Fungicide resistance in wheat powdery mildew in Qld and NSW in 2022

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Take home messages

- The wheat powdery mildew (WPM) pathogen has a high risk of developing fungicide resistance
- The 2022 season, with frequent rainfall and prolonged mild temperatures in spring, was conducive to WPM development in susceptible wheat varieties across southern Qld and NSW
- Widespread resistance or reduced sensitivity to Group 3 DMIs is considered a high risk and a DMI 'gateway' mutation was detected at a high frequency (range 53 to 100%) in all samples collected across southern Qld and NSW in 2022
- Resistance to Group 11 (QoI) fungicides has been detected across most of the southern growing region and was detected at a lower frequency than DMI resistance in 9 of 10 southern Qld samples (range 7 to 56%) and 8 of 9 NSW samples (range 10 to 58%)
- Careful use and rotation of available fungicide actives will help control the spread of resistance in WPM
- 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

Wheat powdery mildew (WPM), caused by *Blumeria graminis* f. sp. *tritici* (*Bgt*), 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.

In 2020, there were concerns across wheat-growing regions of New South Wales and northern Victoria on the performance of fungicides from the DMI group. Despite crops receiving 2–4 fungicide applications during the season, wheat powdery mildew remained a problem for growers in some areas.

DMI fungicide resistance was detected at very high frequencies in samples collected from paddocks around Edgeroi, Wee Waa, Albury, Rennie, Balldale, Deniliquin, Jerilderie, Hillston and Yenda in NSW, and Cobram and Katamatite in Victoria. Genetic and phenotypic analyses of the isolates obtained from these locations revealed a combination of mutations in the DMI fungicide target gene that were associated with the observed resistance to some DMIs. Additionally, all samples tested had some level of strobilurin fungicide resistance (Simpfendorfer *et al.* 2021). Further research by the Centre for Crop Disease Management (CCDM) has associated the DMI mutations to reduced sensitivity to some triazole fungicides such as propiconazole under glasshouse conditions (Lopez-Ruiz *et al.*2023). The 2022 season was conducive to the development of WPM due to frequent rainfall and prolonged mild temperatures during spring. This favoured the development of WPM across parts of NSW and into Qld, so the opportunity was taken to conduct a further survey of fungicide resistance in collaboration with CCDM. This was particularly important for Qld production areas where the status of fungicide resistance within the WPM population has not been previously characterised (Poole *et al.* 2022).

What we did

WPM samples were collected by collaborating agronomists, sent to Tamworth for processing to help ensure viability in transit, then sent to CCDM for molecular analysis of frequency of mutations for DMI (F136 'gateway' mutation, triazoles) and QoI (A143 mutation, strobilurins) resistance within the WPM population in each sample. In 2022, nineteen viable WPM samples were analysed by CCDM from across Qld and NSW, with sample distribution being Qld (10), SW NSW (3), SE NSW (2), CE NSW (2), NE NSW (1) and NW NSW (1) (Table 1).

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.

Table 1: Location of 19 wheat powdery mildew samples collected across Qld and NSW in 2022 along with frequency of DMI (triazole) 'gateway' and QoI (strobilurin) mutations

Location	Year	Region	Variety	Frequency of mutation	
				DMI F136	QoI A143
Bell	2022	Qld	Sunflexⓓ	53%	10%
Bell	2022	Qld	Sunchaserⓓ	99%	17%
Chinchilla	2022	Qld	Sunmaxⓓ	100%	22%
Chinchilla	2022	Qld	Sunchaserⓓ	100%	7%
Gatton	2022	Qld	LongReach Hellfireⓓ	100%	51%
Jandowae	2022	Qld	Sunchaserⓓ	90%	38%
Jandowae	2022	Qld	Sunchaserⓓ	83%	16%
Macalister	2022	Qld	LongReach Hellfireⓓ	100%	56%
Macalister	2022	Qld	Sunchaserⓓ	99%	29%
Surat	2022	Qld	Sunmaxⓓ	72%	0%
Ashley	2022	NW NSW	Westcourtⓓ durum	66%	18%
Narrabri	2022	NE NSW	Breeding line	100%	10%
Grenfell	2022	CE NSW	Sunflexⓓ	100%	20%
Grenfell	2022	CE NSW	Breeding line	100%	0%
Balldale	2022	SE NSW	Scepterⓓ	100%	28%
Tocumwal	2022	SE NSW	Livingstonⓓ	100%	47%
Deniliquin	2022	SW NSW	Scepterⓓ	100%	11%
Finley	2022	SW NSW	Scepterⓓ	100%	58%
Widgelli	2022	SW NSW	Breeding line	100%	47%

All Qld and NSW WPM samples collected in 2022 had a DMI F136 mutation frequency of between 53 and 100% (Table 1). A lower frequency of the QoI A143 mutation was detected in 17 of the 19 WPM samples in 2022 which ranged from 7 to 58% (Table 1). This is the first report of DMI and QoI resistance within WPM in Qld but has been previously reported in NSW from testing conducted in 2020 and 2021. Presence of the QoI 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 concerning; as 2 of the 10 WPM samples tested from Qld (Gatton and Macalister) and 1 of 9 from NSW (Finley) had 100% resistance mutations to DMI (Group 3) in combination with >50% QoI (Group 11) modes of action (MoA), which could potentially result in dual resistance to both fungicide 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 Qld and NSW WPM pathogen populations is likely increasing the rate of selection for QoI resistance. A concerning aspect in relationship to the QoI A143 resistance gene, is that it confers cross resistance to all fungicides within the group 11 mode of action group (strobilurins) whether applied as a foliar spray or seed treatment.

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, QoIs, 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 or heading towards increased selection of dual resistance within WPM populations in some paddocks in southern Qld and NSW, 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 susceptible–very susceptible (S–VS) 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 southern Qld 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 southern Qld 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 to a lesser but developing extent QoI (strobilurin) fungicides. 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). Further information on fungicide resistance and its management in Australian grain crops is available at the AFREN website at grdc.com.au/afren.

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