Keeping ahead of a changing disease

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Yellow rust

Yellow rust has become the bane of both growers and plant breeders over the past decade. At last month's UK Cereal Pathogen Virulence Survey (UKCPVS) meeting, delegates heard why the disease has become so unpredictable when it comes to the robustness of varietal resistance. *CPM* reports.

By Lucy de la Pasture

There was a time when yellow rust was predictable. Every five to ten years a new variant would arise and then become dominant, often in response to the area of a particular wheat variety being grown at the time.

Disease outbreaks followed certain weather patterns and resistance bred into varieties was both dependable and durable, that is until there was a step-change in the yellow rust population and an adjustment in variety choice became necessary. But then everything changed with the arrival of the Warrior race.

The UK yellow rust population used to be clonal, with one dominant race at any given time, explains Rachel Goddard, cereal pathologist at Limagrain. "New variants would arise and over time become dominant and this gave step-wise changes in virulence every few years."

But in 2011, a new race was identified in the UK and Europe which led to a complete change in the yellow rust population, she says. "This was exceptional for a number of reasons. Unusually, the change was identified in a number of countries in the same year, and it also broke a number of effective resistance genes in UK wheat germplasm (not just one as used to occur previously).

"Compared with the old clonal population, this new Warrior race incursion came from sexually recombining populations outside Europe. Effectively yellow rust had become a different disease."

Diverse pathotype

Since 2011 yellow rust has remained very complex in the UK and a new naming system was derived to reflect this — with genotypes classifying the pathotypes within Red, Blue, Purple and Blue groups. While there have been some fluctuations in the yellow rust population over the past few years, the Red group has remained dominant — with Red 37, Red 36 and Red 41 pathotypes the most common in 2021, she explains.

"The Red group is also very diverse, with more than 50 pathotypes identified, and it's possible to see this diversity in the field. In work undertaken by Chris Judge at NIAB, he discovered that different pathotypes could be found in the same region of the field. He also noted that the frequency of different pathotypes could change throughout the growing season.

"That means that the yellow rust pathotypes present at the beginning of the season could be very different to those present at the end, even in the same area of the field. So it's quite difficult to predict pathogen population change because the situation is so fluid," says Rachel.

Back in the day, when a clonal population of yellow rust presided, the disease was more predictable as it preferred mild winters — which enabled it to overwinter — but frosts and cold weather would stop it in its tracks. In spring warmer weather was tolerated, but if it became too warm yellow rust would slow down, she explains.

"Since Warrior has become prevalent, yellow rust is more adaptable and able to withstand changes in the environment without being inconvenienced. It can tolerate a greater range of temperatures and this means it can keep going at 20°C and above, which is when older pathotypes would have given up."

Warrior-types are also much more aggressive, adds Rachel. "The Warrior group pathotypes have a shorter time from infection to sporulation, which gives the potential for the disease cycle to repeat several times within the season. They also produce more spores."

As well as acting differently, the disease can look very different in the field too. "We often see black telia on the leaves later in the season instead of the usual yellow pustules in stripes on the leaf. That's also an indication that these newer pathotypes evolved from a sexually recombinant population."

Because the disease has changed, the way breeders look for and incorporate resistance has also changed, says Rachel. To illustrate this, she highlights two complete ▸

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SET SIGHTS ON GRASS WEEDS

FORWARD CEREAL CROPS AND ADVANCED GRASS WEEDS WILL MAKE SPRING HERBICIDE TIMING AND APPLICATION TECHNIQUES ESPECIALLY IMPORTANT THIS SEASON.

Left uncontrolled, it's those larger, well-established plants that will be far more competitive to the crop and produce a much greater viable seed return at harvest, warns **Syngenta Technical Manager, Georgina Young**.

- **Hit grass weeds whilst still small**
- **Use AXIAL® Pro first in the spring herbicide sequence**
- **Increase application rates on larger weeds**
- **Treat when growing conditions are good**
- **Adapt application technique to target weeds**

"It's more important, and very much more cost effective, to target the established grass weeds early," she advocated. "Even if some grass weeds were to still emerge later in the spring, they are likely to have a more limited yield effect on the crop and produce many fewer viable seeds."

Where overwintered wild oats can be targeted before they reach GS29, Mrs Young advised they can be effectively controlled with AXIAL Pro application rates of 0.6 l/ha.

"But if any grass weeds in the field are left to get larger, to wait for further spring emergence, then rates should increase, up to 0.82 l/ha," she added.

Best use advice would always be to increase application rates if spring growing conditions are poor, which might impede herbicide uptake and speed of effectiveness. Larger weeds could have the chance to recover - with associated risks of herbicide resistance developing.

Treating grass weeds early, before they are hidden by the growing crop, makes it easier for sprays to hit the target, according to **Syngenta Application Specialist, Harry Fordham**.

For early treatments, he advocated application using angled nozzles with a smaller droplet spectrum, best suited to targeting narrow grass weed leaves and hitting small plants under the crop canopy. Nozzles should be fitted to alternate facing forwards and backwards along the spray boom for all round coverage of the target, with a water volume of 100 l/ha.

If treatments are delayed and the crop has grown taller to cover the weeds, a switch to a more vertical spray pattern and a larger droplet spectrum, can achieve better spray penetration through the canopy and down to the weeds. An increase in water volume, to 200 l/ha, can achieve better coverage on the larger weed leaves, he added.

Spray Assist

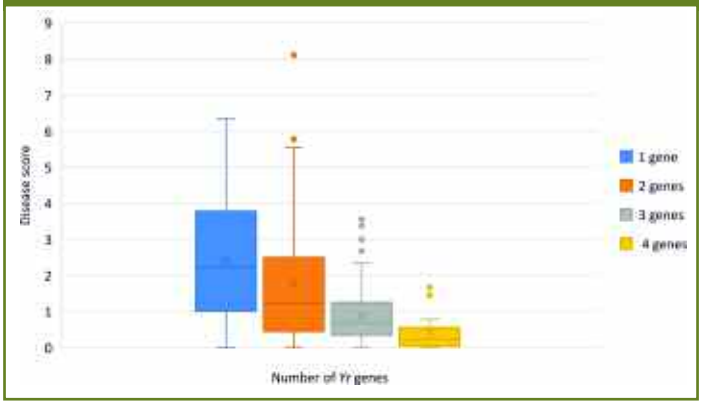
SPRAY ASSISTANCE

This season, operators can receive instant individual advice to optimise every AXIAL Pro application. Each product box now comes with a QR code for operators to quickly scan and download the Spray Assist App.

Simply completing a few details on farm location, and equipment, the App's powerful algorithms combine a wealth of application trials results with weather data, crop, growth stage and treatment, to instantly compute the optimum available sprayer settings and recommendations.

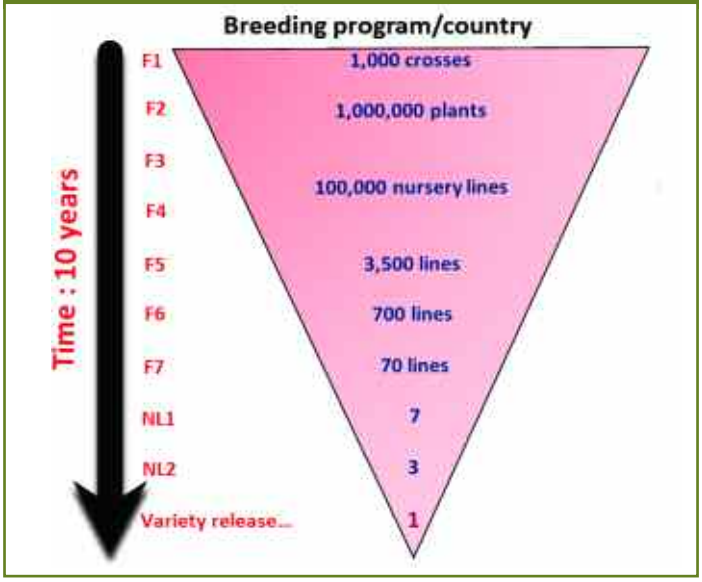
Syngenta Spray Assist provides a powerful tool to enhance spring grass weed control, as well as other application timings and crops throughout the season.

Stacking genes increases durability



Source: Limagrain, 2022

Time to produce a new variety



Source: Limagrain, 2022

▸ shifts in yellow rust resistance breeding in the UK.

"Following the breakdown of Brigadier in 1997, Claire was used extensively in breeding programmes. It had a single adult plant resistance gene — *YrClaire* — which provided complete protection against yellow rust.

"For ten years the *YrClaire* gene was very effective, however, following the appearance of Warrior in 2011 there was a marked increase in its susceptibility. In more recent years in the Limagrain nurseries (2019-2020), Claire has an infected leaf area of 60% or more, indicating it's still very susceptible to yellow rust."

But for Brigadier, which broke down in 1995-1996 before the ingress of Warrior, the story has a very different ending. "In the Limagrain nurseries, Brigadier was susceptible to yellow rust after its resistance broke, but from 2017 onwards it's become very resistant to the disease. This means Brigadier has *Yr* genes which were defeated by the old clonal lineage of yellow rust but now provide resistance against the Warrior population," she explains.

So, what's next for plant breeders? Breeding for durable resistance is the Holy Grail but the unpredictable nature of the yellow rust population makes it very difficult to anticipate which host resistances genes will continue to work long-term, says Rachel.

"We know single genes are unlikely to endure so we're looking at combinations of genes together, but it's difficult to forecast which combination will prove to have the most longevity."

Trying to breed for resistance post-Warrior means plant breeders have to use all the data available to try and make the best and most-informed choices, she believes. That's where the data collected by the UKCVPS comes in useful.

Significant changes

"As plant breeders we work with the wheat host genetics and not the pathogen, so the work of the UKCPVS helps us understand if there any significant changes in the yellow rust population — providing an early warning system to potential problems, as well as validating new races."

The survey work also identifies new pathotypes and provides breeders with information on the virulences these have and at what frequency they're present, she adds.

There are at least eight effective resistance genes for yellow rust present in the varieties currently on AHDB's Recommended List. Those that have three or four *Yr* genes have greater resistance than those with less, says Rachel.

But not all resistance genes are effective against Warrior. To establish which genes are working well together and which are losing efficacy, Limagrain closely monitors its nurseries. "By monitoring resistances year-on-year, we can see which gene combinations are shifting."

Pre-breeding also provides an added opportunity to introduce resistances, particularly because the elite wheat gene pool is fairly narrow, she says.

"If you cross an elite wheat with another elite wheat then you produce a limited number of *Yr* gene combinations. So, it may be necessary to introduce *Yr* genes from elsewhere."

Approximately 75% of yellow rust resistance genes are native to Triticum aestivum but others, such as *Yr5*, *Yr8*, *Yr9* and *Yr17*, are non-native.

"There are a number of additional resources we can exploit. Wheat has three gene pools, with the primary gene pool from elite wheats, landraces and genetic stocks; the secondary gene pool from wheat progenitors; and a tertiary gene pool made up of crop wild relatives. The secondary and tertiary sources can bring more diversity and new resistances."

But as always with plant breeding, there's no magic wand and new traits are often accompanied by unwanted ones. "Often these genetics produce plants that are very tall and prone to lodging, they can have lower yields and are difficult to cross, with sterility all too commonly encountered.

"Because of these problems, introduction of new resistances into breeding programmes takes 2-3 times as long compared with using elite sources."

And that isn't good news because traditional plant breeding already takes about ten years to progress from the initial cross to nursery stock selection, through to yield trials and eventually National List and RL trials.

"A further downside is that new breeding lines derived from crosses made 4-5 years ago may be less resistant by the time they reach NL trials due to the diversity and speed of change in the yellow rust population."

Rachel says that for these reasons breeders have to be selective with resistances and the use of DNA markers is essential to help pick those combinations they believe will be most useful, taking into account changes in the pathogen population and how quickly they're occurring.

"But it's no easy task! To protect resistance genes we have to stack them together as this provides more durability, but it requires 1000s of lines to be screened with markers in order to create effective gene stacks with four or more resistance genes." ■