> "Now is the time to have a new resistance."

A breakthrough in genetics

Technical Innovation insight

After 20 years of research and testing, LSPB has commercially launched two oilseed rape varieties containing a new resistance gene – *RlmS* – with claims it offers greater protection against phoma. *CPM* explores the breakthrough in genetics.

By Charlotte Cunningham

Since *Rlm7* came onto the scene, oilseed rape has enjoyed the protection the gene has brought against phoma — arguably one of the most important diseases in OSR production.

And while the gene continues to be an effective part of the strategy, there's no escaping the concern that reliance on any kind of singular resistance will undoubtedly, eventually, lead to challenges.

This, teamed with the effects of global warming and the wet and mild winter often worsening the prevalence of resistant pests and diseases give considerable cause for breeding to focus on the 'what's next' of the resistance strategy.

And it was this sentiment exactly that has led to the birth of the new winter OSR varieties containing the *RlmS* gene — a product of more than 20 years of hard work by breeders NPZ — LSPB's exclusive shareholder.

To set the scene, plant breeders in countries such as France are beginning to see a widespread breakdown of the *Rlm7* gene. And while it's important to note that the same issues aren't yet a problem for UK growers, experts say that if the gene isn't protected, then there's a strong possibility that the same series of events could well follow.

Losing its efficacy

Putting this into perspective, 2020 studies carried out by Marie-Hélène Balesdent in France have shown that *Rlm7* is losing its efficacy with only 70-80% non-virulent races identified from across eight trial sites. In contrast, the new *RlmS* gene proved to be 100% effective.

So how do we protect it? Much like using a range of actives is key for the protection of chemistry, to protect *Rlm7*, breeders believe using a range of resistant genes is essential. This is where *RlmS* comes in — as an alternative, not a direct replacement.

But before we move into the nitty gritty of how it works, let's jump back to how and where it all began, and ask how exactly one goes about breeding phoma resistance.

NPZ's winter OSR breeding leader Dr Christian Flachenecker says there are two options when it comes to developing phoma resistant varieties. "When you're looking for new resistance, you go back to academic partners and research to guide you on where you might source this from. But when it comes to the resistance itself there are two kinds to be aware of."

Firstly, there's quantitative resistance, which is based on several genes with minor effects, he explains. "Selection is made by field observations, and while it doesn't stop infection, it can reduce the impact, is often more durable and supports the longevity of R-gene resistance.

"The other type is R-gene related resistance. This is based on one gene with a major effect. Selection is based on cotyledon testing and — if possible — molecular markers, with the resistance itself often introgressed from wild relatives. Unlike quantitative resistance, it stops infection from the beginning."

Cotyledon testing involves infecting the plant seven days after sowing and scoring after 14 days. "The advantage of this is that ▸

Dr Christian Flachenecker is leading the winter OSR breeding programme at NPZ.

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A new gene, and subsequent new genetics, can really give growers more robust control as well as helping to protect what they already have, says David Leaper.

▸ it's a fast way to detect phoma resistance in breeding material and works well for the R-gene related strains of resistance," explains Christian. "The disadvantages of this method, however, are that farmers are interested in the adult plant resistance and this doesn't take into account quantitative resistances (needed for high adult plant resistance) and some major R genes."

In the case of *RlmS*, the challenge came as there was no molecular marker at the time of discovery which could be used to confirm the resistance. "Here, we had to use the 'Winkelmann test' which was developed by an NPZ breeder around 15 years ago to assess adult plant resistance. This involved bringing plants from the field and replanting them in a cold house, before purposely infecting them with phoma spores which meant cutting the stems and placing the spore on the injured part of the plant.

"The plants were then left to grow in the cold house and at stage BBC65 (flowering) were dug out again and the stems were cut at the base to score the cross section for phoma symptoms. This method enabled us to bring the *RlmS* resistance into elite material."

Main challenge

The main challenge with breeding new resistance is the time it takes, explains Christian. "New resistances are often screened in co-operation with academic partners. If we decide on a promising resistance donor, for example, from a related species, it takes many crosses and back-crosses with elite germplasms to produce a plant which looks like OSR and carries the new resistance. This is the longest part of the process and can take anywhere between 5-10 years.

"After this, breeders take over the material — which is still not adapted to the final market. For example, in the case of RlmS, resistance was introduced from turnip rape to spring OSR and then we as breeders had to find a way of putting it into winter material for winter OSR, which involved procedures such as bringing up the winter hardiness as well as getting rid of any undesirable traits.

"This takes another three to four years and it can be a real challenge to get rid of unwanted traits while maintaining that high level of resistance."

Just like the coronavirus, the fungal pathogens causing phoma stem canker can mutate and change rapidly, presenting another challenge to both breeders and growers, explains Christian. "This means new races develop that can overcome the resistance that has been bred. It's not an if, but a when, and even with a new gene like *RlmS*, we know as breeders that it's a matter of time before it become less effective, which is why we're always looking for the next generation of resistance.

"Remember, the *RlmS* process started a long time ago, and while the launch may be well timed due to reduced efficacy from other resistant genes, it's something we were working on before this was a potential issue. In fact, when this process began *Rlm7* was very new and very effective, so there was no 'need' for something new at the time. But the more widely grown these genes are, the more chance they have at eventually breaking down.

"What is happening in France — where more than 40% of all varieties grown contain the *Rlm7* gene — is a prime example of why it is essential to have several resistances in the mix to protect."

In 2015, NPZ was able to register the first winter OSR variety containing *RlmS*, but since then, have continued to improve the varietal package taking us to today where LSPB have two new varieties in their portfolio — both boasting this new resistance in an all-round attractive package for growers.

"Historically, we've probably not been loud enough about who we are and who our shareholders are, meaning the innovation we've brought to the UK hasn't always been seen and recognised as ours," explains Chris Guest, managing director at LSPB.

Respect and Flemming come from a new and exciting generation of hybrids, says Chris Guest.

A breakdown in resistance

In 2018 a studied carried out by Mitrousia et al, from the University of Hertfordshire, looked at the effectiveness of *Rlm7* resistance against *Leptosphaeria maculans* — more commonly known as phoma stem canker — in UK winter OSR cultivars.

Dr Yongju Huang was one of the researchers working on the project. "The *Rlm7* gene in OSR is an important source of resistance for control of phoma stem canker on oilseed rape caused by the fungus Leptosphaeria maculans. This study showed the first report of *L. maculans* isolates virulent against Rlm7 in the UK.

"*L. maculans* isolates virulent against *Rlm7* represented 3% of the pathogen population when cultivars with the *Rlm7* gene represented 5% of the UK OSR area in 2012/13.

"However, the Rlm7 gene has been widely used since then, representing >15% of the UK OSR area in 2015/16. Winter OSR field experiments included cultivars with the *Rlm7* gene, with the *Rlm4* gene or without *Rlm* genes and took place at five sites in the UK over four cropping seasons.

"An increase in phoma leaf spotting severity on *Rlm7* cultivars in successive seasons was observed. Major resistance genes played a role in preventing severe phoma leaf spotting at the beginning of the cropping season and, in addition, quantitative resistance in the cultivars examined made an important contribution to control of phoma stem canker development at the end of the cropping season.

"Deployment of the *Rlm7* resistance gene against *L. maculans* in cultivars with quantitative resistance in combination with sustainable disease management practices will prolong the use of this gene for effective control of phoma stem canker epidemics."

With no molecular marker available to confirm genetic resistance, NPZ used the 'Winkelmann' test.

"We are 100% owned by NPZ, who have operations all over the globe and their own innovation department, meaning we can put ourselves right at the forefront of game-changing developments, to deliver significant improvements to the UK market through genetics."

Looking a little more closely at the varieties which boast *RlmS* resistance, Respect — which was added to the AHDB Recommended List this year — is one of the latest additions to the LSPB portfolio. "It's a hybrid that we believe will become a new benchmark for plant health and yield stability," says Chris.

"Along with its resistance to phoma it has a high, consistent yield performance and vigorous growth habit in the autumn and spring regrowth."

Flemming is another first for the UK market as a next generation hybrid with stacked traits, adding turnip yellows virus resistance (TuYV) to the *RlmS* resistance, he adds. "It's on the RL candidate list coming up for consideration this autumn and promises the same yield performance and autumn vigour as Respect, with a more prostrate growth habit."

It's important to note that the *RlmS* gene is distinct from those widely found in current OSR varieties, notes Chris. "By developing our hybrids with different genetics, we give extended and resilient phoma resistance in the field.

"The unique phoma resistance is also associated with strong overall plant health, and the gene has especially good stem resistance which we believe also brings better protection against the increasingly important pathogens of verticillium and sclerotinia."

Chris reckons that the OSR area is set to rebound to sustainable levels this autumn as, by most measures, it's the best break crop on a gross margin basis. "The heightened resistance from our new varieties to phoma - and added TuYV resistance — will be an important weapon in the armoury for growers."

Succession of improvements

He says that the introduction of the RlmS gene is the next step up for LSPB's breeding programme which has delivered huge benefits to growers in recent years. "Our winter OSR breeding programme has brought a succession of improved varieties to the RL over the years. Currently these include clubroot resistant Croozer and Crome, plus the HEAR variety Resort.

"Respect and Flemming are a new and exciting generation of hybrids set to continue our track record of innovative breeding advances for the benefit of all UK OSR growers.

"Genetic resistance brings real security to growers. We have the market for it, and we can be certain that the varieties do have resistance — which helps to bring an element of reliability to a crop which has had a turbulent few years."

Agrii's David Leaper has been assessing the performance of Respect in trials over the past two years and concurs that the new *RlmS* gene will help provide greater security to growers. "There has always been concern over putting too much pressure on single

The RlmS breeding process began over 20 years ago in Australia.

genetics and we're in a situation in the UK where there's a lot of reliance on *Rlm7*," he explains. "A new gene, and subsequent new genetics, can really give growers more robust control, as well as helping to protect what we already have — it's a tremendous triumph that breeders have developed this."

David says Respect has performed well in Agrii trials last year with high treated (108%) and very high untreated (103%) yields. "It has a good autumn and spring growth habit, stiff stem and outstanding disease resistance which makes it a suitable variety for earlier drilling. It has also performed consistently well in AHDB trials over the past three years."

"It's suitable for all soils and the East and West region of the UK until further information is available, and can be drilled from early Aug right through to early Sept. At 143cm, it's a relatively tall variety, but also has, good stem stiffness (8), lodging resistance (8) and medium maturity (5)."

"Respect has an excellent disease profile, obviously including the new *RlmS* gene which provides an alternative to *Rlm7* genetics and is good for long-term and sustainable phoma control.

"It also has a robust light leaf spot rating (7) and the best tolerance of verticillium (8) of any variety tested by Agrii last year, though it's worth pointing out that it doesn't have the trait for pod shatter resistance or TuYV." ■

RlmS nomenclature

If you were wondering why the new *RlmS* gene doesn't follow the usual number-naming pattern, Yongju explains the nomenclature.

"For the host resistance genes against phoma stem canker pathogen *L. maculans*, they have been named according to the understanding of the corresponding pathogen effector genes. There is a gene-for-gene relationship between the host and the pathogen. Because the pathogen effector genes were named as *AvrLm1*, *AvrLm2*…, the corresponding OSR resistance genes were named as *Rlm1*, *Rlm2*…

"As I understand, the resistance gene *RlmS* is derived from turnip rape and there is no information about the corresponding pathogen effector gene. LSPB believe that this is a new type of resistance gene, so it is named as *RlmS*."

Christian adds: "Yongju mentioned *RlmS* is derived from turnip rape, more precise from brassica rapa subsp. sylvestris. In the first publications from Australia, they also called it sylvestris-resistance and we believe that the "S" refers to Sylvestris."

Innovation Insight

CPM would like to thank LSPB for kindly sponsoring this article, and for providing privileged access to staff and material used to help put the article together.

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