‘In ten to fifteen years’ time, the whole variety package will have been turned upside down’

‘In breeding work, the standards are set higher and higher and the development of varieties is getting faster and faster. This means that in ten to fifteen years’ time, the whole variety package will have been turned upside down. As a result, a variety such as Spunta will also be minimised over this period’, says Robert Graveland, Director of HZPC Research. ‘We need to make the added value of our new varieties so important that nobody cares for the old varieties anymore.’

HZPC Research is located in the north of the Dutch province of Friesland, in the middle of the seed potato fields. Near the company’s characteristic mill in the village of Metslawier, contractors are busy expanding and modernising the buildings. But it’s not only the buildings that are changing rapidly, the working methods of the breeding station have also been taken in hand in recent years. ‘Since 2007, we’ve opted for a sector-based approach to commerce and breeding. As a result, our growers have focused more on research than development. Annually, we spend 16 percent of the gross margin on R&D. Research has become more important in supporting the development of breeding. In recent years, this has resulted in a budget of 10 million euros per year. And that in turn has increased the breeder’s level of competence. With this, we’ve closed the gap between science and practical application in a few years. Our current breeders indicate what they need in order to grow a variety for a specific market segment. Scientific research provides the crossing parents to achieve this, for which certain characteristics and resistances have been mapped out with the use of DNA techniques. Hence the search for new varieties has become real team work, bringing together the wishes of the breeders, the knowledge of plant pathologists, DNA specialists, data analysts and biochemists’, Graveland explains. ‘Within breeding, we now have three approaches: classical breeding, gene editing and hybrid breeding’, he tells us. To show what these different practices look like, he gets up energetically and walks to one of the huge greenhouses behind the breeding station.

‘The more markers we have, the more directly we can make our crossings.’

Five hundred thousand potential varieties every year

In one of these greenhouses there is a huge number of crossing parents from the classic breeding programme where the fertilised berries bulge out in carefully placed bags that contain a card with a code. ‘In our strategy it’s important that we harvest a lot of seed from our crossings, because we start each year with 500,000 potential varieties’, reports

'In ten to fifteen years' time, the whole variety package will have been turned upside down'

HYBRID VARIETIES READY FOR THE AFRICAN MARKET IN 2025

'We already have the building blocks of hybrid potato breeding ready', says Ad Vrolijk, hybrid potato breeding manager. 'In 2023, we plan to register a variety in the Netherlands and in other target countries, which we'll use commercially in Central Africa in 2025', he discloses. 'The advantage of hybrid breeding is that you can export seed as well as tubers. This suddenly brings areas that were previously difficult or impossible to reach close at hand'.

'When you can go to countries where we don't transport tubers, you can soon compete with the lower quality of the locally-grown varieties', Gerard Backx explains.

The potato from seed, True Potato Seed, is already well-known from the 1960s. The Internationale Potato Centre CIP in Peru has already developed seed-based varieties for developing countries. 'We always believed that growing potatoes from seed only makes sense if you can make hybrids out of them. That's only possible if you can self-pollinate them at diploid level. The scientific discovery of a self-pollinating gene in Japan in 1999 made this possible. That's why we started experimenting in 2004', explains Gerard Backx, CEO of HZPC. 'In 2011, we decided to scale up the hybrid programme. We deliberately looked for someone who's not active in potato breeding. We wanted to stay away from the potato dogmas and develop a new approach. It wasn't the potato that was important in the beginning, but the hybrid system. Only then will we bring in the potato characteristics. In terms of testing, this latter part runs parallel with the classic breeding, where we use the same markers for both programmes,' Backx explains.

'In 2023, we plan to register a variety in the Netherlands and in other target countries, which we'll use commercially in Central Africa in 2025', Ad Vrolijk discloses.

A diploid is also just a potato

'In hybrid breeding, we started with material from the gene pool of Wageningen UR, but we discovered that we would never get the yield from the current varieties. This is why we've brought all existing successful varieties and crossing parents to diploid level and started experimenting with them by making them homozygous with inbreeding techniques. We noticed that not all varieties can be crossed,' explains Vrolijk in the greenhouse. 'In classic breeding the copy of the tuber is your variety and in hybrid breeding two parent lines with certain fixed characteristics form the basis of the variety. The seeds from this cross are all the same and have all the characteristics of the father and the mother. All the seeds together are then your variety. Broadly speaking, you can say that the classic approach is a bit of breeding and a lot of selection. Hybrid is a lot of breeding and a small part is selection', Vrolijk explains. 'In hybrid breeding, you have to make parental lines. This starts with making a diploid plant homozygous by inbreeding to fix certain characteristics.

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Once you’ve done that, the characteristic is fixed and won’t go away. You can then “stack” characteristics’, which means adding an extra characteristic. You then cross one of those homozygous parents with another diploid. After that you carry out another self-pollination and follow the new characteristic in the offspring with the DNA techniques. This means you can make parents more and more complete in terms of characteristics. At this point, we can exactly predict the characteristics of a cross in the variety. However, we still have to do field tests to determine whether a variety is interesting for production. So even in hybrid breeding, selection in the field remains necessary. The better we know the parent lines, the higher the predictive value. In maize breeding today, they can predict in advance on paper what will happen in the field. So as our parent lines improve, we’ll also move faster and faster in time with potatoes. Compared to classical breeding, where it takes fifteen years for a variety to be marketable, we can achieve this in five years with hybrid breeding. In addition to greater efficiency, hybrid breeding has the advantage that we can do two cultivation cycles a year and are therefore twice as fast as conventional breeding. When asked whether a diploid potato is also an ordinary potato, Vrolijk confirms that this is the case. ‘Why go back to tetra when diploid is good enough? From next year onwards, hybrids will be included in the variety trials. I hope no one sees the difference. If you look at other crops, sugar beets were first tetra, then tri and now they’re all diploid. They all look similar. That will also apply to potatoes soon. The consumer won’t be able to tell the difference.’

All the seeds from a hybrid cross are then your variety.

'In 2023, we plan to register a hybrid variety in the Netherlands.'

Opening up new markets

As for the market approach, Backx notes that with seed HZPC can serve countries much further away than with tubers. ‘When you can go to countries where we don’t transport tubers, you can soon compete with the lower quality of the locally-grown varieties. We’ll be more successful there than in countries such as Algeria, for example, where there is already a lot of high-quality Dutch seed. Initially, countries that buy tubers will continue to do so for the moment. In areas such as South Sudan, Rwanda, Central Asia, Western China, you can already create added value with potato seed. There we can build up a market share, without any competition in our existing markets. In addition, we currently only cover a small part of the world with tubers. If growers worldwide, with a potato area of 18 million hectares, move from 2.5 percent to 10 percent of certified planting stock, considerable growth is still possible. If we as HZPC further increase our gross margin as a result, our budget for breeding work will also increase considerably and we can develop new varieties even faster’, Backx explains the HZPC vision.

Graveland. ‘In the early days, you made a cross, chose a series of clones and after a few years you checked what characteristics you had. With the DNA techniques, in which we use genetic markers, you first look at what there is and you start developing a series of plants which already have the required characteristics right from the start. Next, after a number of years, you start checking these clones at different locations in the field to see if they’re good for French fries and if there’s a prospect of a good and sustainable yield. A lot of the characteristics still have to be tested for quite some time in the field. Genetic markers are an extra tool to develop the right varieties for our customers. In the past, you were looking for a needle in a haystack, now you’re looking at a pile of needles. The only thing is that one needle is a bit sharper than the other’, says Graveland. ‘This means that we’re now making the start of the breeding process much more targeted, because we start with a number of characteristics that you can select with markers. For example, you can extract characteristics such as tuber length and certain resistances to diseases at an early stage. This means that we’ll be throwing away at least 85 percent of the clones in the greenhouse in the first year, before you’ve seen a tuber at all. We therefore have a much more objective, targeted start with what’s left. And that’s quite different from a subjective hybrid, which will have a very small chance of multiple resistances later.

Three quarters of the varieties will be resistant to Phytophthora and virus by 2030

That fact that HZPC has confidence in the approach described by Graveland is also shown by the recently presented sustainability report. In this report, the company sets out its objective of having three quarters of the new varieties resistant to AM nematodes as well as Phytophthora and virus Y by the year 2030. In order to achieve this, Graveland has invested heavily in new equipment, as he proudly shows in the laboratory. The latest acquisition is a robot developed under the company’s own direction

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In order to achieve the sustainability objectives, HZPC has invested heavily in new equipment.

that 'washes' DNA from raw plant material fully automatically. Graveland shows how this method fits in with modern cultivation work in a room with a specially coloured LED light where germinating seeds grow well. From each harvested seed of a crossing, the company grows a small plant in a frame with 96 small pots filled with a special cultivation medium. As soon as the plants are big enough, an employee cuts off a piece of leaf from each plant and puts it in a special research plate, which also contains 96 holes. These holes correspond exactly to the order of the plants in the larger frame. 'You have to get this exactly right because, after the DNA analysis in the laboratory, the result determines which of the plants we'll continue with and which will be discarded. So it's important that our people who do this work are able to work routinely and faultlessly.' In its own DNA lab, HZPC tests which plants have the desired characteristics and which do not. 'From this tray with 96 pieces of plant, there are ten with the desired characteristics, for example. These potential varieties have never yet produced a tuber, but we already select them. If the plant, a potential variety, has the desired characteristics, it goes into a larger pot and then to the greenhouse. Here we grow larger plants from them and harvest the tubers, which we'll plant out in the field the following year, after which the "normal" breeding work starts. The big difference is that we've already given up to fifteen tested characteristics to the basis of such a potential variety. 'This specific combination of genes will provide the sustainable varieties that our customers are waiting for.

Automation provides knowledge

'Thanks to automation, we've made the selection knowledge-rich, which enables

Contractors are busy expanding and modernising the buildings of HZPC Research.

‘In ten to fifteen years’ time, the whole variety package will have been turned upside down’

‘KEEPING GENE-EDITING OUTSIDE EUROPE IS A FALSE SECURITY’

‘If you see what we’ve achieved in 150 years of potato cultivation, it’s in stark contrast, for example, to the breeding of sugar beet and maize. By making very specific adjustments in the DNA with certain techniques such as CRISPR-Cas, you can make rapid and significant progress, especially in the current clonal potato varieties’, says Gerard Backx.

‘In Europe, however, the gene-editing technique is legally labelled as GMO, whereas in North America it is an approved method of potato cultivation. Because we have a lot of confidence in this method, it means that here in Metslawier we develop varieties in the lab and send the interesting specimens to North America to be trialled in the field. We send them, like classically-grown varieties, as in-vitro plants. Upon arrival, we must indicate the technique with which the variety was developed. We must also declare that we haven’t put in any foreign DNA, for example. When this is approved, the variety will fall under the classic breeding category and we don’t have to communicate this any further. This is a big difference from Simplot’s Inate potatoes, which are already approved in America and developed through GMO techniques. You do have to communicate this to the consumer, because you’re introducing very specific DNA with different techniques. But the use of gene-editing, such as the CRISPR-Cas method, doesn’t have to be shared with the market. The competition won’t know that either. This means that as soon as such a variety has been admitted to the North American market, anyone can start crossing it and then build in effective resistances in new varieties. This means that a gene-edited variety can also be used as a crossing parent in the future. Because we do know the origin, we won’t do that ourselves, as we don’t think it’s ethically justified. But if Europe thinks they can keep gene-editing out, they’re creating a false security. After all, with varieties coming to Europe, you’ll no longer know which varieties have been created with gene editing or which originated from crossing them. With hybrid breeding you can achieve even faster results with gene editing than in classic breeding’, Backx explains the future of breeding work.

‘The use of gene-editing, such as the CRISPR-Cas method, doesn’t have to be shared with the market.’

‘We start with a number of characteristics that we select with markers’, says Robert Graveland in the LED room.

us to make controlled and faster product-market combinations’, Graveland explains. In order to map out the half million varieties and all the research material, a DNA lab has been set up that an average laboratory would envy. After the self-developed robot in which the 96 holes are washed ‘clean’ so that only the DNA material remains, the plate moves on to the next department. ‘Here each plate gets a barcode, which is linked to every step in the process to guarantee the link with the plant in the LED room. The plates with 96 holes are then transferred to a plate with 384 smaller holes and after that to one with 1536 even smaller holes. The reason for this is that the less volume we have left per hole, the less buffer we need to use. And the less buffer, the cheaper the DNA test. We then test all the plants with the PCR method and within two weeks after manually filling the 96 holes we know exactly which varieties have the desired

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As soon as the plants are big enough, an employee cuts off a piece of leaf from each plant and puts it in a special research plate.

The plates with 96 holes are transferred to a plate with 384 smaller holes.

combinations and we'll continue with these.

Own markers

In addition to routine research with well-known markers, the company also conducts a great deal of research. 'Every breeding station that conducts DNA research has developed its own specific markers. Our genetics and the markers are our capital. The more markers we have, the more we know about the crossing parents, and the more directly we can make our crossings. We're basically interested in every molecule in the cell. We ask ourselves questions such as: why is a plant strong, why are the chips tasty? We link that to DNA and that's how we work towards the markers. The markers give us control and through this control we can increase the speed in our breeding work. When asked whether he also has markers for a major disease like Erwinia, Graveland shakes his head. 'Of course, that's what we're looking for. Resistance to this type of complex disease is probably caused by a large number of genes. Artificial Intelligence (AI) is possibly a data method to achieve results in the future. We're already working with this technique.' ●

Jaap Delleman

'In the greenhouse we grow larger plants from the crossings with the desired characteristics and harvest tubers which we plant out in the field the following year.'