

Fungicide resistance in wheat powdery mildew in NSW and northern Victoria in 2020-2021

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Take home messages

- The wheat powdery mildew pathogen has a very high risk of developing fungicide resistance
- Resistance to Group 11 (QoI) fungicides has been detected across most of the southern growing region and was detected in parts of NSW in 2020 and 2021
- Widespread resistance or reduced sensitivity to Group 3 DMIs is considered a high risk and a DMI 'gateway' mutation was detected at very high frequency across NSW and northern Victoria in 2020/21
- Careful use and rotation of available fungicide actives will help control the spread of resistance in wheat powdery mildew
- Agronomic practices that minimise disease pressure reduce the need to apply fungicides
- Good management will help protect the long-term efficacy of current fungicides.

Introduction

A key challenge in 2020 winter cropping season was the level of wheat powdery mildew (WPM), caused by *Blumeria graminis* f. sp. *tritici* (*Bgt*), across much of NSW and northern Victoria. High mineralised soil nitrogen levels following 2-3 years of drought favoured thick canopies and elevated leaf nitrate levels which favour WPM infection. WPM infections progressed into heads late in the season in some regions. Infection occurred in a range of bread wheat and durum varieties, especially Scepter[Ⓢ] and Vixen[Ⓢ] (Table 1) which are susceptible-very susceptible (SVS) to WPM and grown widely across the affected regions. WPM occurred predominantly in high-value, irrigated cropping regions, which create ideal conditions for disease development but was also prevalent in a number of dryland crops in the wet 2020 season. Lower levels of WPM were observed again in some crops in 2021. There were concerns around fungicide management with less than desirable control achieved. Factors contributing included:

- Potentially reduced fungicide sensitivity and/or resistance in the pathogen
- Application timing - i.e., too much time between stripe rust fungicide timings to cope with the quicker cycle time and rapid infection that occurs with WPM and/or
- Spray coverage, especially of heads, which are a horizontal target.

Many crops in 2020 had 2-4 in-crop fungicide applications during the season, yet WPM continued to progress. The WPM pathogen '*Bgt*' has a remarkable ability to adapt to fungicide treatments and is at high risk for the development of fungicide resistance.

In response, a collaboration with the Centre for Crop Disease Management (CCDM) based at Curtin University in WA was established to collect and analyse WPM samples for levels of fungicide resistance.

Wheat powdery mildew is favoured by susceptible wheat varieties growing in mild and humid weather (15° to 22°C, relative humidity > 70%), with a dense crop canopy, high nitrogen levels, good soil moisture profiles and extended periods of damp, humid conditions under the canopy. *Bgt* survives on wheat stubble and volunteer wheat plants. Spores can be spread to crops by the wind over moderate distances (kilometres). The pathogen is crop specific and only infects wheat, not barley or other grain crops.

What we did

WPM samples were collected by collaborating agronomists, sent to Tamworth for processing to help ensure viability in transit and sent to CCDM for molecular analysis of frequency of mutations for DMI (F136 'gateway' mutation, triazoles) and Qol (A143 mutation, strobilurins) resistance within the WPM population in each sample. In 2020, nineteen viable WPM samples were analysed by CCDM from across NSW and northern Victoria, with sample distribution being; NE Vic (4), SE NSW (5), SW NSW (8), NE NSW (1) and NW NSW (1)(Table 1). In 2021, three WPM samples collected from NSW were sent to CCDM for investigation. Further laboratory and glasshouse testing is ongoing with CCDM to determine the relative sensitivity of these WPM populations to various DMI actives.

What we found

The F136 mutation, also known as a 'gateway', has been previously associated with reduced sensitivity to some DMI (Group 3, triazole) fungicides. This mutation is normally found together with other mutations that are ultimately responsible for the resistant phenotype observed in the field. Once the frequency of the F136 and other mutations in a WPM pathogen population reach moderate levels, then reduced sensitivity to DMI fungicides is possible under field conditions. Very high frequencies may result in resistance to WPM and spray failure under field conditions with some DMI actives. The F136 'gateway' mutation itself does not necessarily mean field failure. It is however an initial warning that issues with continued DMI fungicide use exist. Field efficacy of different DMI fungicides in the presence of this 'gateway mutation,' can vary considerably, depending on what other mutations exist once this 'gateway' mutation occurs within a WPM population.

All 22 NSW/Vic WPM samples from 2020/21 had a F136 frequency of between 62 to 100% (Table 1). Such a high frequency of DMI resistance across NSW/Vic was surprising but not unexpected given the lack of field control in these crops in 2020. A lower frequency of the Qol A143 mutation was detected which ranged from 3 to 98% (Table 1). Presence of the Qol A143 mutation in the WPM pathogen population is associated with complete resistance to strobilurin fungicides (e.g., azoxystrobin), with the strobilurin fungicides becoming ineffective under field conditions at pathotype resistance frequencies above 50%. This is alarming; as four of the WPM samples tested (3 in 2020 and 1 in 2021) showed high or very high levels of resistance mutations to DMI (Group 3) and Qol (Group 11) modes of action (MoA), which could potentially result in dual resistance to fungicides from both of these MoA groups. The strobilurins are known to rapidly succumb to fungicide resistance, which is why they are always mixed with another MoA fungicide group (usually DMIs, Group 3). The high frequency of DMI F136 in NSW/Vic WPM pathogen populations is likely increasing the rate of selection for Qol resistance.

A concerning aspect in relationship to the Qol A143 resistance gene, is that it confers cross resistance to all fungicides within the group 11 mode of action group (strobilurins).

Table 1. Location of 19 wheat powdery mildew samples collected across NSW in 2020 and 3 in 2021 along with frequency of DMI (triazole) gateway and Qol (strobilurin) mutations

Location	Year	Region	Variety	DMI F136	Qol A143
Katamatite	2020	NE Vic	Scepter [Ⓟ]	100%	90%
Katamatite	2020	NE Vic	Scepter [Ⓟ]	100%	90%
Cobram	2020	NE Vic	Scepter [Ⓟ]	100%	46%
Cobram	2020	NE Vic	Scepter [Ⓟ]	100%	28%
Balldale	2020	SE NSW	Scepter [Ⓟ]	100%	98%
Walbundrie	2020	SE NSW	Scepter [Ⓟ]	100%	5%
Rennie	2020	SE NSW	Suntop [Ⓟ]	85%	27%
Rennie	2020	SE NSW	Scepter [Ⓟ]	85%	20%
Deniliquin	2020	SW NSW	Scepter [Ⓟ]	99%	35%
Deniliquin	2020	SW NSW	Scepter [Ⓟ]	99%	20%
Deniliquin	2020	SW NSW	Scepter [Ⓟ]	83%	20%
Jerilderie	2020	SE NSW	Scepter [Ⓟ]	100%	37%
Hillston	2020	SW NSW	Vittaroi [Ⓟ]	96%	21%
Hillston	2020	SW NSW	Vixen [Ⓟ]	94%	3%
Hillston	2020	SW NSW	Vixen [Ⓟ]	85%	6%
Yenda	2020	SW NSW	Cobra [Ⓟ]	100%	44%
Yenda	2020	SW NSW	Vixen [Ⓟ]	100%	12%
Edgeroi	2020	NE NSW	Lillaroi [Ⓟ]	82%	29%
Wee Waa	2020	NW NSW	Bindaroi [Ⓟ]	62%	51%
Corowa	2021	SE NSW	Scepter [Ⓟ]	100%	94%
Wee Waa	2021	NW NSW	Aurora [Ⓟ]	100%	20%
Finley	2021	SW NSW	Scepter [Ⓟ]	100%	38%

Fungicide resistance terminology

To address the ‘shades of grey’ surrounding fungicide resistance and how it is expressed as a field fungicide failure, some very specific terminology has been developed.

When a pathogen is effectively controlled by a fungicide, it is defined as sensitive to that fungicide. As fungicide resistance develops, that sensitive status can change to:

- **Reduced sensitivity**

When a fungicide application does not work optimally but does not completely fail.

This may not be noticeable at field level, or the grower may find previously experienced levels of control require higher chemical concentrations up to the maximum label rate. Reduced sensitivity must be confirmed through specialised laboratory testing.

- **Resistance**

When a fungicide fails to provide disease control in the field at the maximum label rate.

Resistance must be confirmed by laboratory testing and be clearly linked to a loss of control when using the fungicide correctly in the field.

- **Lab detection**

A measurable loss of sensitivity can often be detected in laboratory *in vitro* tests before or independent of any loss of fungicide efficacy in the field. Laboratory testing can indicate a high risk of resistance or reduced sensitivity developing in the field.

The Australian grains crop protection market is dominated by only three major mode of action (MoA) groups to combat diseases of grain crops; the DMIs (Group 3), SDHIs (Group 7) and

strobilurins (or quinone outside inhibitors, Qols, Group 11). Having so few MoA groups available for use increases the risk of fungicide resistance developing, as growers have very few alternatives to rotate in order to reduce selection pressure for these fungicide groups.

With two of the three fungicide MoA groups now compromised in some paddocks in New South Wales and Victoria, all growers and advisers need to take care to implement fungicide resistance management strategies to maximise their chances of effective and long-term disease control.

The Australian Fungicide Resistance Extension Network (AFREN), a GRDC investment, suggests an integrated approach tailored to local growing conditions. AFREN has identified the following five key actions, 'The Fungicide Resistance Five', to help growers maintain control over fungicide resistance, regardless of their crop or growing region:

1. Avoid susceptible crop varieties
2. Rotate crops – use time and distance to reduce disease carry-over
3. Use non-chemical control methods to reduce disease pressure
4. Spray only if necessary and apply strategically
5. Rotate and mix fungicides/MoA groups.

Managing fungicide resistance

It is important to recognise that fungicide use and the development of fungicide resistance, is a numbers game. That is, as the pathogen population increases, so does the likelihood and frequency of naturally resistant strains being present. A compromised fungicide will only control susceptible individuals while the resistant strains within the population continue to flourish.

As a result, it is best if fungicides are used infrequently and against small pathogen populations. That way, only a smaller number of resistant individuals will be present to survive the fungicide application, with many of these remaining vulnerable to other competitive pressures in the agro-ecosystem.

Keeping the pathogen population low can be achieved by taking all possible agronomic steps to minimise disease pressure and by applying fungicide at the first sign of infection once the crop has reached key growth stages. In cereals, the leaves that contribute most to crop yield are not present until growth stage 30 (GS30/start of stem elongation.) Foliar fungicides applied prior to this are more often than not a waste of money and unnecessarily place at risk the longevity of our cost-effective fungicide resources by applying an unneeded selection pressure on fungal pathogens for resistance.

Integrated management strategies

Management practices to help reduce disease pressure and spread include:

- **Planting less susceptible wheat varieties**
Any level of genetic resistance to WPM slows the rate of pathogen and disease development within a crop and reduces the reliance on fungicides to manage the disease. Avoid growing SVS and VS wheat varieties in disease-prone areas.
- **Inoculum management**
Killing volunteer wheat plants during fallow periods and reducing infected wheat stubble loads will reduce the volume of spores spreading into an adjacent or subsequent wheat crop.
- **Practicing good crop rotation**
A program of crop rotation creates a dynamic host environment that helps reduce inoculum levels from year to year. Rotating non-susceptible wheat varieties can also provide a more

dynamic host environment, forcing the pathogen to adapt rather than prosper.

- **Disease levels can be higher with early planting**

Later planting can delay plant growth until after the initial warm and damp period of early winter that favours WPM. This is important as infection of young plants can lead to increased losses at maturity. Later sown crops also tend to develop smaller canopies which are less conducive to powdery mildew infection. However, delayed sowing can have an associated cost of reduced yield potential in some environments which should be carefully considered by growers.

- **Careful nitrogen management**

As excess nitrogen favours disease development, nitrogen application should be budgeted to measured soil N levels and target yield so as to be optimised to suit the growing purpose.

- **Encouraging air circulation**

Actions that help increase airflow into the crop canopy can help lower the relative humidity. This can include wider row spacing, reduced plant populations (note yield potential should still be maximised). In mixed farming systems grazing by livestock can be used to reduce and open up the early season crop canopy, with potential to reduce the level of disease inoculum present at commencement of stem elongation when the 'money leaves' start to appear.

Fungicide recommendations for wheat

Planning of fungicide rotations needs to consider all fungal pathogens that may be present in the crop. Otherwise the fungicide treatment for one pathogen may select for resistance in another. For example, whilst there is little evidence of the development of fungicide resistance in rust populations globally, growing S-VS rust varieties means the only control option is fungicides. This can potentially have off-target selection pressure on the development of other fungal pathogens such as *Bgt* which is very prone to developing fungicide resistance.

Careful fungicide use will minimise the risk of fungicide resistance developing in WPM in Australia and help ensure the longevity of fungicides.

Advice to NSW and Victorian wheat growers includes:

- **Avoid using Group 11** fungicides in areas where resistance to QoIs has been reported.
- **Minimise** use of the **Group 3** fungicides that are known to have compromised resistance.
- **Monitor Group 3** fungicides closely, especially where the gateway mutation has been detected.
- **Rotate Group 3** fungicide actives within and across seasons. In other words, do not use the same Group 3 product twice in succession.
- **Avoid** more than three applications of fungicides containing a **Group 3** active in a growing season.
- **Group 11** fungicides should be used as a preventive, rather than for curative control and should be rotated with effective **Group 3** products.
- **Avoid** applying **Group 7** and **Group 11** products more than once per growing season, either alone or in mixtures. This includes in-furrow or seed treatments that have substantial activity on foliar diseases, as well as subsequent foliar sprays. Combined seed and in-furrow treatments count as one application.

Growers and agronomists who suspect DMI reduced sensitivity or resistance should contact the CCDM's Fungicide Resistance Group at frg@curtin.edu.au. Alternatively, contact a local regional

plant pathologist or fungicide resistance expert to discuss the situation. A list of contacts is on the AFREN website at grdc.com.au/afren.

Further information on fungicide resistance and its management in Australian grains crops is available at the AFREN website at grdc.com.au/afren.

Conclusions

NSW and Victorian growers need to be aware that issues with fungicide resistance already exist with WPM which could result in reduced fungicide sensitivity or potentially spray failures with DMI (triazoles) and QoI (strobilurin) fungicides. Further testing by CCDM is ongoing as to the level of reduced sensitivity to different DMI actives in these WPM pathogen populations, which will be communicated to growers and their advisers once available. Fungicide resistance is real and needs to be managed using an integrated approach to limit further development of fungicide resistance within WPM pathogen populations and in other at-risk fungal pathogens (e.g., net-blotches in barley and yellow spot or *Septoria tritici* blotch in wheat).

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