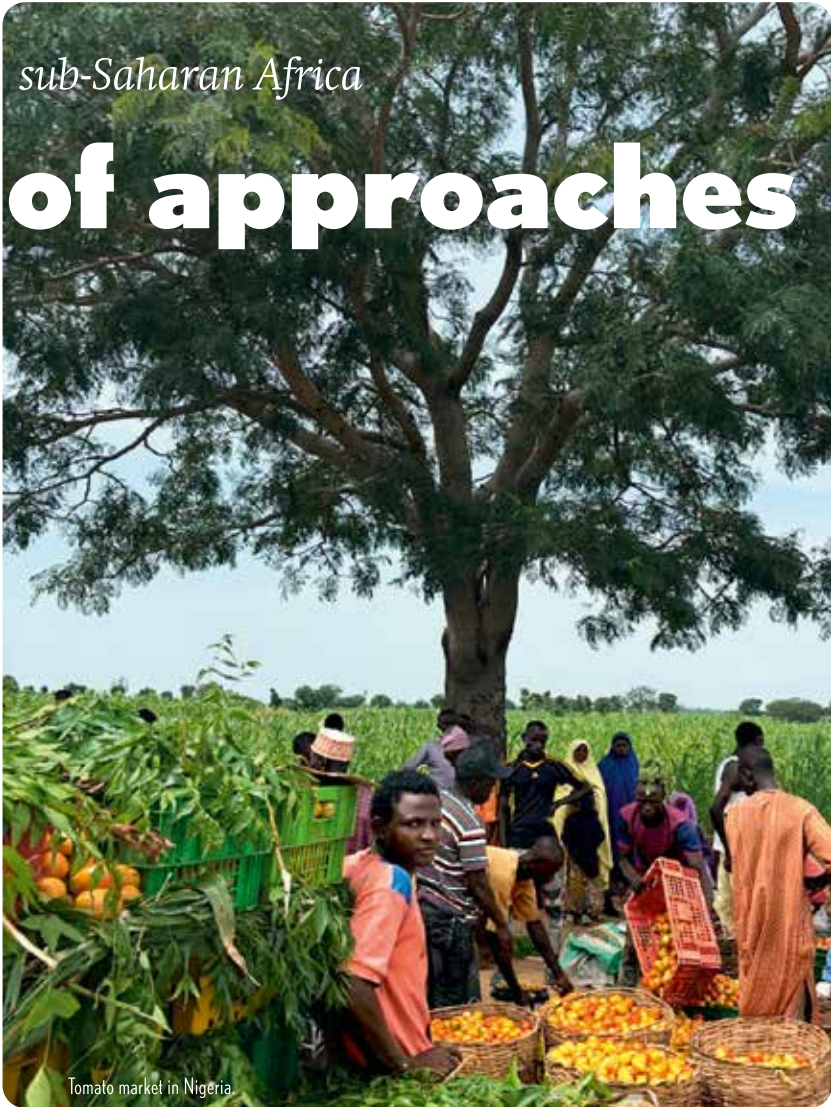
Meanwhile, market-driven seed sector development remains a controversial phenomenon, with some celebrating technological advancements and others raising concerns about seed sovereignty and farmers’ dependency on the private sector. However, it should be noted that such a thing as ‘the private seed sector’ may not exist. Rather, it consists of a wide variety of actors with different business models and strategies.

A linear trajectory

Interviews with leading vegetable seed companies provided insights into both their shared perspectives and their distinctive strategies. One widely shared view is that vegetable seed sector development follows a linear trajectory, alongside improvements in agronomy and produce markets, towards increasingly advanced seed types: from standard open-pollinated (OP) varieties to improved OPs and, where technically feasible, to basic and advanced hybrids.

Not static roles

Within this general trajectory, however, distinctive strategies emerge. These strategies are shaped by companies’ available resources and competitive advantages. Companies may focus on one or more functions within the seed value chain, including marketing and sales, seed multiplication, and breeding for, or even within, these markets. These roles are not



Tomato market in Nigeria

static; they evolve as business opportunities expand across seed system functions and market segments. Companies with strong breeding programmes are more likely to focus on establishing a premium brand for advanced farmers supplying professional urban markets. Companies without the resources to develop breeding programmes may instead specialise in distribution, developing extensive networks to bring affordable, quality seeds to remote agrodealer shops and markets. Others may focus on seed production, supplying large volumes of standard seed to humanitarian organisations.

Agronomy and opportunities

Moving farmers towards increasingly advanced seed types requires both improved agronomy and better opportunities in produce markets. For companies to take on additional functions depends not only on their investment capacity, but also

on a range of national policies, including those related to seed systems, intellectual property and biodiversity. Importantly, not only the policies themselves, but also their implementation and enforcement determine whether companies are willing and able to invest. Public-private partnerships can further facilitate the development of vegetable seed sectors.

Promote diversity

The coexistence of a wide variety of (private) actors within a country’s vegetable seed sector helps meet diverse demand and increases farmers’ access to quality seeds of the varieties best suited to their needs. A key objective of national agricultural policy should therefore be to promote diversity within the private seed sector. Seed sector interventions can further enhance inclusivity by supporting viable and innovative business models that serve diverse farming systems, market segments and crop types. •

Prophyta

Emily ter Steeg

This is a preview of a chapter of her PhD thesis, which is defended 15 October at Wageningen University, and published in *Agricultural Systems: ‘Market-driven transitions in the vegetable seed sector in sub-Saharan Africa’*. doi.org/10.1016/j.agsy.2024.104113



One hundred years after the Laboratory of Entomology was founded at Wageningen University & Research, its work has become more urgent than ever: reducing agriculture’s dependence on synthetic pesticides by designing crops that resist pests and support their natural enemies.

One hundred years Laboratory of Entomology

Reducing synthetic pesticides with nature

Plant breeding has transformed food production. Yields have risen spectacularly, and breeders routinely select for quality and disease resistance. Yet many crops still rely heavily on pesticides to keep insect pests in check. That dependence is increasingly difficult to defend at a time when biodiversity is under severe pressure and concerns about pesticide impacts on human health are mounting. Insects are often seen only as enemies of crops. That is misleading. Insects are the most species-rich group of animals on Earth, and while many feed-on plants, many others prey on those plant-feeders. In natural ecosystems, outbreaks are rare precisely because predators, parasitoids and other beneficial insects help keep herbivores in balance. Agriculture can learn from that.

Resistance that lasts

Integrated pest management (IPM) was developed to prevent and control pests while using chemical pesticides only as a last resort. Resistant crop varieties are central to that strategy. By selecting for plant traits that make crops unattractive or unsuitable to herbivorous insects, breeders can prevent pest populations from establishing and multiplying. Absolute resistance can be dramatic, but it is often broken within a few years as insects adapt. A Wageningen collaboration produced iceberg lettuce with absolute resistance to the lettuce aphid *Nasonovia ribis-nigri*.

Marcel Dicke

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More often, partial resistance offers the better route: less spectacular, but frequently more durable.

Breeders and entomologists need each other

Developing such varieties requires close cooperation between plant breeders and entomologists. Breeders identify useful variation in plant traits; entomologists show how insects respond. Which cues guide an insect to a host plant? Which plant characteristics matter? How easily can an insect overcome resistance?

Reading insect behaviour

Wageningen entomologists and partners have developed tools to answer those questions. The electrical penetration graph method records the feeding behaviour of sap-sucking insects such as aphids, revealing where their mouthparts are in the plant and what they are doing. Automated video-based behavioural analysis makes it possible to screen large numbers of crop lines for insect resistance. Both methods are now commercially available.

Crops as ecosystems

Biological control is another pillar of IPM. Natural enemies can keep pest populations below damaging levels, but they must be able to function on the crop itself. In Dutch greenhouse horticulture, more than 95% of growers use biological agents, such as predators and parasitoid wasps.



Aphid Myzus persicae attacked by parasitoid wasp Aphidius matricariae



Aphid Myzus persicae; an annoying plant eater

Yet plant traits can help or hinder them. On common cucumber varieties, dense leaf hairs strongly impeded the searching behaviour of the parasitoid wasp *Encarsia formosa*. On a semi-hairy cucumber, control of greenhouse whitefly improved because the wasps found more larvae. Plants can also “call for help” by releasing odours after insect feeding. These cues guide natural enemies to pests, though crop varieties differ in how strongly they emit them. Breeding can therefore select not only for pest resistance, but also for crops that actively assist biological control.

Towards fewer pesticides

The challenge now is to make pesticides truly exceptional in crop protection. That will require crops that are sufficiently resistant to pests and, at the same time, compatible with the insects that suppress them. For the next century of entomology, the message is clear: sustainable agriculture depends on crops bred not just to survive pests, but to work with the ecological allies already present in the field or greenhouse. •



Students in the online MSc in Plant Breeding come to Wageningen University once a year for practicals. During Breeding for Resistance, they work with potato plants and study resistance to Phytophthora.

In a rapidly changing business environment, individuals, companies and organisations are expected to keep pace with new knowledge, innovations and technologies. Lifelong learning and the continuous broadening of knowledge have become increasingly important.

Wageningen University and Research offers wide range of learning tools

Online plant breeding education supports professional development

In plant breeding and seed technology, Wageningen Academy, part of Wageningen University and Research in the Netherlands, offers flexible learning options for employees of seed companies and related organisations. These range from online self-study modules to on-campus and in-company courses. Wageningen also offers nine courses from its online MSc programme in Plant Breeding. The full degree takes three to four years of part-time study; individual courses last about four weeks.

Develop careers

The programme attracts participants from seed companies in the Netherlands and abroad. Jan-Kees Goud, lecturer in Plant Breeding, says many are assistant breeders who use the online MSc to develop their careers within their companies. The degree is officially accredited, and normal admission requirements apply.

Fresh research results

Most teaching staff also have research projects, allowing recent developments to be included in the courses. Vivianne Vleeshouwers, Associate Professor of Plant Breeding, says her course Breeding for Resistance can provide fresh research

results on topics such as ToBRFV resistance. Courses are updated annually, and company students often choose thesis topics relevant to their employers.

Out of comfort zone

Students are encouraged to look beyond their usual field of work, for example through internships in unfamiliar areas. Goud and Vleeshouwers say students are open in discussions while respecting company confidentiality. They also present themselves and their work in video clips.

Expand networks

The programme has an international profile, with most students from EU countries and others from Asia and the Americas. In the first two years, students spend two weeks in Wageningen for practical work, excursions and meetings with fellow students, helping them expand professional networks.

Time is obstacle

For companies, additional training builds knowledge and supports career development. Many companies contribute to costs, but the main obstacle is often studying time. Clear agreements between employer and employee are therefore essential.

Up to date

WUR's ongoing challenge is to keep courses current despite limited time. New technologies such as CRISPR-Cas, data use and artificial intelligence are increasingly important in breeding. According to Goud and Vleeshouwers, no other European university currently offers the same range of plant breeding learning options. •

WAGENINGEN UNIVERSITY

At academic level, Wageningen Academy offers self-study and on-campus courses, Summer Schools, online masters courses and in-company training. Wageningen University offers 44 masters programmes, three largely online. It is regularly ranked as the world's leading institution in agriculture and food.

More information
wur.nl/en/education/for-professionals

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Idy van Leeuwen on knowledge transfer in plant breeding

“Mutual exchange is even more important”

Plant breeding companies are growing rapidly. They are becoming more international, specialised and knowledge-intensive, which increases the distance between departments. Employees know more about their own field but may lose sight of the bigger picture. That is why knowledge transfer remains indispensable, says Idy van Leeuwen, founder of BreedWise. “People need time and a good platform to talk to one another. That is where understanding, connection and new insights emerge.”



A company tour provides the possibility for interaction.

Steven van Paassen

Van Leeuwen studied at Wageningen University and spent many years developing professional training programmes (both in Dutch and English). In 2003, she founded BreedWise, offering specialised courses for professionals in plant breeding. After more than thirty years in the field, she is handing over the company to Peter van Duin and Peter van Enckevort. She will remain involved, while day-to-day management moves to the new owners.

Unique

According to Van Leeuwen, BreedWise has a distinctive position. “The Netherlands has a high concentration of international plant breeding companies. Worldwide, there are very few providers of genuinely specialised courses.” Alongside BreedWise, she mentions HAS Green Academy Naktuinbouw, Wageningen Academy and UC Davis. The need for such training, she says, has only grown.

Diverse participants

Participants represent a broad cross-section of the sector: crop maintenance assistants who want to understand the crop better, operations specialists working with seed, vocational graduates moving towards assistant breeder roles, and

experienced breeders deepening their knowledge of topics such as molecular biology. “That diversity makes training enjoyable,” says Van Leeuwen. “Everyone brings questions, experience and practical examples.”

No time

Theory remains essential: plant physiology, genetics and breeding techniques continue to develop rapidly. Yet a course is more than transferring subject matter. “Traditionally, knowledge was passed on by a manager or experienced colleague. But there is less time for that, and not everyone is equally skilled at teaching. A course offers structure, calm and space.”

Interaction

That space matters because many participants are strongly practice-oriented. Therefore, BreedWise builds training around interaction, recognisable examples and practical stories. Sometimes this includes a company tour, although confidentiality can be an obstacle. “Exchanging different ways of thinking and working is incredibly refreshing,” says Van Leeuwen. “Participants learn from me and from one another, and I learn from them too.”

Same chain

BreedWise's basic breeding courses for employees not directly involved in breeding programmes, ‘Breeding for dummy's’, are also popular. In large international companies, departments can become separated by distance, specialisation or hygiene protocols. Yet employees still collaborate internationally on the same product. “You are all a link in the same chain. It helps enormously if you understand how a breeding programme is structured and what it involves.”

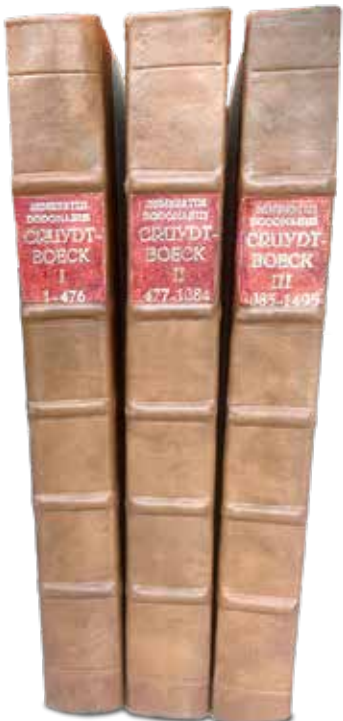
Overview bigger picture

That need will continue to grow, she believes. Plant breeding companies work with more specialists: researchers, applied researchers, product developers, crop teams and support departments, each with their own knowledge, language and priorities. Without mutual understanding, collaboration becomes harder. “An overview of the bigger picture can no longer be taken for granted. That is exactly why conversation remains necessary. A course is an excellent place for that.” •



Idy van Leeuwen
Founded BreedWise and has developed and delivered international courses for plant breeding professionals since 1992. BreedWise has now been taken over by Peter van Duin and Peter van Enckevort.
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Spotlight on a herbal book



The three volumes of Dodonaeus 'Cruydt Boeck'

Jan Timmerman

Sow to Grow possesses two different editions of the famous herbal 'Cruydt Boeck', written by the Flemish physician and botanist Rembert van Joenckema (1517-1585), better known as Dodonaeus.

The original edition appeared in 1554 and, at the time, was a highlight in the field of medicine. It consists of three volumes and describes hundreds of plants. The editions in the possession of Sow to Grow stem from 1618 and a facsimile of the edition from 1644. Both reprints have been revised in 1606 by among others Carolus Clusius, who added many plants from the East and West Indies.

Dodonaeus was the first to classify plants according to their characteristics, rather than the alphabetical order customary at the time. For each plant, he records the various forms, growth and flowering pattern, parts such as leaf and flower, habitat, flowering time and medicinal value.

In the first edition, he refers to the tomato as the 'golden apple' or 'apple of love' and describes two varieties: red and yellowish white. The fruits have ribs and are the size of a small apple. Regarding its medicinal and nutritional properties, he states that its beneficial effects are still unknown. He calls the tomato exotic and doubts whether it is healthy to eat them, partly due to the strong smell. The 1618 edition adds that the tomato is supposedly good for the eyes. The fruit is widely consumed in Italy, but it is not very nutritious and can even be bad for one's health according to botanist Lobelius. •



SOW TO GROW

Sow to Grow is a so-called 'plant science experience centre', where people can learn more about plant breeding and its crucial importance for human health and wellbeing, as well as for the environment. It is based on self-discovery learning, for instance, by making changes in a giant DNA string to develop a healthy, red-coloured sweet pepper, made visible on a large screen. Besides the regular visitors, the museum also receives school groups for a one-morning experience. Another activity is a 6-week course for new employees in the seed industry to learn about plant breeding, seed production and regulatory aspects.

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