Slowing sensitivity shifts

> *"It's really difficult to look after MoA when you're down to the last two standing."*

AHDB

from theory to field

Septoria is a bit of a shape-shifter when it comes to single-site fungicides. Minimising selection pressure and maximising control using both cultural and chemical strategies form the focus of two major AHDB projects. *CPM* reports their findings.

By Lucy de la Pasture

The concept of pathogen mutations and the possibility of vaccine escape has been perfectly illustrated during the COVID-19 pandemic. In the same way *Zymoseptoria tritici* in wheat crops has become adept at finding ways to avoid the main groups of fungicides used to control the disease epidemic.

Shifts in sensitivity to azole and SDHI chemistry are independently monitored by AHDB with the help of plant pathologists at Rothamsted Research and NIAB, and the results were reported during Agronomy Week last December as part of the fungicide performance studies. Although 2020 was generally an easy year for obtaining septoria control, it's clear that septoria is continuing to evolve resistance.

Catherine Harries, crop protection scientist at AHDB, says the fungicide performance work is backed by two significant projects which are seeking to find ways of slowing the evolution of resistance in the field.

Septoria resistance

"The first project is studying how to best manage septoria resistance evolving concurrently to two or more modes of action (MoA), as is happening in the field with decreased sensitivity to azoles and SDHIs. This project brings industry together to work out the best strategies so that advice can be pulled together in one unified message through the Fungicide Resistance Action Group (FRAG-UK), where AHDB is represented."

Dr Neil Paveley, director of crop protection at ADAS, is leading the project, which is still awaiting genotyping data from 2020 which has been delayed due to the impact of COVID-19.

"The current focus on managing resistance for each MoA individually needs to be broadened. If two or more single-site acting fungicides are being used to control septoria, the resistance management strategies used should be those which optimise the effective life of the MoA combination," he says.

Within the project, septoria pathogens are monitored in field trials at five sites, with a geographical spread from Teagasc in Ireland to the East of the UK. The field experiments are run in conjunction with disease modelling and where these sometimes disagree, this highlights the need to find out why the pathogen may be behaving differently in the field to the 'governing principles' of pathogen evolution which underpin the modelling.

A focus of the project is to look at the 'trade-offs' which may happen when using mixtures, alternation and limiting the number of treatments — practices undertaken to

Neil Paveley says the current focus on managing resistance for each MoA individually needs to be broadened.

manage resistance.

"One of the strategies being looked at is whether we could safely remove limitations on maximum number of applications for resistance management, allowing more flexibility within a limit of maximum total dose. Work is continuing to identify under what circumstances dose-splitting does, or doesn't have a substantial effect on resistance," explains Neil.

"The field data we've collected so far shows that dose-splitting hasn't increased selection pressure on the SDHI, but the modelling indicates that there should be a small increase in selection pressure so we're looking at why there's a difference."

The preliminary conclusions from the work suggest that alternation is only likely to be better than mixtures at reducing selection pressure where dose-splitting increases selection and the mixture partner is relatively ineffective. Where dose-splitting has little effect on selection, limiting total dose (rather than the number of treatments) may be an effective resistance management strategy and give growers flexibility to adjust spray programmes.

Agrochemical manufacturers are getting adept at tweaking fungicide molecules so that they can still bind to the target site in the septoria pathogen, even though mutations have changed its shape.

Although it's bad news that septoria pathogens continue to shift in sensitivity, Neil believes there is also good news and he sees a number of 'gamechangers' coming.

Pathogen evolution

"We're all hearing a lot about pathogen evolution and how vaccines target spike proteins in a virus. If the virus mutates and changes the shape of its spike protein sufficiently so that the vaccine can't bind to its target, then we're told the vaccines can be easily tweaked. Exactly the same thing is happening with fungicides.

"The target site for the fungicide is an enzyme, which is a protein, and when the pathogen changes the shape of the protein, the fungicide can't bind to the target site. In the past, these types of mutation signalled the end of a group of chemistry, as happened with the MBCs, but now agrochemical manufacturers are getting adept at tweaking the molecules so that they can still bind to the target site in the septoria pathogen, even though mutations have changed its shape.

"Pipeline molecules such as Iblon (Bayer), Adepidyn (Syngenta), Revysol and Pavecto (Sumitomo/BASF) are all examples of existing MoA that have been tweaked — sometimes to form new sub-classes of MoA."

Neil points out that with new molecules from existing groups of chemistry on the way, it's all the more important to discover how to look after them, especially as it's a much longer process to bring a new fungicide to market (several years) than it is to tweak a vaccine.

"We've been on a downward spiral for some time with fungicide chemistry and it's really difficult to look after MoA when you're down to the last two standing, as we are currently with azoles and SDHIs. So we have to get onto an upward spiral."

The second gamechanger is 'targeting', with disease forecasting, in-field diagnostics, sensors and the Internet of Things. Ultimately, these will deliver on the hype that has surrounded them, believes Neil.

But the 'gamechanger' that's closest to home is IPM, he adds. "It's something the industry has been talking about for decades but with highly effective fungicides to hand, it was easy to keep crops clean. Now there's been a significant switch towards more ▸

Chemistry and genetics need protection

BASF's Dr Jonathan Helliwell believes understanding the link between IPM practices and fungicides to control septoria, as explored in Chloe's project, is going to play an increasingly important role in the future.

"The scenario in the UK is that we have strong varieties and strong chemistry so we're able to utilise variety resistance as effectively as another MoA. There's a need to protect genetics as the genetic pool is getting smaller — so it goes both ways, we have to protect chemistry and varieties."

That means using all the tools in the box rather than being reliant on just chemical or cultural controls, he adds. Additionally, active ingredients are coming under pressure from a political perspective and new chemistry is harder to register.

"We have to celebrate new chemistry. But the pipeline still represents a narrow spectrum in terms of MoA, so a key focus is effectively protecting new actives when they arrive," he says.

He points out that there's been an erosion in the performance of conventional triazole chemistry for some time and that's where the arrival of Revysol (mefentrifluconazole), with its ability to bind strongly to mutated binding sites, is in a good position to offer a strong element of protection to other MoAs.

"From the SDHI perspective, it's important to acknowledge that even though the sensitivity is shifting, we're still getting good control in the field. BASF surveillance monitoring shows that the moderately adapted mutations are increasing, whereas the more severe mutations exist at very low levels and remain more or less stable in the population."

"Traditional micro-titre data is 'in-vitro', so whilst incredibly useful for monitoring shifts in sensitivity at an academic level, it doesn't fully represent the in-field 'in vivo' situation where there's an interaction between the kinetic and physical properties of the active ingredient, plant and fungal cells. All these affect the degradation and binding power of the triazoles, in particular, in a field situation."

Jonathan says that academic research suggests increased dose of SDHI drives selection pressure, so it's important to not over-expose the class of chemistry and continue to protect them with other effective MoA. Looking at the other possibilities for resistance management in Neil's work is important.

Jonathan Helliwell believes understanding the link between IPM practices and fungicides to control septoria is going to play an increasingly important role in the future.

"Whatever the outcome, a fungicide application will still drive resistance to some degree. We have to find the balance of measures to maximise the effective life of chemistry, whilst giving protection against disease to maximise economical return.

Chloe Morgan explains that the results of the combined agronomy project are being used to quantify the effect of drilling date on a variety's septoria resistance rating.

▸ resistant varieties and if farmers can reduce their dependence on fungicides and target them more effectively, then it will help look after the new fungicide pipeline," he adds.

The second AHDB project is all about the IPM aspect of managing fungicide resistance, says Catherine. "This project looks at combining agronomy, variety and chemistry to maintain control of septoria in the field. It has a focus on making the best use of resistant varieties and this is something we're extending through our Strategic Cereal Farm network."

Leading the project is Chloe Morgan, crop pathologist at ADAS and she explains that as chemical control of septoria is becoming more difficult, cultural controls will become increasingly important, even with new chemistry.

The trial was set up to determine the value of agronomic factors and to establish the extent fungicide use can be adjusted for current cultural control strategies.

"We looked at four different factors — variety (susceptible, intermediate and moderately resistant to septoria), seed rates (high and low), sowing dates (mid-Sept and mid-Oct) and fungicide treatments (untreated, low, medium and high input)."

A total of 25 randomised, fully replicated trials were carried out over a 5-year period at a range of sites. "In the trials we saw seed rate was probably the least important factor and was inconsistent across sites. The more interesting factors were sowing date, variety and fungicides.

"In the first septoria assessment, made 3-4 weeks after the T2 fungicide timing, there was a clear difference in disease level on leaf 3 between varieties, reflecting their natural resistance to septoria. Sowing later also reduced the septoria burden on those varieties. This influenced their response to fungicides, with the largest effects seen in the early sown, susceptible variety.

"At a later disease assessment, looking at leaf 2, 6-8 weeks after T2, the sowing date effect wasn't as pronounced. The biggest fungicide responses were in the early-sown, more-susceptible varieties but in the later-sown varieties there was little to gain from more than a medium fungicide input programme in this trial and season."

One of the things that the research has looked to quantify is whether the sowing date affects the resistance rating of a variety. Chloe stresses that the results are provisional at the moment but are showing some interesting findings.

"In this analysis, the sowing is based on the average early and late sowing dates in the trial — 20 Sept and 18 Oct. We've also assumed that the AHDB resistance ratings are based mostly on the 'later' sown trials," she explains.

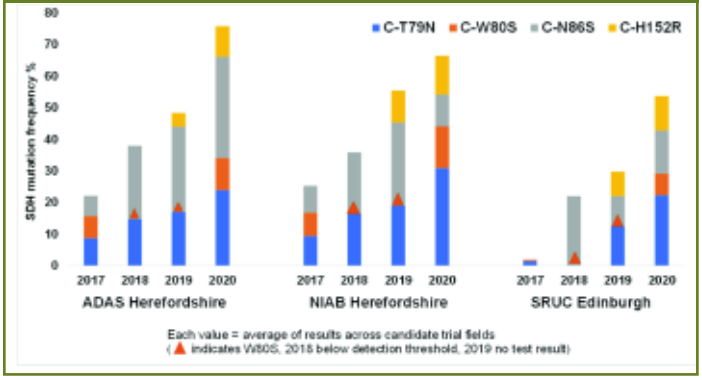
Using the data from the trial and aligning it to the AHDB methodology for calculating the resistance ratings, it was found that early sowing has the greatest effect on varieties with a higher resistance rating.

"If the variety has a resistance rating of 6.5 and it was sown early, then it will perform as if it had a resistance rating of 5.5. A variety with a resistance rating of 5 will have fallen to approx. 4.5. It's something that will help growers take into account the effect of sowing date when they design their fungicide programmes."

Summing up the results, Chloe explains that variety and fungicide programme were the most important of the factors tested, and this was followed by sowing date.

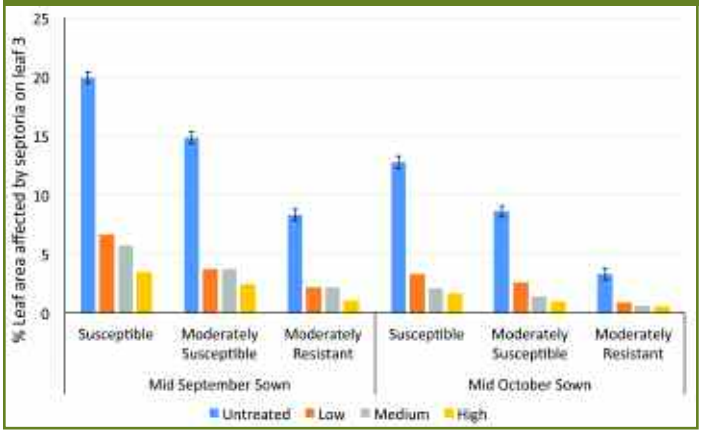
"Sowing date influences the disease pressure, with later sown crops exposed to septoria for a shorter period of time and this delayed the start of the epidemic. As expected, varieties with an inherent resistance to septoria reduced the disease, also slowing the epidemic and reducing risk." ■

Increase in septoria mutations since 2017



Source: ADAS, 2021

All trials disease assessment



Septoria levels assessed on Leaf 3 at T2 plus 3-4 weeks. Results are average across 21 sites.

Source: ADAS, 2021

Research roundup

From Theory to Field is part of AHDB's delivery of knowledge exchange on grower-funded research projects. *CPM* would like to thank AHDB for its support and in providing privileged access to staff and others involved in helping put these articles together.

AHDB Project No 21120058 – 'Managing resistance evolving concurrently against two or more modes of action, to extend the effective life of new fungicides' runs from Jan 2017 to March 2021 at total cost of £464,500 (AHDB-funding £196,500). The project is led by ADAS, with scientific partners: Rothamsted Research, NIAB, SRUC, Teagasc and industry partners: Adama, BASF, Bayer, Corteva AgriScience and Syngenta.

AHDB Project No 2140003105 – 'Combining agronomy, variety and chemistry to maintain control of *Septoria tritici* in wheat' runs from Aug 2016 to March 2022, at a total cost of £135,404. The project is led by ADAS.