

FUNGICIDE ROTATION FACT SHEET



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Fungicide rotation

KEY POINTS

- Fungicide resistance is caused by repeated use of the same fungicide group.
- Rotation of fungicide Modes of Action (MoA) or Groups creates a dynamic environment where resistant individuals are unable to flourish.
- Rotations should avoid repeating use of any single fungicide group, including across seed/in-furrow and subsequent foliar applications.
- Fungicide rotations should be planned across seasons and crop rotations, to avoid selecting resistant pathogens on stubble.
- Use a year-round integrated disease management strategy to lower disease pressure and reduce the need for fungicide applications – for simpler rotation planning, cost savings, and long-term protection of fungicide efficacy.
- Suggested fungicide rotation sequences are available in the AFREN Fungicide Management Guide.

Photo: © Nicole Baxter, GRDC.



Applying fungicide, insecticide and herbicide on a Scepter[®] wheat crop near Old Junee, New South Wales.

Repeated exposure to the same fungicide group is the fundamental means by which fungicide resistance is selected for and promoted. Mixing and rotating fungicide groups helps prevent the resistant strains within a pathogen population from flourishing.

Introduction

Reduced sensitivity and resistance to fungicides is a significant risk to Australian cropping and can severely limit disease protection when growing conditions support widespread infection.

Changing the fungicide group at each application (fungicide rotation), when practised within a wider integrated

disease management strategy, vastly reduces the risk of fungicide resistance development.

Over-reliance on fungicides and failure to rotate products by group risks the loss of fungicide effectiveness in the paddock and could lead to a district-wide resistance problem.

How does fungicide resistance develop?

Fungicide resistant individuals are found in every fungal population. These individuals will carry mutations that reduce the effectiveness of a particular fungicide or multiple fungicides within a chemical group such as DMIs (Group 3).

When fungicides are applied, sensitive individuals are controlled while those with resistance mutations are not. Repeated applications of the same fungicide will continue to control the sensitive individuals while the resistant population increases.

In this way, the resistant strain can come to dominate the entire fungal population. The over-exposed fungicide will progressively lose its paddock effectiveness (reduced sensitivity) and require increasingly stronger doses to provide adequate disease control.

If use of the affected fungicide continues without rotation, resistance will continue to be selected, and the fungicide will eventually have no effect at all.

When a fungicide is overused, other fungicides within the same fungicide group can be impacted. For example, DMI propiconazole-resistant wheat powdery mildew pathogens are also resistant to DMI prothioconazole products.

Fungicides at risk of a 'domino effect'

Australian grain growers often have a limited range of permitted fungicide options for each crop they grow. Group 3 (DMI), Group 7 (SDHI) and Group 11 (QoI) are the most common fungicide groups for the highly effective single-site mode of action fungicides.

If one of these groups becomes less effective due to its repeated use, for example Group 3, the remaining rotation options could come under higher pressure or even be limited to Group 7 and Group 11 products.

These may then need to be applied more frequently, increasing the risk of selecting for resistance to one of those fungicide groups and restricting the available control options even further.

How fungicide rotation helps control resistance

While every fungal population will naturally contain some individuals with a resistance to one of the fungicide groups registered for use on that disease, it is rare for an individual to carry multiple resistance traits. However, if fungicides are over-used, individuals with resistance to multiple fungicide groups can emerge rapidly.

Therefore, following an application of fungicide from one fungicide group with a product from a different group is the best strategy for controlling individuals with resistance to either one of them.

Where possible, including at least one other fungicide group in the rotation will strengthen the spray program's effectiveness by providing a 'double knock' effect against resistant individuals before the fungicide group that favours them is re-applied.

Between the two applications, the entire population can be effectively controlled – but this strategy only works if it is implemented early.

Mix and rotate seed, in-furrow and foliar applications

Fungicide applications should be planned to achieve effective disease *and* fungicide resistance management.

This planning should not be limited to foliar applications. The mode of action group of products applied as seed dressings or in-furrow applications also need to be considered when planning mode of action rotations for subsequent foliar applications.

Mixtures provide broad control

Products comprising a mix of more than one fungicide group can provide broad coverage of resistant individuals in the population and more flexibility in rotation planning. However, the use of mixtures can easily lead to repeated applications of the same fungicide group and care must be taken to ensure groups are being adequately rotated.

It is important to account for each fungicide group in a mixture and use a sequence of single and mixture products to avoid excessive repetition.

Fungicide resistance terminology

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 a paddock 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 paddock 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 paddock.

■ LABORATORY 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 paddock. Laboratory testing can indicate a high risk of resistance or reduced sensitivity developing in the paddock.



Aerial application of fungicide on in the York region of WA.

Photo: © Eran Collis Photography.

Consider off-target pathogens

While the target pathogen for each fungicide application may be different (e.g. seed treatment targeting smuts followed by a foliar spray targeting powdery mildew), it should be assumed that off-target pathogens are also present in the paddock, even at non-detectable levels.

A small pathogen population may result in a more severe resistance problem if sensitive strains are eliminated, as the starting population will then comprise a far higher proportion of resistant individuals.

Off-target pathogens should always be considered when planning fungicide

rotations, especially where a high risk of reduced sensitivity or resistance is already known to exist.

Plan rotations across seasons

Fungicide rotations need to be planned across multiple seasons, as an ongoing program.

The first fungicide application in a new season should not be from the same fungicide group that was sprayed at the end of the previous season.

For example, if the final foliar spray before harvest was a Group 7 fungicide, then a Group 7 product should not be applied as a seed dressing for the following season.* Doing so may select

Group 7 resistance within the crop, which could impact control efforts later in the season and spread to other paddocks.

In this case, planning to use a Group 3 + 11 (DMI + QoI) mixture product or Group 3 only product for the foliar spray before harvest will allow safer use of a Group 7 seed treatment in the next season.

*Group 7 (SDHI) fungicide applied to seed or in-furrow may have differential foliar activity and will need to be assessed on a fungicide active by fungicide rotation basis.

Crop rotation still needs fungicide rotation

Even though almost all fungal pathogens are specific to one host crop, seasonal crop rotations do not remove the need for ongoing fungicide rotation. Many pathogens or their inoculum can survive on crop stubble for several years before being completely broken down.

Therefore, repeating a fungicide application in the subsequent crop can still select for resistance in the pathogen population on any remaining stubble.

Keep the plan flexible

Fungicides are a significant input cost for growers. The timing, severity and location of an infection (e.g. blackleg upper canopy infection on late flowering canola) can reduce the economic benefit of fungicide applications. Seasonal conditions can also influence the need for more or fewer treatments.

Fungicide rotation planning should include an assessment of disease risk, including past severity of infections and

whether the season may be excessively wet or dry.

In wet years, it may be wise to plan a 'spare' rotation in case disease is even more prevalent than expected, but growers should always be prepared to hold back an application if it is not needed. The unused fungicide stock can be saved for a future use, while not exposing the pathogen to a treatment will reduce the selection pressure on that fungicide group.

Growers should consult an agronomist or adviser and make use of tools such as the Canola CM and StripeRust WM smartphone apps, to determine whether a fungicide application will have an economic benefit.

Incorporate new fungicides in rotation

It is also important to integrate any new fungicides groups that become available into a rotation of effective product options.

Where established fungicide groups are affected by resistance or reduced sensitivity, there can be a temptation to rely on new and highly effective options. However, doing so will immediately favour individuals in the population with mutations conferring resistance to the new chemistry.

Maintaining a proper rotation sequence across seasons and across all the available and effective fungicide groups is essential to protect the effectiveness and longevity of each fungicide chemistry, including any new fungicide groups.

Minimise disease pressure to protect fungicides

Growers should use all available agronomic techniques to minimise disease pressure, so that fewer fungicide applications are needed in a typical growing season.

This makes planning fungicide rotation simpler, helps limit fungicide costs, and reduces each pathogen's exposure to individual fungicide groups.

Fungicides should be seen as the final element in a year-round integrated disease management (IDM) strategy that builds on disease risk awareness and variety selection, supported by non-chemical practices including crop rotation, stubble and green bridge eradication, and time of sowing decisions.

These principles are outlined in the AFREN 'Fungicide Resistance Five' (FR5).

Even with reduced yield potential, varieties with superior genetic resistance can provide better economic returns than a susceptible high-yielding crop once fungicide costs and yield losses are taken into account.

Rotating crops, paddocks and fungicide groups all help create a highly dynamic environment where disease and resistant pathogen strains have difficulty flourishing.

Strategic fungicide applications when seasonal conditions are favourable to disease development and thus can be more effective, and the efficacy of each fungicide group can be preserved for the longest possible time.

AFREN PRINCIPLES

AUSTRALIAN FUNGICIDE RESISTANCE EXTENSION NETWORK

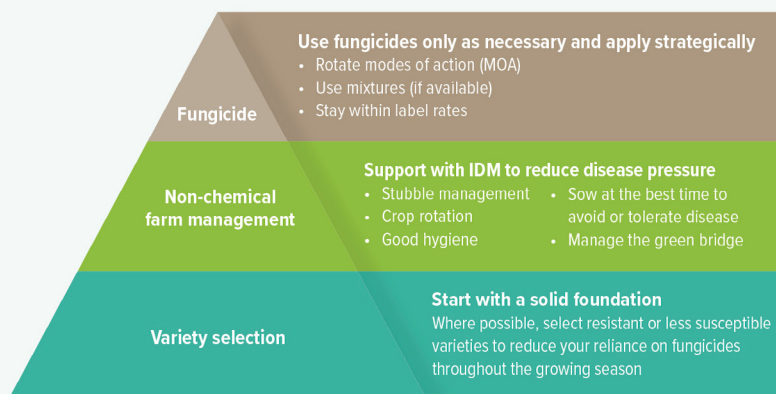


The Fungicide Resistance Five provides a creed to follow.

The Fungicide Resistance Five

- 1 Avoid susceptible crop varieties
- 2 Rotate crops – use time and distance to reduce disease carryover
- 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

Growers should seek to provide a strong and reliable foundation of resistant or less susceptible crop varieties, supported by non-chemical integrated disease management (IDM) that can be complemented by strategic and responsible use of fungicides.



FREQUENTLY ASKED QUESTIONS

Are there resources for planning fungicide rotations?

Yes. AFREN pathologists have developed a number of fungicide rotation recommendations that advisers and growers can adopt for barley, wheat and canola rotations. Each plan includes a seed/in-furrow treatment plus subsequent foliar sprays using a sequence of single fungicide group and mixture options.

On-farm application of these recommendations should account for the specific pathogen(s) being targeted, local fungicide registrations for the pathogen and crop, and any known fungicide resistance issues or risks.

The rotation sequences can be found in the AFREN Fungicide Resistance Management Guide. (See 'Useful resources'.)

How does fungicide resistance develop?

Fungicide resistance occurs when fungicide resistant strains of a pathogen come to dominate the pathogen population in a paddock or region. Repeated applications of the same fungicide will control the non-resistant population but allow these resistant strains to thrive.

For more on the causes and effects of fungicide resistance, read the GRDC AFREN Fact Sheet 'How Fungicide Resistance Develops'. (See 'Useful resources'.)

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

If a fungicide application fails to exhibit full control of the disease, or if the application rate for a fungicide must be steadily increased from application to application, there is cause for concern.

Who do I contact?

Contact your agronomist or adviser and have them review the crop and your fungicide application records. Alternatively, you can visit the AFREN website 'About' page for details of fungicide resistance experts in your region.

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'.)

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USEFUL RESOURCES

Australian Fungicide Resistance Extension Network (AFREN)

Dedicated site for the latest fungicide resistance information, reference materials, case studies, grower survey and news.
afren.com.au

AFREN Fungicide Resistance Management Guide

Comprehensive guide to fungicide resistance issues, instances and management – including details of fungicide MOA groups, chemical actives and diseases by crop. Prepared by AFREN and published by GRDC.
afren.com.au/resources/#management-guide

GRDC Fact Sheet Fungicides and fungicide resistance

afren.com.au/wp-content/uploads/2022/03/5542-AFREN-FR-in-Aust-Fact-Sheet_FA_online.pdf

GRDC Fact Sheet Understanding how fungicide resistance develops in cropping systems

afren.com.au/wp-content/uploads/2022/03/5542-AFREN-Fungicide-Resistance-Fact-Sheet_FA_online.pdf

GRDC Management Apps

grdc.com.au/resources-and-publications/apps

MORE INFORMATION

Australian Fungicide Resistance Extension Network afren.com.au

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DISCLAIMER While every effort has been made to ensure the scientific accuracy and currency of all information and recommendations, our understanding of fungicide resistance is constantly developing and readers are advised to seek further information regarding fungicide resistance from the [AFREN](http://afren.com.au), [CCDM Fungicide Resistance Group](http://ccdm.org.au) and [CropLife Australia](http://croplife.org.au) websites.

Not all active constituents/products in each MOA group are registered for use on the target pathogens indicated in each region.

It is the responsibility of growers and advisers to ensure that the fungicide is registered, or that permits are current, for the target pathogen, crop and region.

Current information on registered fungicides can be found on the [APVMA website](http://apvma.gov.au).

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