FUNGICIDE RESISTANCE IN BARLEY

FACT SHEET

GRDC
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Fungicide resistance in barley crops: causes, management and mitigation strategies

KEY POINTS

- Fungicide resistance is the loss of fungicide effectiveness against a specific pathogen.
- Net form net blotch (NFNB), spot form net blotch (SFNB) and barley powdery mildew have all exhibited fungicide resistance in Australia.
- Rotate crops, plant resistant cultivars and manage stubble loads to minimise disease pressure.
- Avoid using a fungicide or fungicide Mode of Action (MoA) group in consecutive applications or more than twice in the same season.

Net form net blotch (NFNB), spot form net blotch (SFNB) and powdery mildew are important diseases of barley that have exhibited fungicide resistance in Australia. All fungal diseases of barley have the potential to develop resistance to any single-site fungicide that is used repetitively. Adopting good integrated disease management and fungicide usage practices now will help preserve the effectiveness of these useful chemicals.

Numerous cases of reduced sensitivity and resistance to fungicides have been identified in Australia's barley growing regions. More cases are expected to arise as survey and detection methods improve, and if current fungicide use patterns continue.

Fungicide resistance occurs when a previously effective fungicide fails to control a disease such as net blotch or powdery mildew.

It is a preventable issue, caused by repeatedly exposing a pathogen to a single fungicide active or to the chemical actives of a single Mode of Action (MoA) group.

It can become a major constraint to good disease control in barley, especially where no alternative fungicide or host-plant resistance is available.

Fungicide resistance can be a regional problem. Spores released by some fungicide resistant fungi such as barley powdery mildew can spread over large areas in a short time. Stubble-borne diseases, such as net blotches, can also be spread over large distances if infected straw is moved. Misuse of fungicides and poor disease management practices on a single farm can affect everybody in the district.

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Fungicide resistance in barley

Resistance to certain Group 3 (DMI) and Group 7 (SDHI) fungicides has been identified in net form net blotch (NFNB), spot form net blotch (SFNB) and barley powdery mildew.

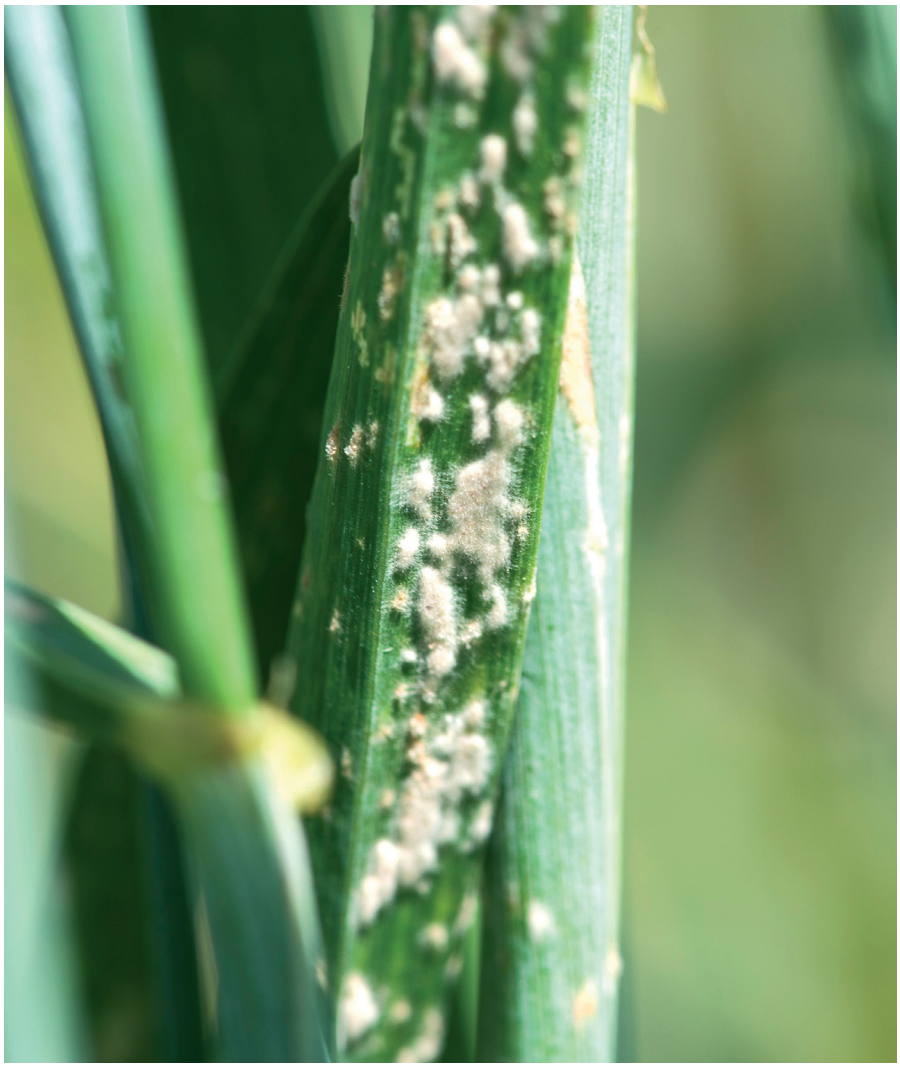
Growers should take all possible agronomic and usage precautions to avoid putting excessive pressure on fungicides.

This includes planting barley varieties with improved levels of genetic resistance to critical fungal diseases in your region, as well as rotating and mixing fungicide actives and MoA groups to avoid consecutive applications of the same chemistry, including between seasons if only one application is needed within a season.

Remember that seed treatments and in-furrow fungicides with foliar activity also count as a fungicide application, so avoid applying a foliar application from the same fungicide group in the same season.

Reduced sensitivity or resistance to a specific chemical active in a particular region should be treated as an indication of risk for other chemicals in the same MoA group within that region, as well as in other regions that share similar environments and/or employ similar agronomic practices.

Photo: GRDC.



Barley powdery mildew.

Known fungicide resistance issues – barley

The following information is correct at the time of publication and is subject to change. For the latest data on fungicide resistance in pulses, please consult an agronomist or refer to the AFREN website.

Barley powdery mildew

(Caused by *Blumeria graminis* f. sp. *hordei*)

Barley powdery mildew is typically favoured by susceptible hosts, mild and humid weather (15-22°C, relative humidity > 70%), higher nitrogen status, dense crop canopies, good soil moisture profiles, and extended periods of humid and damp canopies.

The pathogen has a short latent phase and can multiply quickly under optimum conditions.

Severe infections can occur in winter during both early and later crop growth and can cause significant yield loss in crops with high yield potential.

The pathogen survives on barley stubble and volunteer barley plants, from which spores can be spread by the wind.

FUNGICIDE RESISTANCE PROFILE

- **Resistance** to Group 3 (DMI) fungicide tebuconazole (e.g. Folicur®, Raxil®, etc) in Western Australia.
- **Reduced sensitivity** to Group 3 fungicides propiconazole (Tilt®, etc) and flutriafol (Armour®, Impact®, etc) in Western Australia.
- **Lab detection:** Target site mutation affecting Group 3 fungicides detected in samples from New South Wales, Queensland, Tasmania, Victoria and Western Australia.

Fungicide resistance result	Impact on fungicide use
Sensitive	Still works
Reduced sensitivity	Might still work okay • May need to use maximum label rates • Higher risk of developing resistance
Resistant	Doesn't work – avoid use
Lab detection	None – but indicates a potential risk to field effectiveness.

Tebuconazole-resistant barley powdery mildew was first identified in Western Australia in 2010, following widespread planting of susceptible varieties such as Baudin and repeated applications of Group 3 fungicides.

The outbreak has been largely controlled through planting less susceptible varieties and timely applications of effective fungicides.

Target site mutations associated with reduced sensitivity or resistance to Group 3 fungicides have since been detected in all other states except South Australia, with none of these detections associated with any reduced sensitivity or resistance in the field to date.

Net form net blotch (NFNB)

(Caused by *Pyrenophora teres* f. *teres*)

Net form net blotch (NFNB) is typically favoured by susceptible hosts, early sowing, mild weather (15-25°C) and extended periods of leaf wetness.

It is more damaging in wetter seasons, especially in systems with a high inclusion of susceptible barley in rotations, and where barley is sown into paddocks with high barley stubble loads.

NFNB survives between seasons on stubble, volunteer plants and seed.

FUNGICIDE RESISTANCE PROFILE

- **Resistance** to Group 3 (DMI) fungicides propiconazole (e.g. Tilt®, etc) and tebuconazole (e.g. Folicur®, Raxil®, etc) in the Esperance and Kwinana West port zones, Western Australia.
- **Resistance** to Group 7 (SDHI) fungicide fluxapyroxad (Systiva®) on the Yorke and Eyre Peninsulas, and the Kybybolite region, South Australia.
- **Reduced sensitivity** to Group 3 (DMI) fungicides epoxiconazole (e.g. Opus®, etc), propiconazole, prothioconazole (e.g. Prosaro®, etc) and tebuconazole in South Australia and Western Australia, and to propiconazole and tebuconazole in Victoria.
- **Reduced sensitivity** to Group 7 (SDHI) fungicide fluxapyroxad in South Australia.

Photo: Linda Thomson

Net form net blotch (NFNB)

- **Dual resistance/reduced sensitivity** – both reduced sensitivity to the Group 3 fungicide tebuconazole and resistance to the Group 7 fungicide fluxapyroxad have been detected in isolates from the Yorke Peninsula, South Australia.

NFNB isolates with reduced sensitivity and/or resistance to Group 3 fungicides have been detected in the Albany, Kwinana West and Esperance port zones of Western Australia since 2013.

The various resistance and reduced sensitivity cases detected in South Australia from 2019 have been associated with continuous planting of barley and repeated use of fluxapyroxad seed treatment. Many growers in the region have increased their rotation of crops, barley varieties and fungicides to provide a more dynamic host environment and reduce the impact of NFNB and associated fungicide resistance.

Spot form net blotch (SFNB)

(Caused by *Pyrenophora teres* f. *maculata*)

Spot form net blotch (SFNB) is also more prevalent in wetter years, especially in systems with a high inclusion of barley in rotations and where barley is sown into paddocks with high barley stubble loads.

SFNB is typically favoured by susceptible hosts, early sowing, mild weather (15-25°C) and extended periods of leaf wetness.

The pathogen survives between seasons on stubble and volunteer plants, from which spores can be spread by the wind.

FUNGICIDE RESISTANCE PROFILE

- **Resistance** to Group 3 (DMI) fungicides epoxiconazole (e.g. Opus®, etc), propiconazole (e.g. Tilt®, etc) and tebuconazole (e.g. Folicur®, Raxil®, etc) in the Albany and Esperance port zones of Western Australia.
- **Resistance** to Group 7 (SDHI) fungicide fluxapyroxad (Systiva®) in some areas of the Kwinana West port zone in Western Australia.
- **Reduced sensitivity** to Group 3 (DMI) fungicides epoxiconazole, propiconazole, prothioconazole (e.g. Prosaro®, etc) and tebuconazole in Western Australia.
- **Reduced sensitivity** to the Group 7 fungicide fluxapyroxad in some areas of the Kwinana West port zone in Western Australia.
- **Reduced sensitivity** to the Group 3 fungicide tebuconazole in South Australia and Victoria.
- **Lab detection** of dual reduced sensitivity to both the Group 3 fungicide tebuconazole and Group 7 fungicide fluxapyroxad in the Kwinana West port zone of Western Australia.

Spot form net blotch (SFNB).

Examples of resistance and/or reduced sensitivity to several Group 3 fungicides have been detected in Western Australia since 2016. Resistance/reduced sensitivity to fluxapyroxad was also detected in Western Australia in 2020. Further lab testing of these isolates detected incidences of dual resistance/reduced sensitivity to both Group 7 fluxapyroxad and Group 3 tebuconazole fungicides.

The development of these resistance and reduced sensitivity cases have largely been associated with continuous planting of barley and repeated use of fungicides such as propiconazole and fluxapyroxad.

Barley scald

(Caused by *Rhynchosporium secalis*)

FUNGICIDE RESISTANCE PROFILE

No known resistance issues in Australia.

There is a moderate risk of fungicide resistance developing. Resistance to Group 1 fungicides is common and widespread in the UK and reduced sensitivity has been detected for Group 3 and Group 11 fungicides in Europe.

Barley leaf rust

(Caused by Puccinia hordei)

FUNGICIDE RESISTANCE PROFILE

No known resistance issues.

The risk of fungicide resistance developing is low. Despite prolonged and continued fungicide use to manage cereal rusts on a global scale, resistance has not been reported to date.

Ramularia leaf spot

(Caused by *Ramularia collo-cygni*)

FUNGICIDE RESISTANCE PROFILE

No known resistance issues in Australia.

However, there is a high risk of fungicide resistance developing for this pathogen. Resistance to Group 1, 3, 7 and 11 fungicides has been reported in Europe and UK. Resistance to Group 7 and 11 fungicides, as well as reduced sensitivity to Group 3 fungicides, has been reported in New Zealand.

Integrated disease management (IDM) in barley

Good integrated disease management, backed up with strategic use of fungicides only when they are necessary, underpins good fungicide resistance management.

Agronomic strategies

- Plant barley varieties that are less susceptible to diseases of concern - avoid the most susceptible varieties in disease-prone areas.
- Avoid barley on barley by rotating crops and managing stubble and green bridge barley volunteers.
- Adjust sowing time to manage risk – early sowing can favour the development and impact of a number of diseases, including barley powdery mildew and net blotches.
- Apply fungicides only if necessary and apply strategically – fungicide use may not be economical or necessary in low disease pressure scenarios.
- Ensure correct disease diagnosis prior to applying fungicides. Net blotches in particular can be easily confused with physiological spotting which is common in some barley varieties.

When managing for barley powdery mildew:

- Avoid using excess nitrogen and provide adequate potassium.
- Control volunteer barley plants and weeds to deny the pathogen a green bridge.

When managing for net blotches:

- Use clean seed as NFNB is also seed transmissible.

Fungicide use and rotation

- Rotate and mix fungicide actives and MoA groups, while minimising the use of fungicides known to have compromised efficacy due to resistance.
- Avoid using the same fungicide active or MoA consecutively, both within and across seasons.
- Use mixtures containing different MoA groups whenever possible, especially if disease pressure is high.

GROUP 3 (DMI) FUNGICIDES

- Minimise the use of Group 3 fungicides that are known to be compromised for your target diseases.
- Avoid using stand-alone tebuconazole, propiconazole and epoxiconazole (e.g. Opus®, etc) against any disease in barley, to avoid selecting for resistance in non-target pathogens that may also be present.
- Limit use of any products containing a Group 3 fungicide to no more than three applications per growing season. In regions where resistance to Group 3 products has already been reported, reduce this to as few applications as possible.
- Rotate Group 3 fungicide actives within and across seasons as they are not equally affected by fungicide resistance.

Western region, barley powdery mildew management:

- Tebuconazole-based fungicides are no longer effective against barley powdery mildew in Western Australia and should not be used.

GROUP 7 (SDHI) FUNGICIDES

- Avoid using more than one application of fungicides containing Group 7 actives (solo or in mixture) per season and do not apply them more than twice in any growing season. This includes foliar sprays and in-furrow or seed treatments that affect foliar diseases. In-furrow and seed treatments count as one application each.
- Never apply consecutive treatments of fungicides containing a Group 7 active, including in-furrow treatments with foliar activity.

For example, if such an in-furrow treatment of Group 7 fungicide is applied at planting, the first foliar treatment must not contain a Group 7 product.

When managing for net blotches:

- Minimise use of Group 7 seed treatments and foliar sprays.
- Do not use Group 7 fungicides to control net blotches in areas where resistance has been reported.

GROUP 11 (QOI) FUNGICIDES

- Avoid using more than one application of fungicides containing Group 11 actives (solo or in mixture) per season and do not apply them more than twice in any growing season. This includes foliar sprays and in-furrow or seed treatments that affect foliar diseases. In-furrow and seed treatments count as one application each.
- Never apply consecutive treatments of fungicides containing a Group 11 active, including any in-furrow applications. For example, if an in-furrow treatment of Group 11 + 4 fungicide is applied at planting, the first foliar treatment must not contain a Group 11 product.

GROUP 13 FUNGICIDES

- Do not apply fungicides containing Group 13 (aza-napthalene) actives more than twice per growing season.

When managing for barley powdery mildew:

- Group 13 products (registered only for powdery mildew in barley) should be used in mixture with an effective partner or in rotation with fungicides of a different MoA group.
- If barley powdery mildew is already established, Group 13 actives should only be used in mixture or rotation with an effective curative fungicide.
- Where a Group 13 fungicide is applied alone, it should only be used as a protectant (preventative) treatment, not as a curative.

The Fungicide Resistance Five!

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

FREQUENTLY ASKED QUESTIONS

How does fungicide resistance develop?

Fungicide resistance occurs when fungicide resistant strains of a pathogen dominate the whole pathogen population. Fungicide resistant strains are 'selected for' by applications of the fungicide. That is, the non-resistant strains are controlled by the fungicide allowing the resistant strains to proliferate.

For more on the causes and effects of fungicide resistance, read the AFREN Fact Sheet How Fungicide Resistance Develops.

How do I know if I have a fungicide resistant disease in my crop?

If a fungicide application fails to provide adequate control of the disease, or if the lower range of application rates on the label for a fungicide must be steadily increased from application to application, there is cause for concern.

You should keep an accurate record of every fungicide application – including dates, times, weather conditions, application rates, crop growth stage and notes of any evidence of a disease being present.

What should I look for?

It is important to inspect the crop after every fungicide application to confirm whether the expected level of control has been achieved.

If the disease is still present or increasing, review records of the application for reasons why it may have failed. If there is no obvious cause, consult an expert and consider having samples of the infected crop tested for fungicide resistance.

Who do I contact?

Contact your agronomist or adviser and have them review the crop and your fungicide application records. If they suspect fungicide resistance, they will be able to arrange further investigation, sample collection and lab analysis.

Alternatively, you can visit the AFREN website About page for details of fungicide resistance experts in your region.

USEFUL RESOURCES

Australian Fungicide Resistance Extension Network (AFREN)
Dedicated website for the latest Fungicide Resistance information, reference materials, case studies, grower survey and news.
afren.com.au

AFREN Guide - Fungicide Resistance Management in Australian Grain Crops
Comprehensive guide to fungicide resistance issues, occurrences, and management – including details of fungicide Mode of Action groups, chemical actives, and diseases by crop. Prepared by AFREN and published by the GRDC.
afren.com.au/resources#FRManagementGuide

GRDC Fungicides in Australia Fact Sheet
GRDC How Fungicide Resistance Develops Fact Sheet
afren.com.au/resources#factsheets

GRDC Spot Form Net Blotch Fact Sheet
grdc.com.au/spot-form-net-blotch-factsheet

GRDC Barley Powdery Mildew Fact Sheet (Western Region)
grdc.com.au/resources-and-publications/all-publications/factsheets/2012/12/barley-powder-mildew

GRDC Control Strategies for Powdery Mildew (Western Region)
grdc.com.au/GRDC-FS-ControlStrategiesPowderyMildew

GRDC Powdery Mildew in Barley and Wheat Fact Sheet (Southern Region) grdc.com.au/GRDC-FS-PowderyMildewBarleyWheat

State Crop Guides - GRDC National Variety Trials
nvt.grdc.com.au/resources/crop-sowing-guides

Currently available barley varieties with disease susceptibility ratings, by growing region, from the GRDC National Variety Trials website.

REFERENCES

The content in this Fact Sheet is based on the content and sources included in the AFREN Guide **Fungicide Resistance Management in Australian Grain Crops.** See 'Useful Resources' opposite.

MORE INFORMATION

Australian Fungicide Resistance Extension Network (afren.com.au)

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