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The science of selection

Innovation **Grow** the best wheat

There’s an art to choosing potential winners from the hundreds of crosses a modern plant breeder makes every year, but increasingly genetics and clever science put confidence into the decisions made. *CPM* visits RAGT’s UK plant-breeding station to get an insight.

By Tom Allen-Stevens

Rather as a schoolteacher might pass through the classroom, Célia Bequain passes through the ear rows of RAGT’s wheat-breeding program at Ickleton, Cambs.

This is the very first venture out into the field for these wheat crosses, each row grown from just a single unique ear, and they’ve recently come into ear themselves. As senior wheat breeder, Célia’s checking to see how they perform, stooping occasionally to take a closer look, to straighten a flag leaf or inspect their stems.

In one row, she bends a wheat ear and smiles. “It’s lovely to see the progeny of Skyfall. It may be the number one wheat but I know what I have here is an improvement on its quality, yield and disease resistance.”

It’s one of hundreds of progenies from the landmark variety which was awarded the

NIAB Cereals Cup in 2015 for its outstanding merit and value in the marketplace. But you’d hardly recognise the distinctive parent from the variety of wheats that scatter this field.

“When I look at wheat, what I see is diversity — all the phenotypes and all the potential,” enthuses Célia. “So the height, the strength of the stem, whether the flag leaf is wide and floppy or narrow and erect. Does the ear have close, compact florets, or is it more lax? I look for the lovely, even rectangular shape, rather than a tapered ear, that may produce poorer grain set at its tip.”

Breeding technology

It’s the breeder’s eye, combined with the latest breeding technology, that delivers what RAGT believes is its ability to put into the marketplace the best wheats in the UK. There are tens of thousands of combinations made every year and it’s the skill of the breeding team to whittle that down to the few star performers that may one day take pole position on the AHDB Recommended List.

Skyfall itself is a cross of Hurricane with C4148. “It came from our N European breeding centre at Prêmesques, near Lille. C4148 is from an exotic background, bred especially to bring in new genetics, and that’s probably why Skyfall has been so successful,” explains Célia. “It was tested in both France and the UK, but showed up early on as one that performed well in the UK, particularly well suited to our climate.

“What I like about Skyfall is the way it looks — lovely short, stiff straw, with good fertile, well shaped ears. It’s notable for the

way it grows — it’s erect with the ears bunched up, unlike others that spread out into the space available.”

But Skyfall didn’t jump out of the ear rows completely by chance. Like most modern varieties, it was screened using genetic markers to help breeders zero in on wheats of interest. The DNA of a variety is assessed early on for alleles, or gene sequences, that match with known phenotypic traits.

In Skyfall’s case, the genetic markers identified little more than its resistance to orange wheat blossom midge and to eyespot. But the technology has come on in leaps and bounds in recent years as more has been understood about the wheat genome, and the cost of unravelling its complex chromosomes has come down.

“The beauty of our facility here at Ickleton is that we apply the genetic markers early on. We now have a very strong base of ▶



Each row in these plots is grown from just a single unique ear.



Célia Bequain with the progeny of Skyfall – crosses that promise an improvement on the parent's quality, yield and disease resistance.

▶ phenotypic data that gives us real confidence in what the data tells us," explains Célia. This is the breeder's proprietary knowledge — RAGT has associated what's seen in the field by the breeder with the data coming through on its genome. It allows for an effective and reliable way to screen the millions of initial progenies the breeder generates every year and discard those that will clearly never make a variety of note, she says.

"We've really focused on making sure the phenotypic data is robust. All of our strong base of knowledge is linked back to the genetic base, and we now apply these genetic markers at every level, starting with the parents."

This follows down through the generations

and there are usually seven or eight before a variety enters National List trials, by which time the millions of potential new lines that started off the programme have been narrowed down to just ten.

Single seed descent

"We accelerate the programme through single seed descent, which allows us to grow two to three generations in a year, but it still takes over six years to stabilise a variety enough to meet DUS (distinctiveness, uniformity, stability) standards. I prefer not to use double-haploid (DH) techniques, to give us the chance to observe more recombinations — at early generations I can choose tens of lines from any of the close to 1000 crosses we made. With DH, the cost and reduction in genetic variation means that the technique is better limited to specific crosses."

But one new technique Célia does put to



Plant breeders accelerates the programme through single seed descent, that allows them to grow two to three generations in a year.

good use is genomic selection (GS). "This puts all of our phenotypic and genotyping data through a software model — it's a bit like a virtual breeder, although it relies on the skill of a breeder to input good information. Initially we used it towards the end of a programme, but increasingly it's helping us identify parents to cross with."



Florets are more spaced out on a lax ear (left) while a tapered ear (right) may produce poorer grain set at its tip.

Science puts confidence into the art of the breeder

As head of genotyping for cereals at RAGT, Chris Burt puts the data behind the breeder's eye. He runs the genotyping lab at Ickleton, one of two operated by RAGT in Europe, the other being in France. Here, winter wheat, winter and spring barley, pasta wheat and triticale are the main crop types pulled apart, scrutinised and annotated.

"A trait the breeder spots phenotypically in the field, I want to understand genetically, and develop ways to track it through molecular markers," he says.

For some traits, this is now relatively easy and saves a huge amount of screening and time, he explains. "Orange wheat blossom midge (OWBM) is associated with a very narrow part of the wheat genome, so the genetic marker for this trait is now well established — it's why the proportion of varieties offering OWBM resistance has shot up in recent years. But it's one of the most difficult traits to identify phenotypically in the field."

However, traits such as septoria resistance and baking quality are more complex. "Septoria

resistance is controlled by a number of different genes, which each have a moderate effect — it's not absolute like OWBM resistance. The genes also have an effect on yield and other traits. But as we understand more about the wheat genome and apply this through our models, we're improving the genetic markers we use, and are getting better at reliably identifying the varieties with promise."

Increasingly, he also produces whole genome profiles of varieties and breeding lines. "This feeds our GS models and also helps us focus in on specific areas of the wheat genome we're interested in, such as areas we know have a link with yield."

The material he receives comes mainly from within RAGT, which operates 17 research stations across Europe, servicing the company's 300 breeders and technicians. "We also analyse other breeders' varieties — under Plant Variety Rights (PVR) any variety on the EU Common Catalogue can be crossed with our lines to generate new varieties. We also bring in material from further

afield, such as CIMMYT (the International Maize and Wheat Improvement Centre, based in Mexico). We're constantly looking for novel material to enrich our breeders' programmes."

Chris sits on the breeders' panel of the Designing Future Wheat programme — a BBSRC-funded programme spanning eight research institutes and universities which aims to develop new wheat germplasm containing the next generation of key traits. "We prefer to be as open and collaborative as possible with our pre-breeding work."

Chris believes the application of science and genetics RAGT puts to its breeding programme shows through in the way the company consistently brings forward leading varieties. "There's still every chance we'll spot the happy accident in an ear row or cross made in the glasshouse. Now we can apply robust genetic markers and analysis to what we're seeing in the field and that puts more confidence into the decisions made early on."

Breeding pipeline leads with strong wheat candidates

RAGT has four wheat varieties vying for a place on the AHDB Recommended List for 2020/21:

RGT Saki – This Cougar/KWS Santiago cross is the one Célia is most excited about. That's down to its combination of high treated and untreated yields, which is backed up by an impressive array of disease scores. OWBM resistance rounds off a promising package.

RGT Wasabi and RGT Lantern – Two hard feed varieties yielding a shade beneath RGT Saki, but both with a very attractive agronomic offering, reckons Célia. RGT Wasabi is a Revelation/Santiago cross, with OWBM resistance, as well as the Pch1 gene for eyespot resistance. RGT Lantern has KWS Kielder and Relay in its parentage, with OWBM resistance, and performs particularly well as a second wheat.

RGT Blossom – This is the big quality hopeful of the 2019 candidates, with a yield matching Skyfall. Its parentage is complicated, says Célia, with Gladiator, Solstice and Cordiale crossed with Gallant, and each bringing their strength into the

result. Boasting a bullet-proof Hagberg, it stayed true in 2017, when other varieties lost theirs. Baking trials are showing RGT Blossom up as a consistent, top quality performer.

Horizon hopefuls

Look out for RW41723, which is currently in NL2 and showing real promise as a good quality variety, says Célia. But perhaps what's most interesting here is its complicated parentage — it's part of RAGT's parental development programme which brings in some exotic lines to add some aspects you may not have seen before. Current yield scores put it 2% above Skyfall, with a 7.5 for septoria and a 9 for both rusts.

Three RGT Illustrious x Skyfall lines are in NL1. They're all a step-up from their prestigious parents, in yield, disease resistance and quality, reckons Célia. All boast good treated and untreated yields and all have Pch1 eyespot resistance as well as OWBM resistance.



RGT Saki is a Cougar/KWS Santiago cross with high treated and untreated yields, backed up by an impressive array of disease scores.



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Chris Burt aims to understand genetically a trait the breeder spots phenotypically in the field, and develops ways to track it through molecular markers.

This allows RAGT to bring greater diversity into its lines. Célia feels the current RL is too reliant on the progeny of just one parent variety — Robigus — and believes it's through introducing new genetics that will bring superior performance.

The GS model is proficient at giving clarity to results that may have been achieved from two very different growing seasons, and this gives the breeding team confidence when they believe they've identified a potential winner. "RGT Gravity was the first where we really put the model to the test. GS confirmed what we were seeing in the field, and that gave us confidence to multiply up seed and bring it to market a year early," notes Célia.

"Gravity has helped validate the model,

but it's one that is constantly evolving and improving as we understand more about the wheat genome and relate this to our own knowledge on how wheats behave. We can now trust it and use it in more creative ways."

And the fruits of this bold reliance on technology, backed up with the breeder's eye, are in the plots and waving in the wind,

vying for her attention. "Genomic selection has undoubtedly helped us select the Skyfall crosses we now have, the first of which have now entered NL trials. But no matter how far technology comes, nothing will replace the feeling you get as a breeder being here in the field, seeing how the variety expresses itself, getting to know its character and where its true strengths lie." ■

Grow the best

A modern arable business relies on its main cash crops to deliver to a high and consistent standard, and it's the genetics it uses that underpin this performance. Modern breeding techniques have delivered outstanding varieties in recent years, and an insight into how this is achieved can help identify the leading lines of the future.

In this series of sponsored articles, *CPM* has teamed up with RAGT to explore how a variety is selected and how science improves the reliability and the speed with which a winner's found and becomes a farmer's favourite.

One hundred years of farming excellence started for RAGT in 1919, with the creation of RAGT Plateau Central, a farmer co-operative in southern France. It became a private company in 1944, with plant breeding starting in 1962.

Since then, RAGT has built up an enviable reputation for excellence among the agricultural and related industries. In the UK, a significant step for the company was when it bought

the cereals breeding programme from Monsanto in 2004. This brought with it all the breeding excellence and experience from Cambridge-based Plant Breeding Institute (PBI), which defined the post-war UK plant-breeding scene, and provided the backbone to the cereal varieties still in use.

Today, nearly one hectare in every five growing wheat across Europe has been sown with an RAGT variety, while in the UK strong offerings in wheat, barley, oats and oilseed rape are consistently among the leaders in the AHDB Recommended Lists.

