



FOCUS ON EUROPE

Journal for breeders and producers of plant material

Prophyta



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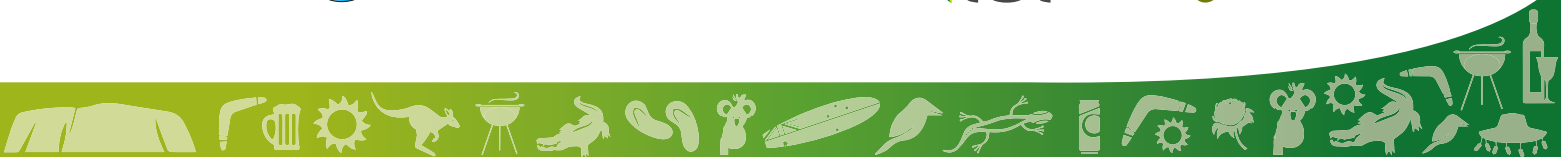


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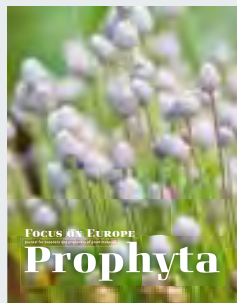
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On the cover: *Anemone multifida* 'Rubra' is one of the varieties in the reference collection of Naktuinbouw (Photograph: Naktuinbouw)

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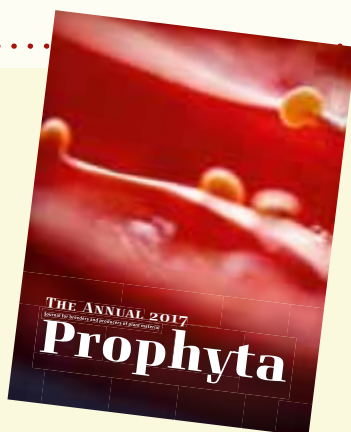


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PROPHYTA – FOCUS ON EUROPE is dedicated to the interests of participants of the ESA Annual Meeting and will be published yearly on the occasion of this congress. For that reason, this publication will be distributed exclusively to professionals in the seed industry, working in the areas of breeding, producing, marketing and sales. In-depth interviews with leading international profession-



als, broad articles about current and future developments; all aimed at providing you with information that really matters.

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Prophyta is represented at the ESA Annual Meeting by Monique Krinkels, Chief Editor. You are welcome to visit her at her desk, where you can receive an extra copy and complete your subscription.

Revolutionary technology protects potato from fungus

LAST AUGUST, the Wageningen company, Solynta, presented their newest breakthrough, a potato resistant against *Phytophthora infestans*. Solynta has opted for a whole new approach to obtain resistance: the company developed hybrid parent lines, which allow propagation with seeds. As a result, the breeders were able to cross-breed resistance genes into the potato plant within a two-year period. The perfectly healthy potato plants in the test field have two resistance genes, whereas those with a single resistance gene exhibit minor signs of infection. Natural protection against phytophthora is of great importance for the environment. This potato disease causes many billions worth of damage worldwide and is a serious threat to food production. Up to now, farmers have only had one option to save their crop when the plants become infected: spraying heavily and frequently with a chemical pesticide. The European Union has co-financed this manifestation with a prestigious Horizon



Organic growers of potatoes were despairing due to last year's outbreak of *Phytophthora infestans*

2020 funding grant. Resistance to phytophthora is just one example of the breakthroughs made possible by hybrid potatoes from seed. This new breeding technique for potatoes makes it possible to rapidly introduce better breeds. Not only with natural protection against diseases, but also with improved taste, suitability for organic farming methods, or with an increased nutritional value. Furthermore, potatoes from seed can be bred very rapidly. One single plant produces about 25 million seeds. In addition, potato seeds

can be distributed quickly and easily around the whole world. One bag of 25 grams of seed replaces 2,500 kilos of seed potatoes.

Organic growers

Resistance against phytophthora is of even greater importance to organic growers, as they have no means at all of protecting their plants against this disease. Together with supermarket chains and organic potato growers, other potato breeding companies have established an agreement to improve resistance against

phytophthora. The reason for this is the phytophthora outbreak among eco-potatoes in 2016. So far, only six resistant varieties have been developed. This number should increase to ten to twelve varieties by 2020. Agrico, HZPC, C. Meijer, Plantera, Den Hartigh, Europlant, Danespo, Caithness Potatoes, Fam Vos and Carel Bouma Biologisch Pootgoed (biological propagating material) have agreed to give priority to breeding and production of resistant seed potatoes.

Local for local

Last year, 148 cities from all over the world entered into the Milan Urban Food Policy Pact. The signatories represent 470 million inhabitants. Their promise: 'We will work to develop sustainable food systems that are inclusive, resilient, safe and diverse.'

Since the Second World War, an adequate food supply has always been secure in Western Europe. But it was mainly thanks to seven decennia of political and economic stability. Throughout history, cities were the cradles of numerous famines. A classic way to conquer a city is to cut off the food supply. Last year that happened in Madaya, Syria, where people were forced to still their hunger by eating leaves, cats and rats. And while war seems to be very far away to Europeans, the Syrians did not expect it either, before 12 March 2011. Having food production close by would have been a blessing. But even a simple factor such as logistics can cause havoc. Take New York City, with its 8.5 million inhabitants. 95% of their food arrives by road transport. Every day, 13,000 trucks pass the bridges and tunnels on their way to distribution centres, which in turn supply the city's 1,600 schools, 20,000 restaurants and 13,000 shops with food. It is estimated that by 2040, the population will have risen to 9.5 million, 60% more than today. Is it possible to build enough roads, bridges and tunnels to enable transport or will traffic into the city come to a standstill?

And the citizens do not only need sufficient food, they need healthy food. About 2.6 billion people live in slums in Africa and Asia, where food preservation is a major problem. Only fried food, prefabricated food and bottled drinks are safe in the short term. Food that is poor in vitamins, minerals and fibres, and rich in salt, sugar and saturated fats, causing welfare diseases.

Vertical farming seems to be a promising solution to provide the world with fresh, healthy produce. Year-round production, needing less crops protection, fertilizers, water and energy, environmentally friendly, close to consumers and therefore increasing food security sounds convincing enough. The main thing that is needed are plant varieties that are able to cope with the special conditions in these farms. 'He who controls the food, has the power,' American politician and diplomat Henry Kissinger once said. And he who creates varieties, lays a firm basis for mankind's wellbeing, one might add.

Monique Krinkels



Photograph ING

Based on his paintings, this Spring a new portrait of Rembrandt van Rijn was presented, 347 years after his death in 1669

Creating the 'next tomato'

WOULD IT BE POSSIBLE to create an ideal tomato if breeders would merge their knowledge with computer technologies? "Yes," says Arjen van Tunen, CEO at Keygene. "If it is possible to paint a 'Next Rembrandt', the 'next tomato' is only a step away." In the project, the 'Next Rembrandt', a team of art historians, material researchers, Microsoft data scientists and engineers, the Technical University Delft, The Mauritshuis and The Rembrandt House Museum taught a computer to paint just like Rembrandt. To teach Rembrandt's style to the computer, the team gathered enormous amounts of data about his paintings - the

geometries, the composition patterns, even the height of the brush strokes off the canvas - and fed it into the machine. The scientists ordered the data and selected all males painted by Rembrandt who looked to the right and wear a hat. The system was not averaging, but used recurrence and relevance to determine the most dominant patterns that make a Rembrandt look like a Rembrandt. This April, 347 years after his death in 1669, a new portrait of Rembrandt van Rijn was presented. "If we would have all the relevant genetic information and all the characteristics the ideal tomato plant should have, we could make a model and a recipe of how to cross breed it," Arjen van Tunen believes. "It might be a futuristic idea, but given time, one day there will be a 'next tomato'."

Patent on purple radish rejected

6

THE SEVEN-YEAR legal battle between Taste of Nature and Cresco about the purple radish sprouts has ended. Taste of Nature submitted an application for the patent in 2001 and it was granted in 2008. Cresco proved that a batch of seeds had been sold before the application date. Furthermore, the sprouts were presented to the general public at a show. The judge of the court in The Hague, the Netherlands, therefore rejected the patent, due to the fact that the radish sprouts were not new. Showing

and selling are both activities that breach the requirement for patenting that a product is novel.

The purple radish had been developed by cross breeding and selecting plants from a gene bank. The purple colour is the result of a high anthocyanin content. According to the European Patent Office, since last July, products of classical breeding cannot be patented anymore. (See page 12 for an article on this subject)



Photograph Cresco

Red radish sprouts are loaded with vitamins, and research suggests that these super-nutritious sprouts have many health benefits



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HOLLAND STRAWBERRY HOUSE



Chris Kik does not only collect seeds but also information from the local farmers in Uzbekistan in the hope that the landraces and wild relatives of species will contain disease and insect resistances

Seed hunter explores Uzbekistan and Jordan

LANDRACES OF MELON and wild lettuce plants were the targets of seed hunter, Chris Kik, head curator of crops at the Centre for Genetic Resources (CGN), the Netherlands. In August this year, he travelled to Uzbekistan to visit markets and farmers in search of seeds of muskmelon, *Cucumis melo*. This melon type is thought to have come from a bitter, sour-tasting melon still found growing wild. As melon has been cultivated in the region for over 2000 years, there is a wide-ranging assortment of landraces available. He brought fifty new accessions home with him

bringing the total amount of melon varieties at CGN to 220. "In Uzbekistan, the size of the melons cannot be compared with the European varieties. A ten-kilo melon is not uncommon, but as the families living in the countryside are often large, the preference for heavy weights is understandable," explains Chris Kik. "In the country's capital, Tashkent, on the other hand, melons that weigh less can also be found." A local snack in Uzbekistan is dried melon, he discovered. "The melon cubes are hung out to dry in the sun and are then braided into 30-centimetre

strings. Tasting not at all unpleasant," he remarks. His second mission this year was to Jordan, where he looked for wild specimens of *Lactuca aculeata*, a lettuce that is closely related to and fully interfertile with cultivated lettuce, *Lactuca sativa*. "*Lactuca aculeata* is still rare in gene banks. At the Centre for Genetic Resources, we only have two or three accessions. Jordan has large populations of this lettuce and it is hoped that cross-breeding with this wild relative will introduce disease resistances to the common lettuce." It was Chris Kik's fourteenth mission since 2008, which

brings the total number of accessions he brought to Wageningen to over 700. The missions are a cooperation between the gene bank and seed companies. The latter co-finance the missions and help to propagate the material. After a period of five years, the accessions are included in the CGN collection and will become available for research, breeding and education. Copies of the accession are also stored in the countries where the plants were found.

Seedsmen buzzing in Riga

Monique Krinkels

8 More than 1,000 participants are expected to join the Annual Meeting of the European Seed Association in Riga, Latvia. “For three days, many crop-specific issues that are important for seed companies in Europe and worldwide will be addressed,” says Garlich von Essen, Secretary General of ESA. He expects a buzzing atmosphere.

• **When, in the Autumn of 2000**, four national seed associations decided to form a European organisation to serve their interests, they started a mission that has been a pervasive success. Today, ESA has 38 national member associations from 26 countries - EU Members States and beyond - representing several thousand seed businesses, as well as more than 70 direct company members.

The membership even goes beyond Europe as Morocco is an associate member. What can ESA do for these countries?

“Generally, ESA wants to have an open approach to collaboration with the international seed sector beyond our direct regional sphere of responsibility. Consequently, the ESA Congress has always been open to participation from non-member companies and countries. And we see a rising interest, specifically from outside Europe, to take part in the ESA Annual Meeting. Seed truly is an international business with a very high level of cooperation and collaboration beyond borders; this is confirmed by the ever-growing attention ESA receives from non-EU countries and companies.

“Of course, there are also very concrete reasons for some companies or associations to become associated with ESA. ESA supported the launch of the European Plant Breeding Academy set up by the University of California; and if we look at Morocco, the EU is by far the most important market for products from Morocco and it is mainly EU-based companies that work for the registration (and protection) of their varieties in the country. ESA remains open to this specific form of membership from non-European companies and associations; but we, of course, also have a number of other forms of cooperation, e.g. via ISF or through specific bilateral discussions.”

How much is ESA focused on the EU? There are several non-EU countries which are member of ESA (Serbia, Switzerland, Turkey and Ukraine)? Originally, it was said that only EU member countries and future EU member countries could become Association members. Nor Switzerland nor Ukraine meet that description.

“ESA’s interpretation of Europe goes beyond the borders of the (current) European Union. This also reflects the market realities with many of ESA’s member associations and companies engaged extensively



Secretary General Garlich von Essen: ‘ESA’s definition of ‘Europe’ is one that reflects concrete political as well as market realities’

in e.g. Turkey, the Ukraine or other countries. In the case of Switzerland, the applicable seed marketing legislation, including the Common Catalogue of varieties, is valid for Switzerland also, without the formal membership of the country in the EU. Simply speaking, ESA’s definition of ‘Europe’ is one that reflects concrete political as well as market realities. Still, our focus, of course, remains with the political entity of the European Union and its institutions.”

Does it make a difference in what you can do whether or not countries are EU-members? And what will be the effect on Britain after Brexit?

“There is, of course, a marked difference between working with a single country and working in the multilateral environment of the European Union. The EU provides very clearly defined processes and a unique institutional framework for policy and decision making, including a defined legislative ‘acquis’. But even within the EU, there are distinct differences

European countries	EU-member since	Association member ESA	Individual members ESA
Albania			
Andorra			
Armenia			
Austria	1995	Yes	
Azerbaijan (partly)			
Belarus			
Belgium	1957	Yes	Yes
Bosnia & Herzegovina			
Bulgaria	2007		
Croatia	2013	Yes	
Cyprus	2004		
Czech Republic	2004	Yes	
Denmark	1973	Yes	Yes
Estonia	2004	Yes	
Finland	1995	Yes	
France	1957	Yes	Yes
Georgia (partly)			
Germany	1957	Yes	Yes
Greece	1981	Yes	
Hungary	2004	Yes	
Iceland			
Ireland	1973	Yes	Yes
Italy	1957	Yes	
Kazakhstan			
Kosovo			
Latvia	2004		
Liechtenstein			
Lithuania	2004		
Luxembourg	1957		
Macedonia			
Malta	2004		
Moldavia			
Monaco			
Montenegro			
Netherlands	1957	Yes	Yes
Norway			
Poland	2004	Yes	
Portugal	1986	Yes	
Romania	2007	Yes	Yes
Russia (partly)			
San Marino			
Serbia		Yes	
Slovakia	2004	Yes	
Slovenia	2004	Yes	
Spain	1986	Yes	Yes
Sweden	1995	Yes	
Switzerland		Yes	
Turkey (partly)		Yes	
Ukraine		Yes	
United Kingdom	1973(-2019?)	Yes	Yes
Vatican City			

in the way individual Member States operate internally, from very federal organisations, such as Belgium or Germany, to more centralised states, such as France, which need to be taken into account when working out outreach and advocacy strategies.

“As regards the UK and Brexit, ESA is, of course, disappointed that an important Member State is leaving the Union and that, as a consequence, the Common Market for seed will become smaller, while moving seed between the EU and the UK is likely to become more burdensome and costly for companies. Of course, ESA, together with its two UK Member Associations, BSPB and AIC, will do all it can to work for a practicable transition between the current system and the future third country relation. But we already see today how difficult this pragmatic approach will be to implement, given the more principal considerations of parties in the Brexit process.”

What are the major topics that will be discussed in Riga? Brexit of course, but what else?

As an important Member State is leaving the Union, the Common Market for seed will become smaller

“The Congress will again provide an opportunity to take stock of all relevant activities in our different crop-specific Sections, as well as our horizontal Working Groups and Committees. Of course, in addition to these, we also make use of the Congress to report back to the wider membership on the implementation of our strategic policy priorities as defined by the ESA Board. Here, we have the implementation of the ESA Position on Intellectual Property Rights with the clarification of patentability of biotechnological inventions and resulting products, the review of the International Treaty on Plant Genetic Resources for Food and Agriculture and specifically its standard material transfer agreement and, probably most importantly, our work on plant breeding innovation in general and specifically on assuring a positive political and regulatory environment for the latest plant breeding methods. All these subjects will feature prominently on the agenda during the Congress.”

A few years ago, ESA developed the European Seed Treatment Assurance, ESTA. Has it gained trust?

“ESTA has, in the meantime, become a recognized household name for an industry-led quality assurance of seed treatment. We have just added yet another so-called ‘agent’ for the implementation of the scheme, this time in Hungary. Also, the number of seed units treated under the ESTA scheme is growing from year to year and we are covering nearly 100% in a number of species already. It is true that we still face challenges in some species and countries, but I am convinced that more and more companies will realise the value such a quality assurance system brings and demonstrates to the market, as well as policy makers. We also hope that this will be reflected in the final discussions around an EU Guidance Document for Seed Treatment and maybe also the possible review of the EU’s legislation for the authorisation and use of crop protection products.”

What is the relationship between ESA and AFCC?

“ESA has been a founding Member of Agri-Food Chain Coalition, AFCC, since 2014 and continues to strongly support this organisation, which meanwhile comprises 13 EU-level associations, all along the food and feed chain. While ESA held the Chairmanship of AFCC in 2016, a common website (www.

We share Johan's ambition to surprise consumers time after time



Johan Solleveld comes from a tomato-growing family and has been involved in variety development at Rijk Zwaan for over 30 years. Thanks to his extensive experience, and to the fact that he really speaks the growers' language, he knows exactly what to look out for when selecting new tomatoes. Over the years, Johan has gained an ever-greater appreciation of the tomato's versatility and potential. He knows that nature can sometimes have surprises in store, and how important it is to remain open to the resulting opportunities. In close collaboration both with colleagues and customers, he strives to make a valuable contribution to creating tasty new products every day.

It is Johan's ambition to surprise consumers time after time. Rijk Zwaan - a global specialist in vegetable breeding - shares this ambition. We are working together towards a healthy future. Learn more at rijkzwaan.com.

Sharing a healthy future



The ESA 2017 Annual and European Seed Trade Meeting takes place from 8 to 10 October in the beautiful capital of Latvia, Riga. The city on the border of the Daugava was founded in 1201

A nighttime photograph of the Riga skyline, Latvia, featuring the illuminated spires of St. Peter's Church and St. Nicholas' Church, with their lights reflecting in the Daugava River.

What is the role of ESA in the discussions around the Nagoya Protocol?

“At the same time, we also wanted to demonstrate our commitment to this, to making this Treaty and its ABS system work. Consequently, in 2015, we donated a sum of 300,000 euro to the benefit sharing fund as a voluntary contribution. To my knowledge, until now, this remains the only significant voluntary financial contribution to the fund. At the same time, we have always underlined that the contribution from the seed

“Nevertheless, finding a way to secure a continual, fair and workable flow of contributions of industry to the ABS fund remains a top priority objective for ESA. And we acknowledge our responsibility here. At the same time, we also underline that the main contributors need to be the contracting parties, i.e. the Treaty’s member countries.”

“As stated, the seed sector continues to become more and more an international one. Exchange of germplasm, breeding, variety development and seed production (including treatment and packaging) are increasingly taking place in different parts of the world. As a consequence, the rules and regulations of these countries become increasingly important for most seed companies. This increases the need to widen our scope of activities and improve our collaboration between different seed industry organisations and structures around the world. I would therefore foresee a more intensive exchange on all relevant levels – this not only challenges the classical repartition of responsibilities of associations, be they national, regional or international, but also requires a more integrated approach within companies in the preparation of positions and definition of priorities.”

All it takes is a 'little' perseverance

Judith de Roos

12 As of 1 July 2017, the European Patent Office (EPO) will no longer grant patents in respect of the products of essentially biological processes. As a result, the patenting of so called 'native traits' in plant breeding should no longer be possible in Europe. This is good news for all breeders who have protested for years against these kinds of patents.

• **The decision to amend** the Implementing Regulations of the European Patent Convention (EPC) was taken on 29 June by the Administrative Council of the EPO. The amendment says: European patents shall not be granted in respect of plants (and animals) exclusively obtained by means of an essentially biological process. This is completely opposite to the conclusion of the Enlarged Board of Appeal (EBA) of the EPO in the Tomato and Broccoli II case, that the exclusion in the EPC does not have a negative effect on the product claims.

Harmonisation

The Administrative Council was able to pass the amendment because it is not in conflict with the Convention and considered as an incorporation of the current interpretation of the European Directive of Biotechnological inventions (98/44/EC). This interpretation was not yet available at the time of the decision in the Tomato and Broccoli II case. The EPO represents 38 member countries and is an independent legal organisation and, therefore, not directly bound by EU legislation. However, it follows from the EPC that the relevant provisions and their interpretation shall be in full accord with the EU Biotech Directive. This is understandable because it creates harmonisation between the patents granted by the EPO and those granted by the national patent offices. Nonetheless, because the Implementing Regulations have been amended and not the Convention itself, the Enlarged Board of Appeal of the EPO needs to confirm whether the rule is considered valid and enforceable in case this comes up in a new opposition case. The Administrative Council considered in its deliberations that it is highly likely that the EBA will confirm this rule by taking into account the new information. Furthermore, in the situation where the Enlarged Board makes a negative decision, the logical response of the EPO Administrative Council would be to amend the Convention itself.

The main reason for not doing this right away is that a quick solution was needed in order to proceed with the examination of hundreds of applications concerning plants obtained by classical breeding techniques, as well as several opposition procedures that are pending. Another more challenging possibility is that the clarification given by the European Commission

Patented plants

Plants resulting from classical breeding cannot be patented anymore. But that does not mean patents in respect of plants will not be possible. As soon as a technical process, such as a technically induced change in DNA, has been used to introduce or create a new plant trait, the resulting plants could still be the subject of a patent if the trait is considered new and innovative. This patent may, however, not cover plants containing that same trait but that have been created independently by classical breeding.

about the legislative history of the Biotech Directive would be rejected by the European Court of Justice. This would be highly surprising taking into account the thorough study that the European Commission has made of the preparatory work related to the Biotech Directive. And such an outcome would not be beneficial to anyone as it will yet again put pressure on to reopen the Biotech Directive.

Back to the beginning

In 2007, discussions took place within the international seed industry about questions that were put forward to the Enlarged Board of Appeal of the EPO in two opposition procedures that we know now as the 'Tomato and Broccoli-cases'. Differences of opinion about patents in plant breeding were not new, but these cases and the possibility for associations to send their opinions by writing a so-called 'Amicus letter' made it rather concrete. As differences were influenced by the geographical and cultural backgrounds of companies, with the US as a strong defender of a self-regulated patent system without the need for specific exclusions, one common position about patentability at international (ISF) level turned out to be difficult. This probably triggered the forming of positions on a regional or even national level. By the end of 2007, not only had ISF sent in their Amicus letter, but so had ESA, Plantum and BDP. In 2009, Plantum took an overall position against the blocking effect of patents in plant breeding by stating that biological material should remain freely available for further breeding, regardless of any patent claims on the material. In other words, Plantum asked for

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Patenting native traits is no longer possible in Europe

a full breeders' exemption in patent law. This was a rather strong position and this was partly due to the fact that Plantum wanted to raise more public and political awareness about patents in the plant breeding sector. Later, Plantum took a more pragmatic approach in which the focus was shifted towards the existing exclusions of patentability. More pragmatic because this could be reached without opening the EU Biotech Directive and because it was in line with the positions taken then by ESA as well as other national seed associations, and because this received broader political support in Europe. Nonetheless, for Plantum the free availability of plant biological material has always remained a leading principle, also in other dossiers.

The Dutch government did take an interest in the subject and, in spring 2010, a study about the interaction of patent and plant breeders' rights in the plant breeding sector was published. This study, entitled 'Breeding Business', gave six recommendations; introduction of a limited breeders' exemption in Dutch legislation, evaluation of the European legislation, improvement of the quality of patents, education, enhancement of patent transparency and facilitation of an industry agreement on licensing. The Dutch parliament strongly and unanimously endorsed in

particular the recommendation to amend the EU Biotech Directive, which led the Dutch government to start discussions on a European level.

Essentially biological processes

In the meantime, in December 2010, the Enlarged Board of Appeal of the EPO published its conclusions in the 'Broccoli and Tomato case I'. They stated that the exclusion on 'essentially biological processes' refers to processes which contain or consist of the sexual crossing of whole genomes (meiosis) and subsequent selection of plants. This does not change when a step of a technical nature is used to enable or assist in this process. This decision was welcomed, but it remained unclear whether the plants resulting from such a process could also be patented, which led to new questions in the 'Tomato and Broccoli case II'. In March 2015, the EBA of the EPO finally stated that it could find no arguments to apply the exclusion on 'essentially biological processes', also to the products resulting from such a process.

This triggered a series of developments in a rather short time period, not least because at that time also farmers organisations as well as civil society organisations started to ask for a solution. The European Parliament reacted with a resolution in December

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• 2015, which called upon the European Commission
• to, amongst others, clarify the Biotech Directive in
• order to ensure the prohibition of patents in respect
• of products resulting from essentially biological
processes. In May 2016, the Dutch presidency of the
EU at that time, together with the European Commission, organised a symposium about the balance between plant breeders' rights and patents. During this symposium, the European Commission announced a set of measures to restore this balance. Attention would be paid to improvement of the quality of patents, especially by further cooperation between the EPO and the CPVO, to increase patent transparency by, for instance, the PINTO database and to encourage industry agreements, such as the International Licensing Platform (ILP) for Vegetables. But most important was a commitment by the European Commission to publish a clarifying notice about the exclusion of 'essentially biological processes'. This notice was published in November 2016 and clarified that it had never been the intent of the European legislator, when writing the EU Biotech Directive, to make patents possible in respect of plants developed by classical breeding. The interpretation was unanimously confirmed by the EU member states in February 2017, after which it was put forward to the EPO. Four months later, an amendment in the rules of the European Patent Office was made.

What happens now

There are about 300 patent applications pending at the EPO in respect of conventionally bred plants. The EPO expects that these will be handled in the coming 1-1.5 years. Patents that have already been granted will remain valid in principle, but can be contested before a national court. As this amendment is not a change of the Convention, but a new interpretation, it can be well argued that it should be applied retrospectively. The question, of course, is how eager a patent holder would be to take the risk of enforcing such a patent.

How exactly the EPO will henceforth grant claims in respect of plant related inventions remains to be seen. Plants resulting from a technical (non-essentially biological) process remain patentable, but not every trait developed in this way is innovative per se. And the claims of such a patent cannot cover parallel

developed plants by means of an essentially biological process. This should be safeguarded by means of a disclaimer, but it is unclear whether this is an upfront obligation necessary for having the patent granted or whether it is the own risk of the applicant in order to avoid invalidity proceedings at a later stage. What exactly will qualify under the definition of a technical process also remains to be seen. The Administrative Council of the EPO concluded that technically induced mutagenesis, such as CRISPR-cas9, is considered a technical process, whereas random mutagenesis is speculative and therefore not patentable. But this certainly needs confirmation in practice. On 29 November 2017, a public seminar will be co-organised by the EPO and CPVO during which the outcome of the EPO's decision and its effects in the examination practice of the EPO will be further reviewed. Of course, another important topic at the seminar will be the co-operation between the EPO and CPVO if it comes to (an exchange of) knowledge of the prior art in plant breeding. In this exchange of knowledge, the industry itself will also play an active role. In November, ESA will also have a separate bilateral meeting with the EPO, as it has organised several times before. And it is foreseen that the implications of the EPO's decision will be monitored and evaluated in 1.5 years from now, which is probably the time we need to see whether this amendment brings us what it promises.

Third countries

Nevertheless, it has to be realised that the new situation only applies to the EPO-territory and not beyond. It can well be that a patent in a third country (such as the US) can be enforced against a plant conventionally bred in the EU as soon as the plant is marketed in this third country. Patents in respect of conventionally bred plants have not gone completely and because of the international character of the seed sector, caution is certainly still required.

Finally, it is important to note that it is possible for the seed sector to realise a change in the application of policies and laws. All it takes is a strong belief in the importance of the matter, the flexibility to find a common and pragmatic approach and a 'little' perseverance.

'A palm tree in your back garden has already become quite normal'

16 Pieter van Velden

Climate change runs like a common thread through the work of taxonomist Marco Hoffman. Plants, shrubs and trees did not survive the cold winters in Northwest Europe a few decades ago. Now they are doing extremely well in our climate. "Once in a while, like in 2012, you see frost damage, but this is becoming less and less common," he says.

The Netherlands Inspection Service for Horticulture, Naktuinbouw, publishes Lists of Names of woody plants and perennials. They contain a trade summary of all crops and varieties from the Netherlands and Europe. Annually, growers, trade fairs and auctions report more than a thousand new names. "Those lists give us a good insight into the changes within the assortment," explains Marco Hoffman. For many years, he has been closely involved in research into climate change and its impact on plants.

Temperature rise

"With the exception of a rare individual, nobody doubts the change in climate that has taken place in recent decades. Especially during the last twenty years, the average temperature in Western Europe has risen alarmingly and abnormally quickly," he continues. "The winters are milder and wetter. In addition, we are more frequently affected by extremes. That this happens has been scientifically demonstrated. Climate experts just do not know yet exactly what will happen to the air currents in the summer. Will they continue to come mostly from the southwest or are they turning more towards the east? If that happens, our climate will change even more. Not to mention the rise in sea level."

At the same time, Hoffman has observed changes due to urbanization. Cities are increasing in size. In urban areas, the temperature increases even more proportionally, due to the disappearing of green and making room for bricks. It is also becoming drier there. Much precipitation disappears almost immediately into the sewers. "We need to respond with more and specific planting and green roofs that hold rainwater for longer," he believes.

Other species

The taxonomist identified which effects this climate change has on the variety of cultivated plants. Garden plants that were still well-known until the fifties as being moderately hardy, now remain outside for ten to fifteen years without any problems. If they do freeze, they are easily replaced. He has observed that growers are registering more 'softer' species for the

Climate change

According to the Intergovernmental Panel on Climate Change (IPCC), global climate change has already had observable effects on the environment. Glaciers have shrunk, ice on rivers and lakes is breaking up earlier, plant and animal ranges have shifted and trees are flowering sooner. The intergovernmental organisation of the United Nations, evaluates the risks of climate change.

Temperature: In the period 1880-2012, the average air temperature at ground level has increased by 0.9°C. Scientists forecast that global temperatures will continue to rise by 1.5 to 5°C over the next century, largely due to greenhouse gases produced by human activities. The temperature rise will not be uniform across the world. Since 1951, the increase in Northwest Europe has been twice as high as the global rise of the average temperature.

Precipitation patterns: Since 1901, the average precipitation on land has increased in countries with a moderate climate on the Northern hemisphere. Between 1951 and 2013, the increase was 14% in Northwest Europe. Worldwide, the amount of water vapour has increased due to the temperature rise. The recent trend towards increased heavy precipitation events will continue. Droughts and heat waves will become more intense, and cold spells less intense.

Sea level: Since 1901, the average sea level has increased by 19 centimetres. Since 1993, the increase has been 3.2 millimetres per year. It is predicted that the sea level will rise this century by 30 to 120 centimetres, as a result of melting land ice and the expansion of sea water as it warms. The Arctic Ocean is expected to become essentially ice free in summer by mid-century.

Wind: The strength of the western winds has increased between 1950 and 1990 in countries with a temperate climate on the Northern hemisphere. Recently, the number of storms have decreased, probably because the path of storms has shifted northwards. There are not sufficient data on frequency and intensity of hail and thunder, so no prediction can be made.

Evaporation: Potential evaporation (the evaporation when the soil contains sufficient water) has increased during the summer months by 12% between 1958 and 2013.

Growing season: The length of the growing season in the Northern hemisphere will increase by between one and two months if heat-trapping gas emissions are not reduced





It has been scientifically demonstrated that we are more frequently affected by extremes

breeders' rights examination than in the past. Such as the ornamental shrub *Viburnum tinus* or the grass *Pennisetum alopecuroides*. Of course, breeders also work on hardiness. As a consequence, these mild crops are also better suited to the Dutch climate due to breeding improvements.

But more has happened. People started to travel to Southern Europe or even further afield. They have been charmed by the plant growth in other countries and associate this with holidays. Hence, there is also more demand for exotic species, such as olives and lavender. Precisely these plants like a warm and dry climate. They are ideally suited to, for example, an urban environment combined with the warming climate. "A palm tree in your back garden has already become quite normal."

Invasive exotics

Nature responds to the shifting of climate zones, because plants also move. However, the latter happens less quickly. Nevertheless, plant species do spontaneously appear, which do not naturally belong in the Netherlands. Take, for example, Kenilworth ivy (*Cymbalaria muralis*). This small rock plant originates from Southern Europe. It has now established itself here and is found in large numbers on old city walls and on pavements. If the migration has occurred

spontaneously, then it is a natural phenomenon. But often feralisation takes place from gardens. By far most of the new species grow modestly and do not cause any economic or environmental damage.

When new species start to behave too dominantly in their new environment, they are sometimes called 'invasive exotics'. A strict policy from the Ministry of Economic Affairs must prevent the development of invasive exotics. The Netherlands Food and Consumer Product Safety Authority, which operates on behalf of the Ministry of Economic Affairs, then imposes restrictions on trade. Like most other EU Member States, the Netherlands had its own list of invasive exotics until recently.

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Implications on the sector

Since August 2016, there has been a European ban on some species on a so-called 'Union list'. This will further expand in the coming years. This is awkward because Europe has different climate zones. A plant which is designated by a southern Member State as an invasive exotic does not necessarily cause any bother in the Netherlands. Examples of these are spindle (*Euonymus fortunei*) and the box elder (*Acer negundo*). Hoffman: "Such a crop may subsequently not appear for trade, also not in the Netherlands. That is at least debatable, because it can have major consequences for the horticulture sector and for users."

Challenge

As a result of global trade, Dutch breeders are also affected by new diseases and pests. An example of this is the bacterial disease *Xylella*, which has a quarantine status. Some imported diseases survive only in greenhouses, but also more frequently outside in nature. "But it does not even have to be so extreme," Hoffman says. "We are dealing with a longer growing season. As a result, organisms stay alive for longer or an additional generation develops. This then causes a significant increase in the infection pressure. Given the decline in the use of chemical correctors, we can still anticipate a huge challenge ahead."

Changing focus from colour to eco-friendly to crunchiness

Monique Krinkels

18 When, in 1968, the triumph tulip 'Ile de France' was added to the Classified List of the Royal General Bulb Growers' Association, it was the cardinal colour and the sturdy stem that stood out. Thirty years later, the flower proved to fit well in an organic growing system. Today, nearly fifty years since it was first introduced, a famous chef admires its crunchiness and chestnut-like taste. Niche marketing 2.0.

It is unlikely that Jan Blom from Blom & Padding in Beverwijk, the Netherlands, could have foreseen that the vivid red tulip he bred would end up as a tasty side-dish, a snack and a liquor. In nearly fifty years of its existence, 'Ile de France' has proven to be more than just a colourful and strong addition to the flower assortment.

Choosing organic

In 1996, a group of bulb growers decided to drastically change their modus operandi as the 'normal' cultivation of flower bulbs belongs to the most polluting activities in agriculture. Instead of using crop protection chemicals and fertilizers, they opted to produce organically grown bulbs. "Today, we have six members with in total 35 hectares of flower bulbs," says Jan Timmerman, Chairman of Biobol, the association of organic flower bulb growers. "And we may very well double in size next year," he predicts. The Biobol members do not only grow tulips, but also hyacinth, narcissus, crocus, dahlia, gladiolus, muscari and many other species. "We strive to broaden our assortment as widely as possible."

All in all, it is not easy growing eco bulbs. It demands true craftsmanship to cultivate a crop without the use of chemistry. "If a disease occurs or insects appear,

there is not much that we can do about it. Furthermore, the limited availability of nutrients from manure causes the yield to be lower than in traditional growing systems. The retail price of an organic bulb is therefore at least 30% higher."

So far, breeders have not focused on organic cultivation and information whether cultivars are suitable to organic production is scarce. Proeftuin Zwaagdijk has tested several tulip cultivars, but for many other flowers this is still an

unknown territory. One of the approved tulip cultivars is the flaming red 'Ile de France' which has proven to be hardy and very reliable.

Growing popularity

The market for organic ornamentals is expanding. "Especially in Switzerland, Austria and Germany,



Together with Oos Kesbeke, chef Jonnie Boer developed the pickled tulips

consumers prefer bee-friendly flowers in their gardens. And the same goes for bouquets. Annually, 2 million organic tulip flowers are sold. But also, more and more landscapers are choosing organic products as local governments have become more aware of their responsibility for the environment."

In other western European countries, such as Scandinavia and the Netherlands, the interest of the consumers in organic ornamentals is steadily growing. "Several retail chains have been testing whether people want to pay that little bit extra for an eco-product. That seems to be the case, as a large supermarket chain and garden centres have chosen to sell our products."

Especially since the commotion started about the decline of bees, many people have been paying extra attention that the plants in their gardens offer healthy



'Ile de France', a flower bred in the sixties, has evolved to a side-dish, a snack and a drink



At De Librije, tulips are served as a 'vegetable' combined with oysters (photograph Thomas Ruhl)

nectar for bees and butterflies. The cities of Amsterdam and The Hague, in the Netherlands, decided recently to use only organic flower bulbs. "But it is still a niche as only 0.1% of the area with bulbous flowers is grown organically," says Jan Timmerman. One of the problems the Biobol members encountered with organic production is that the flower bulbs, especially those of tulips, easily absorb remaining chemicals from the soil, as well as from the wood of the pallet boxes. "To produce chemical-free bulbs, new boxes are therefore required," explains Jan Timmerman. "But our bulbs are checked regularly whether they are truly organic. Our members are all Skal certified companies. Skal is the designated Control Authority responsible for the inspection and certification of organic companies in the Netherlands."

A niche in a niche

An unexpected angle has increased the potential of the organic flowers. "One day in 2012, I received a phone call from the famous chef Jonnie Boer," tells Jan Timmerman. "He and his wife Thérèse are the owners of De Librije, a renowned restaurant with three Michelin stars. He wanted to know whether I could deliver organic tulip bulbs. And of course we can, but I never imagined our tulips could become food. It is a new niche inside the organics niche." He wondered why someone would chose to use tulip

bulbs as food, as they have a bad name as a source of nutrients in the Netherlands. At the end of the Second World War, during the so-called 'hunger winter', people in the cities were starving. Due to strikes and blockades, food transport across land had become impossible and the rivers were frozen over. Tens of thousands of people died and only the lucky ones found tulip bulbs to eat. Today, many of the elderly still remember the sweet sickly and slightly bitter taste of the meals in their teenage years.

But that does not go for a freshly harvested 'Ile de France'. Due to its densely formed bulb, it is crunchy and it has a delicate chestnut-like taste. "Jonnie breaks the bulbs apart, to obtain a shell shaped 'vegetable' and combines it in a dish with codfish and blue cheese, but also with crabmeat. The tulip bulbs are prepared at a low temperature to remain crispy," explains Jan Timmerman.

A year ago, a brand new product entered the market. Together with Kesbeke, an Amsterdam company specialized in gourmet pickles, Jonnie Boer developed 'pickled tulips', a smaller sized tulip bulb preserved in vinegar, with mustard seed, peppers and other spices. It can be eaten as a snack, but also combined in a dish where its chestnut-like taste blends in nicely. It gives the song 'Tulips from Amsterdam' by Max Bygraves a whole new meaning.

Other entrepreneurs saw the promising qualities

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From colour to eco-friendly to crunchiness



Vodka distilled from flower bulbs has a floral aroma

of tulips as well. Last year, the company Veld introduced tulip vodka. “It started out as a hobby,” says Wouter Vos. “Together with Marcel Vosse, we distilled vodka from fruits and grains. But others had done the same before and we were looking for something new. Then, all of a sudden, we realised that, as vodka can be made from anything that contains starch, our famous Dutch tulips could be a candidate, so we began experimenting.” According to USA law, vodka should be colourless, odourless and flavourless. A bartender once described the flavour of vodka in general as ‘watered down nail polish remover’. But that does not go for Veld Vodka. “It has a floral aroma, one recognises the tulip in it, with a little radish-like aftertaste,” says Wouter Vos. “It is therefore best to drink it pure, but of course you can also mix

it, for instance, with red vermouth, Angostura or Amaro.”

The tulips are grown by John Huiberts, one of the members of Biobol. The harvest of 2016 was the first vodka that was for sale in several liquor stores, hotels and restaurants. The production takes place in distillery ‘De Tweekoppige Phoenix’ (the two-headed phoenix) of Arthur Kruijt. As tulip vodka is a seasonal product, this year’s produce will become available in October.

“Most importantly is that our tulips have a story; they are not a mass-produced commodity,” says Jan Timmerman. “We care about nature and the environment. We have ample crop rotation, use natural manure, green fertilizers and nutrients based on seaweed. And our organic product can be used as garden plant, bouquet, food or beverage. This tulip has many niches.”

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Expectations of revision based on dreams or on reality

Anke van den Hurk

- 22 The member countries of the International Treaty on Plant Genetic Resources for Food and Agriculture (IT PGRFA) are planning to amend the Standard Material Transfer Agreement. So far, 23 companies have agreed on conditions upon which they will be ready to pay a regular financial contribution under a subscription system to the Benefit-Sharing Fund of the IT PGRFA.
- **The Governing Body**, the decision-making body, of the International Treaty on Plant Genetic Resources for Food and Agriculture (IT PGRFA) will meet in October/November 2017 to discuss and agree on a package of measures to get more financial benefit-sharing, as well as more genetic resources available under a Standard Material Transfer Agreement (SMTA).
 - For the package, the following elements of improvement have been envisaged:
 - More predictable monetary benefit-sharing through a new SMTA for the exchange of genetic resources;
 - More genetic resources available in the system and extension of the list of crops that can be accessed under the system; there is a wish to put more vegetables on the list;
 - Direct financial contributions by countries to raise sufficient money every year for the Benefit-Sharing Fund.
 - The package will be negotiated by the member countries of the IT PGRFA, so stakeholders are only participating in the process to provide the relevant information. To assist the countries in decision making, 23 companies signed a declaration in which they announced under what conditions they will be ready to pay a regular financial contribution under a subscription system to the Benefit-Sharing Fund of the IT PGRFA.
 - The developed world received the declaration positively, while the developing countries, in general, were less supportive. So now, it is up to the parties to decide if they go for the lower income than expected or hoped, but get commitment from the seed sector, or go for their own expectations and then hope that the seed sector will commit. In case of the latter, the higher the payment rates and the more obligations to use genetic resources, the lower the chance that breeders will commit themselves.

History of SMTA

In 2004, the IT PGRFA came into force. The goals of the treaty are to conserve plant genetic resources, to use plant genetic resources in a sustainable manner and to share the benefits that arise from the use of plant genetic resources. In 2006, a standard contract, the Standard Material Transfer Agreement, was agreed upon, a contract that arranges the obligations

to exchange plant genetic resources that are in the so-called multilateral system of the IT PGRFA. In the multilateral system, in principal, 64 crops are included that are included in Annex I of the IT PGRFA. In the SMTA, you have the choice of two payment options into the Benefit-Sharing Fund. The first one is based on access and may be voluntary or obligatory. It is obligatory when varieties developed with the accessed plant genetic resource are not free for research and breeding, and it is voluntary if those varieties are free for research and breeding. The second one is based on a subscription system, where you pay a sort of membership fee upfront.

Reason to revise SMTA

After seven years after implementation of the SMTA, in 2013, parties to the IT PGRFA concluded that the current SMTA did not fulfil the expectations. On the one hand, the money for the Benefit-Sharing Fund was less than expected and, on the other hand, exchanges have been limited due to the lack of availability as well as the fact that a lot of crops are not included in the multilateral system.

The lack of sufficient financial contributions into the Benefit-Sharing Fund is probably due to several factors. First of all, the subscription model in the current SMTA is not a real option as it is far too expensive. Furthermore, it is due to the fact that plant breeding takes a long time, so the first results could only be expected after eight to ten years after first signing the SMTA. Lastly, a lack of financial contributions is due to the fact that most varieties developed are free for research and breeding. Voluntary contributions directly based on use have not, or hardly, been made yet.

However, this does not mean that benefit-sharing is not taking place. Many voluntary contributions are provided by the seed sector. Unfortunately, the voluntary contributions from the seed sector, including the breeders' exemption, have not been really valued. It is yet to be realized that non-monetary contributions probably provide many more benefits than financial contributions ever would.

Issues at stake

The discussion that started to improve the multilateral system of the IT PGRFA is focusing on other

Anke van den Hurk is deputy director at Plantum, Gouda, the Netherlands



An amendment of the SMTA should ensure more financial benefit-sharing, as well as the availability of more genetic resources

payment mechanisms to create a sustainable and predictable income to the Benefit-Sharing Fund, as well as on the extension of the Annex of the IT PGRFA. The developing world is of the opinion that the payment obligations should go up and do not see a need, at this stage, for the extension of the list with crops, nor extending more availability of the current crops, while the developed world is asking for a realistic payment mechanism in a package with extension of the list and more genetic resources in the multi-lateral system. Even though the seed sector is not a negotiating party, it is the seed company or breeding institute that decides whether to sign the contract or not. If the requirements are unrealistic and do not make sense businesswise, it most probably will not be signed. Most companies and organisations still have sufficient genetic diversity in their own collections to continue breeding.

Declaration by the seed industry

To provide support and further information, 23 plant breeding companies signed a declaration in which they indicate supporting a further improvement of the multilateral system, showing their readiness to provide a yearly subscription fee under certain conditions. The conditions relate to payment rates, the need for different payment options, recognition of the breeders' exemption and exhaustion of obligations for payment, use and transfer of materials. The declaration was provided to help the decision-makers

to understand what may be expected from the seed sector, and what contractual elements are required to make business sense.

The declaration was handed over by Jean-Christoph Gouache as representative of the signing companies during a meeting of experts on the topic from 5-7 September in Rome. He gave explanations about the reasons for the declaration. Moreover, he responded to the questions that were posed by Parties and NGO's.

Some countries found it helpful to understand the business needs, others were less receptive, as they feel that the benefit-sharing should be much higher and should also cover the historical use.

October meeting

So, during the preparation meeting of 5-7 September, experts shared a lot of information, and the industry indicated what would make economic sense to be able to sign a new SMTA. The opinions of the experts were still far apart and there was no readiness for compromises yet. So, the outcome of the Governing Body still remains a surprise and whether they will come up with a realistic SMTA that companies will sign, based on proposals to extend the Annex of the IT PGRFA, or whether they will come up with a new SMTA based on dreams that companies most probably will not sign.

The downfall of a glorious garden plant

Monique Krinkels

24 It was a shock when the Finnish Food Safety Authority, Evira, confirmed last May that an orange Petunia named 'African Sunset' contained a foreign gene. While the plant is absolutely harmless, the fact that it was genetically engineered was enough to demand destruction of all material. Five months later, the list of GE-Petunias has grown considerably.

• **Over 100 varieties of Petunias** should be destroyed immediately, ruled the French 'Ministère de l'Agriculture et de l'Alimentation' on 1 August 2017. According to an investigation, all these varieties contain DNA that has been inserted in Petunia by genetic engineering and are, therefore, not allowed on the EU market. The ripples in the pond caused by a Finnish stone have not yet disappeared.

Loving colours

Since the eighties, researchers have been eager to experiment with flower colours. They discovered which processes determine the colour of the plant and which genes are involved. That made modification of flower colour by sophisticated regulation of flower-pigment metabolic pathways possible. It resulted, for example, in a blue carnation (1995), a blue rose (2004) and a blue Petunia (2014), of which the first two are grown outside Europe. The main pigments targeted for flower colour modification are anthocyanins that contribute to blue, for instance. It is therefore easy to understand the enthusiasm with which Peter Meyer and his colleagues Iris Heidmann, Gert Forkmann and Heinz Saedler at the Max Planck Institute in Cologne, Germany, described the first orange Petunia in nature on 17 December 1987. "The Petunia mutant RLO1 served as a recipient for the transfer of the A1 gene of *Zea mays* encoding dihydroquercetin 4-reductase, which can reduce dihydrokaempferol and thereby provided the intermediate for pelargonidin biosynthesis. Transformation of RLO1 with a vector p35A1, containing the A1-complementary DNA behind the 35S promotor leads to red flowers of the pelargonidin-type. Thus, a new flower pigmentation pathway has been established in these plants," they wrote.

To be honest, the result was a Petunia with a rather more salmon than orange colour, but it was nevertheless notable. The 30,000 Petunias that the team planted in a trial were the first transgenic plants ever released into the field in Germany. Their find attracted attention and the Dutch company, Sluis & Groot (today part of Syngenta), licensed the technology and started to breed a true orange Petunia. It took the s&g researchers several years, but in 1995 they reported having a vivid orange Petunia that could have become the parent of a successful new

breeding line. However, that was not to be, as at the time the public did not endorse genetic engineering and environmental groups systematically opposed any introduction. s&g therefore decided to end the research programme. The Max Planck Institute as well as s&g believe that, at the time, they had wiped out all remaining plants and seeds.

Discovery

The story could have ended there but unfortunately, somewhere in the process, some Petunias or seeds survived and the introduced A1 gene of *Zea mays* somehow made a come-back into the breeding of Petunia. They were discovered in 2015 by the Finnish biologist, Teemu Teeri, when walking by a planter at Helsinki Central Railway Station. The orange Petunias reminded him of an experiment he had read about thirty years before. Today, Professor Teeri is working at the Viki Campus of the University of Helsinki. His research includes the exploration of gerbera secondary metabolism, for example, regulation of anthocyanin pigmentation.

Professor Teeri reported his encounter at the Finnish Food Safety Authority, Evira, who had the plants analysed. They concluded that the Petunias were the variety 'African Sunset' and that they contained a maize-gene. Besides the maize gene, they also had the antibiotic resistance gene *nptII*. Not only 'African Sunset' was involved; eight other varieties from several breeders were also identified as being genetically modified.

"It was not that these Petunias posed a danger to either human or animal health, nor that they would spread spontaneously into the wild in the countryside," says Thijs Simons, policy officer at the Dutch seed association, Plantum, and spokesperson for the breeders involved in the orange Petunia case. "The problem is that the breeders had not applied for market authorisation. Quite obviously not, as they were unaware of the foreign genes."

Destruction

As soon as it was confirmed that the orange varieties were GMOs, the flower auction in the Netherlands, Royal FloraHolland, stopped auctioning these Petunias and the breeders warned their customers not to sell them on the market. The Petunias were



The more rare a plant is, the more we love to have it in our garden

not only banned in Europe, but also in the USA. “The construct is well known in the USA. It has been comprehensively tested and was declared safe by the Environmental Protection Agency (EPA) as well as the Food and Drug Administration (FDA) and the U.S. Department of Agriculture (USDA). It would have been a fairly simple process for someone to apply for market authorisation. Even in Europe, it would not be too hard, I believe, but I don’t expect any application will be made.”

There are, however, still Petunias in private gardens. “The GE-Petunias are not frost-hardy and neither the plants nor their seeds will survive a European winter.” Orange has become a popular colour for Petunias. As the pigment is rare, it is a much sought-after characteristic. So, will the customers not be disappointed if they cannot buy orange Petunias anymore? “That will not be a problem as there are several orange Petunias that are natural mutants. The ‘Cascadias Indian Summer’, for instance, by the Israeli company Danziger, is orange and not a GE-Petunia.”

Blame

The main question that arises is how it is possible that a GE-Petunia became a parental line in several breeding programmes by at least ten companies. “We believe it has all happened in good faith,” according to Thijs Simons. “Once a Petunia is part of a breeding programme, no one will scrutinise its ancestry. During the DUS tests, the officers won’t look whether

a plant is genetically modified or not, as that is not their role.”

Even the specialists among the breeders were not alarmed. This spring, the Petunia x hybrida ‘MyLove Orange’ by the Italian company, Farmen, was elected a 2018 Gold Medal winner by Fleuroselect. It was described as ‘the first male sterile Petunia that is resistant to cold and hot temperatures. Thanks to its extraordinary branching habit, this Winner can be grown in plugs or in the pack without pinching or the use of growth regulators, at lower temperatures than other Petunias. The vibrant colour will appeal instantly to the consumer, who will adore this Jasmin-scented Petunia.’ The variety was hastily withdrawn when it was discovered to be one of the GE-Petunias. The fact that even at the Fleuroselect trial fields, where the expertise of the judges is undisputed, the vibrant orange colour did not raise any questions underlines how difficult it is to detect a genetically modified plant. It means that companies have to be much more aware of the importance of keeping track of the ancestry of their varieties. If only to prevent the destruction of thousands upon thousands of beautiful plants.

CPVO is looking for alternative examination offices

Monique Krinkels

26 When the United Kingdom leaves the European Union on 30 March 2019, the European Plant Breeders' Rights will no longer cover Britain. Furthermore, CPVO will have to find alternative Examination Offices for the 864 botanical taxa that have been entrusted to British researchers. How best to prepare for the time when the United Kingdom becomes a third country?

It is less than one and a half years away, but the consequences of Brexit are still obscure. The discussions about the content of the withdrawal agreement have just started. What has so far been established is that at midnight between 29 and 30 March 2019, all Union primary and secondary laws cease to apply to the United Kingdom. It will end a period of 25 years that Community Plant Variety Rights also covered Britain.

Seamless transfer

Last year, the Community Plant Variety Office (CPVO) in Angers, France, received 3,299 applications for Plant Breeders' Rights – of which 96 came from the UK – and 2,980 new titles were granted. It was an all-time record, CPVO President Martin Ekvad proudly noted in the organisation's Annual Report. In total, over 25,000 varieties are protected by Community Plant Variety Rights. But will that protection still be valid in Britain after

30 March 2019? In a press release last July, Ciopora's Secretary General, Edgar Krieger, proposed 'that all EU-protected varieties should be seamlessly transferred to UK territory for the complete duration of the title period that was originally granted.'

"We have already started to discuss this problem with the CPVO and the EU Commission," says Garlich van Essen, Secretary General of the European Seed Association, ESA. "In our view, the rights of all varieties that are registered in the Common

Catalogue should remain valid in the UK. During the exit negotiations, the EU will probably demand that the UK will not dismantle the legitimate rights of breeders. But how it will be done, nobody knows as yet. It is basically the responsibility of the UK to organise it."

DUS testing

After 30 March 2019, the Examination Offices in the United Kingdom will no longer conduct DUS tests for Community Plant Variety Rights as that is reserved for institutes within the European Union. DEFRA, the British Department for Environment, Food and Rural Affairs, has appointed three Examination Offices where the Distinctness, Uniformity and Stability of new varieties are established during a one- or two-year period. They are entrusted with 864 botanical taxa, for 678 of which no other Examination Office has been assigned in the EU. So far, the CPVO has received applications for 324 botanical taxa that are solely tested in the UK. In order to ensure the continuity of the technical examination, CPVO has organised a procedure called 'the new species procedure' to ensure that the technical examination of these species will not be hampered by Brexit. Breeders will be informed about the new Examination Offices for the respective species. A subsequent procedure to include additional botanical taxa may follow later.

At the moment, seven European institutes are negotiating with CPVO to take over the 864 botanical taxa that have been entrusted to respectively the National Institute of Agricultural Botany (NIAB), Cambridge, England, Science and Advice for Scottish Agriculture (SASA), Edinburgh, Scotland and Agri-Food Bioscience Institute (AFBI), Crossnacreevy, Northern Ireland. "It is a mega exercise," says Bert Scholte, head of variety testing at Naktuinbouw, the Netherlands, which is one of the candidates. "Not only do we need to bring in the expertise in the 678 crops that were covered in Britain, but we also need to build up a reference collection. Next year will be a transitional year, but by 2019 we will have to be ready to cope with all technical examinations of the applications formerly done in the UK."

For British breeders, it will become more difficult

CPVR applications filed in 2016

EU		
	Netherlands	1281
	France	466
	Germany	395
	Denmark	100
	United Kingdom	96
	Italy	81
	Spain	70
	Belgium	48
	Austria	20
	Poland	18
	Sweden	16
	Czech Republic	15
	Hungary	6
	Ireland	5
	Greece	2
	Slovenia	2
	Romania	1

Total 2622

Non-EU		
	United States	302
	Switzerland	168
	Israel	54
	Japan	45
	Australia	21
	Thailand	21
	New Zealand	16
	China	11
	South Africa	8
	Canada	6
	Serbia	5
	Taiwan	5
	South Korea	3
	Mexico	3
	Brazil	2
	Argentina	1
	Belarus	1
	Chile	1
	Costa Rica	1
	Norway	1
	French Polynesia	1
	Uruguay	1

Total 677

10 most important fruit species

<i>Prunus persica</i> (L.) Batsch	48
<i>Fragaria x ananassa</i> Duchesne ex Rozier	26
<i>Malus domestica</i> Borkh.	42
<i>Prunus armeniaca</i> L.	24
<i>Vitis</i> L.	16
<i>Vaccinium</i> L.	10
<i>Rubus idaeus</i> L.	13
<i>Rubus</i> subg. <i>Eubatus</i> sect. <i>Moriferi</i> & Ursini	5
<i>Prunus salicina</i> Lindl.	7
<i>Prunus avium</i> (L.) L.	4
All fruit species	243



to apply for Community Plant Variety Rights as that is only open to EU residents. Companies that do not have an establishment within EU territory or persons who are not domiciled in it should designate a procedural representative to comply with the provisions in the CPVR regulations. Royalty Administration International CV is by far the largest procedural representative with 249 applications in the EU last year and over 600 in the thirty other countries where

if these rights will be honoured completely. So, from a breeder's point of view, all varieties that have Community Plant Variety Rights obtained before 30 March 2019 should be registered automatically in the UK. After Brexit, the costs of applying for plant breeders' rights might double unfortunately. That goes for the British breeders and for the EU breeders, as protecting a variety only in Europe or only in the UK is not very rational."

10 most important ornamental species

<i>Rosa</i> L.	185
<i>Chrysanthemum</i> L.	117
<i>Hydrangea</i> L.	64
<i>Phalaenopsis</i> Blume and <i>xDoritaenopsis</i> hort.	51
<i>Calibrachoa</i> Llave & Lex. and <i>Petunia</i> Juss.	50
<i>Lilium</i> L.	50
<i>Pelargonium</i> L'Hér. ex Aiton	43
<i>Dianthus</i> L.	35
<i>Gerbera</i> L.	30
<i>Anthurium</i> Schott	30

All ornamental species 1396

10 most important agricultural species

<i>Zea mays</i> L.	201
<i>Triticum aestivum</i> L. emend. Fiori et Paol.	153
<i>Brassica napus</i> L. emend. Metzg.	126
<i>Helianthus annuus</i> L.	86
<i>Solanum tuberosum</i> L.	79
<i>Hordeum vulgare</i> L. sensu lato	69
<i>Triticum durum</i> Desf.	26
<i>Beta vulgaris</i> L. ssp. <i>vulgaris</i> var. <i>altissima</i> Döll	21
<i>Lolium perenne</i> L.	14
<i>Avena sativa</i> L.	11

All agricultural species 939

10 most important vegetable species

<i>Lactuca sativa</i> L.	192
<i>Solanum lycopersicum</i> L.	127
<i>Cucumis melo</i> L.	80
<i>Capsicum annuum</i> L.	65
<i>Cucumis sativus</i> L.	45
<i>Allium cepa</i> (Cepa group)	25
<i>Pisum sativum</i> L.	13
<i>Phaseolus vulgaris</i> L.	13
<i>Cichorium endivia</i> L.	10
<i>Spinacia oleracea</i> L.	7

All vegetable species 721

this bureau is active. RAI-director Maarten Leune: "It seems no more than logical that existing breeders' rights will remain in force in the EU as well as in the UK after Brexit. Breeders have obtained plant variety rights that cover all of the present 28 Member States and it is only fair

wide, that is not a nice prospect."

Fair warning

CPVO does what it can to avoid transitional difficulties as much as possible. "Nevertheless, we also need to remind stakeholders that preparing for the withdrawal of the United Kingdom is not just a matter for European and national administrations, but also for private parties. Breeders may thus be required to monitor the developments, adapt processes and to consider the changes described above," warns the CPVO.

KeyGene tackles brains overflow

Monique Krinkels

28 A human brain can only process so much information. Selection in a greenhouse filled with hundreds of plants is donkey work. And yes, there are graphs, statistics and photos available, but many breeders prefer also to observe the 'look and feel' of a new plant. KeyGene's new VR greenhouse presents statistics as well as plants, allows for time travel and international cooperation.

• **"And on the left** you can see our new greenhouse," says Arjen van Tunen, CEO of KeyGene. I bent over to look down from the window, my hands resting on the balustrade. But there is no balustrade and I anticipate a drop to the floor below. Besides giving me palpitations, nothing happens. Fortunately, I am not on the first floor of KeyGene's office building, but in the virtual reality welcome room. It is shocking how realistic the experience is. One moment you are in a stuffy office, the next you find yourself in the middle of a greenhouse, where on the one side graphs and statistics are floating in the air and on the other side 3D images of plants rise up from the sandy floor. The difference: a virtual reality headset and an ingenious computer programme.

Data overflow

It all started two years ago. "Our PhenoFab, where we analyse phenotypic variation, generates loads of information. Every day, every plant is photographed from all angles, producing hundreds of thousands of photographs. We screen for a whole range of traits in which the breeders are interested. The results are summarised in a report and for some people that works out fine. But most people prefer a visualised result. That is where our Virtual Reality Breeding Tool comes in," explains Marco van Schriek, team leader Digital Phenotyping & Greenhouse. "Imagine you have a pile of photographs of different people and someone asks you to sort out the ones wearing glasses. You have to browse through the lot, one by one, to decide which are the ones with glasses. If the same group of people would be standing in a

room, it would take only seconds to divide the two groups. When comparing tomato plants with so many different traits, the difference between the prints and seeing the virtual plants in our greenhouse is even more convincing."

As a fervent gamer, Marco van Schriek had experience with virtual reality. Today, virtual reality gear is mainly used to play games. "Only architects and designers use it professionally," he says. That is when he realised what VR could mean for breeders. He and colleague Rudi van Bavel started experimenting to support breeding with virtual reality and software that is used to create an environment. "Building a greenhouse was fairly simple once I had got the hang of it, but the addition of a high amount of photographs of the plants was a real challenge."

It did not take long before they presented their out-of-the-box idea to Arjen van Tunen, who immediately saw the opportunities it offered. After that, things moved quickly. Together with Christiaan Biemond, business developer digital phenotyping, and the software developers of the company, they have built a new, dedicated world wherein breeders can easily discern the differences between the plants of a new generation.

Big data

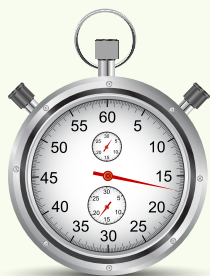
In hindsight, the development of the Virtual Reality Breeding Tool is a logical next step to PhenoFab, a greenhouse service operation that combines high throughput, non-invasive technology with trait interpretation to exploit phenotypic variation. Six years ago, KeyGene was one of the first companies that embarked on automated and robotized phenotyping in the agricultural area. It produces an enormous amount of information.

"A single research project within our digital phenotyping facility with, for example, 1,000 plants generates a huge amount of data. The 1,000 plants will be captured in nine images a day, seven days a week and for five weeks straight. That means that after one experiment over 300,000 digital images have been produced which have to be analysed and its data handed over to the customer. This is truly big data! It requires a complete new approach to data handling and reporting," explains Arjen van Tunen. The cost of the virtual reality hardware is limited.

KeyGene

KeyGene was founded in 1989 by a number of Dutch seed companies. Their goal is to create synergy and higher efficiency in their molecular genetic research programmes and thus improve the breeding effort. At the time of its foundation, KeyGene employed three people. Since then, KeyGene has grown continuously and several times it has had to expand its facilities considerably. Today, KeyGene employs over 150 people. The company has four strategic shareholders active in the field of vegetable breeding: Enza Zaden, Rijk Zwaan, Vilmorin & Cie and Takii & Co.

The Virtual Reality Breeding Tool helps breeders to easily compare and select plants. Curious how the virtual greenhouse looks like? See for yourself: https://youtu.be/ou5_Q1mMLZs



An eye transmits data to the brain at the rate of 10 million bits per second



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A virtual conversation

“Do you see how much these tomato plants have grown since last week,” breeder A asks. “So much better than those of last year, as you can see on the left,” says breeder B. “I’ll show you the pictures from the moment this plant germinated.” A: “Let’s make a new filter. See how well-developed these roots are compared to the other plants.” B: “Can you link the results with the genetic profile of the plants?” A: “Of course, just wait and see.” B: “That is truly amazing. We should ask our colleague C from France to join us and have a look,” proposes A. “Good idea, and tomorrow colleagues D and E in Monterey, California, might want to compare notes. I wonder which plants they will prefer.”

“The headset and hardware costs a few thousand euros. The data handling however is another thing. For a single person to handle more than 80 gigabytes of data real-time is a true challenge!”

We want more

The Virtual Reality Breeding Tool was introduced and demonstrated last January at the Plant and Animal Genome conference in San Diego. At the Crop Innovation & Business Conference in Amsterdam held in April, the Virtual Reality Breeding Tool was explained by KeyGene’s CEO Arjen van Tunen. The tool was also demonstrated to the CEO’s and R&D directors of the four shareholders: Enza Zaden, Rijk Zwaan, Vilmorin & Cie and Takii & Co.

“It is remarkable how easily people get used to a virtual greenhouse. For the young, it resembles the gaming environment they are already familiar with. But even if it is the first time, you can find your way almost immediately,” says Marco van Schriek. That is also my experience. It really does feel like natural

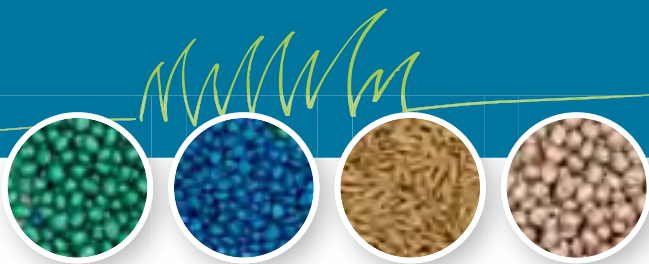
surroundings. The windows of the greenhouse were opened when I visited KeyGene, as it was a bright and sunny summer day. Even the fact that there are floating screens around you does not disturb the feeling of naturalness.

“Of course, there are breeders who find it too modern. They prefer written reports with graphs, statistics and photos and, if so, we can provide them with it. But most breeders react enthusiastically to the possibilities it offers. The most common feedback is that they want more: visualisation of the influence of weather and seasons, video instead of photographs, open field besides the greenhouse; their demands were quite overwhelming. And, of course, we continue to improve the software programme.”



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VanDinter Semo
SEED & SERVICES

Monique Krinkels

Since spring this year, the first hybrid potato named 'Oliver Fr' has been on the market. Unlike other potato varieties, buyers will receive a package of seeds instead of several boxes with seed potatoes. Earlier experiences with onions, shallots and strawberries ascertained that the transition is not easy. The question is whether farmers will adopt true potato seeds.



Seeds are ideal as a starting material. Compared to cuttings and tubers, no diseases can be transmitted by seeds, phytosanitary barriers are therefore limited, they can be stored for years and transport is easy. And hybrid varieties add quite a few extra benefits, not least that desirable traits can be crossed in quickly. But when farmers are used to planting cuttings or seed potatoes, their work process will be turned upside down completely. A new business model is needed.

Gourmet strawberry

"We started to develop a strawberry that could be grown from seeds in the late seventies," says Gé Bentvelsen, CEO of ABZ Seeds. The name of his company literally means strawberries from seeds. "At the time, my predecessor, Wim Sterk, was breeder at Zaadunie, nowadays part of Syngenta. The company had open pollinated varieties of *Fragaria vesca*, the European wild strawberry, as a garden plant. It was a nice herbaceous soil covering but also a treat for gourmets, as the taste is exquisite. And it was a diploid, making hybridisation fairly straightforward."

"At Zaadunie, breeders could spend 10% of their time on projects they favoured themselves. A drawback of *Fragaria vesca* is that the fruits are tiny, so the idea arose to create hybrid strawberries of *Fragaria x ananassa* Duch, an octaploid

ers adopt new production



As the potato chain is well organised in Europe it will be difficult to convince breeders to use true seed potatoes

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that is commonly used as consumption strawberry. Together with the former R&D director, Jasper Veldhuijzen van Zanten, we bought the breeding programme from Zaadunie in 1993,” Gé Bentvelsen explains. “It took us nearly twenty years to obtain stable parent lines. In 1995, we had the first prototype F1 variety for fresh strawberry production.” But in the year 2017, many strawberry growers still prefer using cuttings. “Even though our varieties have a significantly better taste. It is partly due to the fact that strawberries from seeds are no common practice in the industry of commercial fruit production and, of course, growing the variety Elsanta is much cheaper, as after 35 years, it no longer has plant variety protection.” Since propagation from seed is common practice in the bedding plant industry, the varieties of ABZ Seeds have found their way to garden centres. “Nowadays, we have thirteen varieties to be used as garden and patio plants.” In the show garden of Holland Strawberry House, he demonstrates the colourful examples, with the traditional white flowers, but also in pink, deep rose and red, some meant for hanging baskets, others for pots and open soil. He even developed a strawberry whose fruits grow upright for easy transport and eye-catching presentation in the garden centres. Delizz® It was the first strawberry ever to be awarded with the All America Selection. “It seamlessly fits in with the trend to eat from your own garden.” Besides these, he also has several varieties

for commercial fruit production, to be used year-round in either greenhouses, table top or open field. “Most of our Dutch customers sell the strawberries directly to consumers or to restaurants. In other continents, the strawberries from seeds are quickly gaining popularity, as high-quality cuttings are not available. Japan, Australia, United States and South Africa have become important markets for us and the end is not in sight.”

Difficult process

In the nineties, Bejo was the first worldwide to introduce shallots from seeds. Earlier, they had done the same with onions. It took at least five years for growers to accept the novel procedure. And this year, the first variety from true potato seed was launched. “Oliver is intended for the countries where healthy seed potatoes are not available. Our market strategy is to focus on Asia, Africa and Central America,” says crop manager Rien van Bruchem. “Farmers in these countries depend on their own selection and propagation to grow potatoes. The costs are low, but the yields are disappointing and, frequently, threatened by diseases.” So far, Bejo stays away from the European market. “The potato chain is well organised here,” he states. “It is very efficient to produce potatoes from seed potatoes. Growing potatoes from seeds would be more costly and involve more work. And the logistical advantages are minimal, as Europe is relatively small. Furthermore, germinating would be a problem as the temperatures

are too low. Just as with cabbages, the seeds should be planted in a greenhouse and later bedded out as plantlets, making the production process more complicated. It will be difficult to convince European farmers to change from seed potatoes to true potato seeds,” he expects. Hein Kruijt, CEO of Solynta, does not agree. He foresees a growing market for true seed potatoes. In August, he presented a new breakthrough: a potato with a double resistance against *Phytophthora infestans*. “This potato disease causes many billions worth of damage worldwide and is a serious threat to food production. Up to now, farmers have only had one option to save their crop when the plants become infected: spraying heavily and frequently with a chemical pesticide. It took us only two years to breed a hybrid potato with late blight resistance.”

Social impact

This autumn, the Rathenau Institute will start research on the impact of the introduction of true potato seeds. The organisation was founded by the Dutch government to stimulate public and political opinion forming on social aspects of science and technology. Researcher Rosanne Edelenbosch focuses on responsible research and innovation (RRI) in the potato sector. She has developed several scenarios, which will be discussed by social scientists, ethicists, technicians and people from the potato sector. To be continued.

Don't waste your efforts

Steven Groot

32 Seed quality is of major importance for the start of a crop and its productivity. Rapid emergence results in early seedling establishment and better competition against weeds. A faster growing root system enables a better uptake of nutrients. Proper storage proves to be a key factor in maintaining seed quality.

Seed companies put considerable efforts into optimising seed production, harvesting, drying and cleaning to provide their customers with good seed quality. Unfortunately, rather less attention is paid to the fact that the seed quality deteriorates during storage. Even if the total germination does not decline, accumulation of damage will result in vigour decline apparent as slower germination and emergence and reduced tolerance to biotic and abiotic stress in the field.

There is a large variation in the rate of seed aging between different crops. Seeds from onions and leek age relatively fast, whereas aging of barley seeds is much slower. Also within crops there can be variation between cultivars, whereas seed treatments as priming can considerably decrease the tolerance of the seeds to storage. This article describes factors that influence the rate of seed aging and methods to reduce it.

Seed maturity

To enable spreading of their genes, most plants have evolved the characteristic that their seeds are desiccation tolerant and can survive in a dry state for a considerable time. Under dry conditions enzymes cannot be active, so repair of damage is impossible and has to wait till the seeds absorb water. To limit damage induced during this dry period, protection mechanisms are imposed during the maturation process,

Master Class Seed Technology 2018

Wageningen University and Research organises a post-academic course in seed technology. The course is aimed at training staff working at seed companies or the public sector in seed technology. It encompasses background and latest development in seed biology research and their implications for seed production, quality analysis, seed health, upgrading and seed treatments. Seed researchers are often working in a narrow field of seed technology. The course will broaden their view on seed biology and the implications of biological and environmental factors and enable them to make innovations in their activities. The course will be held from 15-19 April 2018 in Wageningen, the Netherlands. For more information and application visit: www.seedcentre.nl/Masterclass-on-Seed-Technology.htm.

Dr. Steven P.C. Groot is researcher at Wageningen University & Research, the Netherlands and has over 30 years' experience in seed science and technology. He frequently gives courses on seed technology, including the Master Class Seed Technology held every year in Wageningen. See: www.wur.eu/seedtechnology.

when the seed is shutting down its metabolic activity. It is like preparing your house when leaving for a long vacation. With seeds, these protection mechanisms include the condensation of the nuclei, degradation of chlorophyll and production of anti-oxidants. Vitamin E is such an important anti-oxidant. Wheat germ oil, extracted from wheat seed embryos, is the main source of this natural anti-oxidant used for food preservation. Mutant seeds disrupted in the synthesis of vitamin E survive only for a few days in the dry state.

The importance of the protection mechanisms implies that when seeds are harvested and dried before full maturity, they are more sensitive to deterioration during storage. For crops that flower over a prolonged period, it is often not possible to harvest individual fruits. When dried quickly, the physiology of these seeds is fixed in a less mature state. It can help to dry the seeds more slowly, preferably while still attached to or in the maternal tissue. Slow drying can maintain for a longer period the moisture needed for the enzymes to impose this protection and also allows less mature seeds to finish their maturation or a large part of it. Since most seeds contain chlorophyll during development and this molecule is degraded during the maturation, it is also possible to upgrade seed lots by sorting the seeds on the basis of the chlorophyll content. The fluorescent properties of this molecule allowed the development of equipment for non-destructive maturity analysis or rapid sorting of seeds (See figure 1).

Limited damage

Damage that has accumulated during dry storage needs to be repaired upon sowing of the seeds, which requires both energy and time. For this reason, stored seeds will germinate more slowly compared to (non-dormant) fresh seeds and the delay will depend on the amount of damage. The more damage that has accumulated, the longer it will take to repair and consequently emergence will be delayed. However, such a delay can have economic consequences, as it will result in a less uniform emergence. Later germination will also result in slower development of roots and shoots, which can have consequences for a slower start of the crop and more problems when competing with weed seedlings.

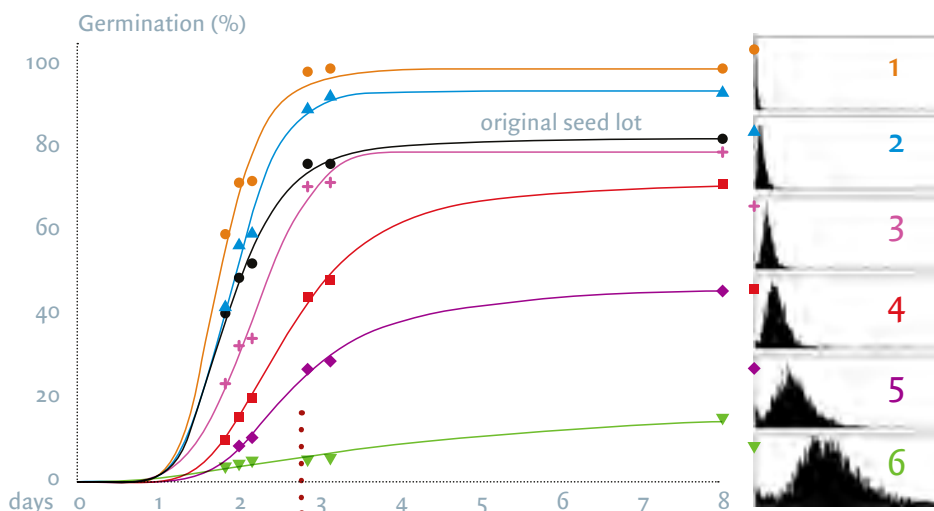


Figure 1: Related to the extended period of flowering of the mother plant, cabbage seed lots can contain a large proportion of less mature seeds. The original seed lot, with only 80% germinating, was sorted into six fractions by chlorophyll fluorescence levels of the individual seeds, indicated on the right side. Fractions 1 and 2, with low levels of chlorophyll, germinated better than the original seed lot, whereas the seeds with higher levels of chlorophyll performed worse (data from Dr. Henk Jalink, Wageningen-UR)

When it comes to aiming at the highest quality seeds, it is important to reduce the induction of damage, due to oxidation, as much as possible. Limited damage can well be repaired by the seeds, and there is no decline in total germination or normal seedlings. It should be realised that to observe a delay in the speed of emergence, it is required to perform daily counting in germination tests. The standard ISTA or AOSTA seed quality tests will only show large differences in germination speed.

Seed storage

With all living organisms, oxidation caused by reactive oxygen species (ROS) causes damage to the membranes, DNA, RNA and proteins. Normally, this damage is constantly checked and repaired. However, repair requires enzyme activity and thus water. Even when well protected, dry seeds slowly accumulate damage during storage. The longer the storage or the worse the storage conditions, the more damage is accumulated. Repair has to wait till the seed is imbibed during sowing.

As oxidation is stimulated by higher temperatures and moisture levels, it is recommended to store seeds dry and cool in order to reduce deterioration. Advanced vegetable seed companies store their seeds in warehouses conditioned at 30% RH and 15-20 °C.

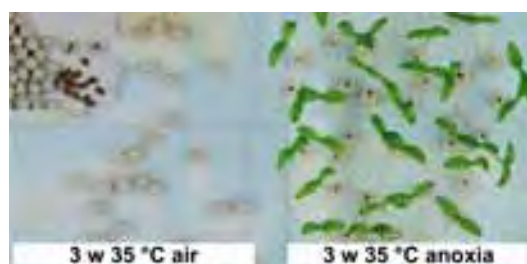


Figure 3. Primed and pelleted celery seeds have a rather poor shelf life. The seeds do not survive three weeks dry storage at 35 °C, but they do rather well when the oxygen is removed from the storage container (data from Wageningen-UR)



Figure 2: Seed companies have hardly any control over the environment in which dealers expose the seeds. Sometimes a display is exposed to direct sun light. Packing the seeds in moisture and oxygen impermeable material is essential

Genebanks have the task of maintaining genetic diversity in the very long term. For these institutions, regeneration is relatively costly and has the risk of reducing genetic variation. At the Centre for Genetic Resources in Wageningen, the seeds are dried at 15% RH and subsequently stored in a freezer at -20 °C. To reduce oxidation during seed storage, it is important to store seeds at low temperatures and moisture levels. Creating such conditions can be expensive, especially under tropical conditions where the climate is warm and humid for large parts of the year. For agricultural seeds, with their large volumes and relatively low individual seed prices, it will hardly be economically feasible to store seeds in temperature controlled warehouses. However, the still common practice of storing seeds in woven or paper bags is best avoided. Seeds are, by nature, hygroscopic and even when initially dried to low moisture level, they will rapidly reabsorb moisture from the air. For the relative higher value vegetable and flower seeds, it will more often be feasible to store seeds in temperature and humidity controlled warehouses, or in hermetically sealed laminated foil bags or tins. Here the risks are especially with the dealers, lacking temperature controlled storage (see figure 2).

The anti-oxidant pool in seeds enables them to scavenge large parts of the reactive oxygen species induced during storage. But this pool is limited, as under dry conditions, the seed will not be able to restore this pool. When the seeds are improperly stored after harvest or the drying is rather warm, then this anti-oxidant pool will be depleted relatively quickly. It is therefore recommended to avoid drying at high temperatures.

Role of oxygen

Less well-known is that the oxygen concentration during storage also influences the rate of deterioration. Anoxia storage of seeds is common practice with the food industry, where nuts and coffee beans are stored under anoxia to avoid the development of a rancid taste as a result of lipid-oxidation. Research

Figure 4: An alternative seed ageing test with high pressure oxygen has revealed genetic loci giving barley seeds an improved shelf life under dry storage conditions



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- at Wageningen UR has shown that also seeds to be
- used for crop production survive much better under
- anoxia conditions, compared to storage in air (see
- figure 3). The risks of molecular oxygen are that it can

be an important source or trigger in the formation of Reactive Oxygen Species.

In itself this idea was not new, already in 1961 it was shown that rice seeds survived better when stored under nitrogen gas. Unfortunately, some later studies failed to show positive results, or even showed more deterioration. As a result, the option of anoxia storage lost its appeal. Now it has turned out that the reason for this discrepancy in effects is due to differences in seed moisture during the anoxia storage experiments. At high moisture levels, the seeds that are metabolically active will have respiration and anoxia will result in suffocation. However, under dry conditions, the respiration enzymes cannot be active and these dry seeds do survive much better under anoxia.

As creation of low temperature environments can be costly, especially in the tropics, storage of seeds under anoxia conditions can be a valuable alternative for sensitive crops, such as onion and bitter melon, or for primed seeds. It is not necessary to create an anoxia storage warehouse, which will be logistically also rather difficult. It is already a large gain when, soon after harvest, the seeds are packed in hermetically closed systems. For small quantities, laminated aluminium foil pouches will function well, also at dealers.

Bags or cocoons made from multi-layered plastics are available in various sizes for storage of larger quantities under anoxia conditions. Within such big bags, seeds in individual smaller sized woven bags can be stacked. The big bags or cocoons can be flushed with nitrogen gas to reduce the oxygen levels. Dry seeds stored in hermetically closed pouches, bags or cocoons are also protected from moisture uptake when stored in a humid environment. As mentioned before, it is essential that the seeds are dry when stored under low oxygen conditions.

An additional advantage of low oxygen or anoxia storage is that it is also an environmentally friendly way to kill insects when present with the seeds.

Genetic variation

There is a large difference between crops in their

tolerance to storage. But also within crops, there is genetic variation. Rice seeds are often stored for half a year till the next planting season, but with some varieties germination may drop below 40% within this period. At present, a PhD project is running at Wageningen UR to identify genes responsible for improved tolerance to storage. For this research, it is important to have a test that identifies differences in storage tolerance already within a short time frame. Traditionally, researchers use tests where they store seeds at a very high humidity and temperature to accelerate the aging. However, this may not give the right representation for storage under dry conditions, as enzymes can be active at high humidity, but not under dry conditions used for optimal seed storage. Therefore, we developed a test by storing seeds at a higher oxygen concentration, using compressed air in steel tanks, while the humidity and temperature are as in seed company warehouses. Genetic loci giving barley seeds an improved shelf life have already been detected with this method (see figure 4).

Survival of biologicals

Seeds contain micro-organisms, sometimes called endophytes, which can be pathogenic, neutral or even beneficial. An example of the latter is grass seeds with endophytes that grow with the developing grass seedling. The endophytes give the plants a bad taste for birds, making it useful for application on golf courses or around airports. These endophytes, however, generally have a lower tolerance to storage compared to the grass seeds. Giving a shorter shelf life for the combined product.

The application of biologicals on seeds is a rapidly increasing market. An important criterion is that the applied micro-organism is desiccation tolerant, so the seeds can be dried after the treatment. Also, here it is important that the storage conditions are optimal, both for the seeds and the applied biological. Under dry storage, hermetic and anoxia packaging may help to maintain product quality. It can be expected that also with these biologicals, there is genetic variation in shelf life under dry conditions. The test developed at Wageningen UR for storage tolerance with seeds may also be useful for the selection of more tolerant beneficial micro-organisms.

EQUIPEMENT FOR DRYING, PROCESSING, BREEDING AND TREATMENT



Fluid drying for batches in boxes



Drying soaked seed:
From 55% to 6% in 4-6 hours



Drying pellets:
Up to 6 million pellets per batch in 3-5 hours

Box drying-installations

- drying per level individually
- high capacity on small surface
- modular in capacity
- free of insects and vermin with top-screens
- suitable for every building
- ideal for internal transport

Individual box drying



Continuous drying with boxes:
Drying per box starts when placed and stops when dry

Economic and efficient method to dehumidify air



- Hybrid dehydration installations; condensation and adsorption
- Central Dehydration Principle; connects all drying-installations and conditioned rooms to one central air drier
- Automatically controlled by the ABC processor

Processing machines



- Flat screen sizers
- Tippers for boxes and octabins
- inventers for octabins
- packaging

**All machines interconnected
by vacuum transport**

Equipment for breeding



Seed treatment



Vacuum transport





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- DNA research
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- Research for Plant Breeders' Rights for agricultural and horticultural crops
- Description of varieties

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- Regular workshops and trainings
- In company workshops and trainings

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