

CEREAL FUNGICIDES FACT SHEET

NORTHERN REGION

MANAGING CEREAL FUNGICIDE USE

Understanding foliar fungal diseases of cereals and how to manage them is in the interests of both the grower and the grains industry as a whole.

KEY POINTS

- Fungicides are only one component of a good management strategy.
- Cultivar resistance is the best protection against fungal diseases. Use moderately resistant (MR) to resistant (R) varieties where available.
- Disease control using fungicides is an economic decision.
- Understand the role of the season and have a plan in place, and if growing susceptible varieties have the right chemicals on hand.
- Remove the green bridge to prevent rusts from over-seasoning.
- Monitor crops throughout the season. Spray if disease threatens key plant parts of varieties that are moderately susceptible (MS) to very susceptible (VS).
- Fungicides do not increase yield; they protect yield potential and cannot retrieve yield lost once disease is established.
- Fungicide resistance is an important issue for powdery mildew control in WA and may develop in other states and other pathogens in the future. Repeat applications of the same active ingredient is not recommended.

Key cereal growth stages

Plant growth in cereals can essentially be broken down into two stages: pre-flowering (anthesis) and post-flowering.

Pre-flowering

Pre-flowering growth develops the leaves, roots and stems and sets the plant's yield potential. Eventual yield is linked to the amount of light the plant can intercept, that is, green leaf area. It is especially important to protect the top three (final) leaves, the flag, flag-1 (F-1) and flag-2 (F-2), from fungal infection.

Zadoks growth stages provide a guide to a crop's development. Table 1 outlines how growth stages can be used as an approximate guide to the emergence of the top three leaves.

Post-flowering

Post-flowering growth is mostly dedicated

to grain fill. The longevity of the crop canopy depends on nitrogen (N) and water. The longer the crop canopy stays green after flowering, the greater the eventual yield.

If neither N nor water is limiting, protection against fungal disease will help to maintain the photosynthetic area and yield potential.

Fungal disease

Biotrophic pathogens require a living plant host and include stem rust, stripe rust and leaf rust. These diseases cannot survive on soil, seed or dead tissue and need a green bridge of self-sown plants, grassy weeds or overlapping crops.

Necrotrophic pathogens kill the host tissue and draw nutrients from the dead cells. These include yellow spot (also known as yellow leaf spot or tan spot), net blotches, scald and septoria tritici blotch. Necrotrophic diseases survive between seasons on crop residues.



PHOTO: HUGH WALLWORK

Net form of net blotch in barley is a necrotrophic pathogen that starts with tiny brown lesions that elongate into dark streaks along and across the leaves. Management includes selection of resistant varieties, crop rotation (avoid sowing barley into barley stubble), seed treatment and crop monitoring with a view to fungicide applications, if required.

Disease epidemics occur when three variables, shown below, combine:

- **Environment:** Wet conditions are more conducive to fungal diseases, and each disease has an optimal temperature range where it develops most rapidly. Net blotches and yellow spot require free moisture for infection but high humidity is sufficient for powdery mildew.
- **Host:** Susceptible cultivars are more easily infected than resistant cultivars and produce more inoculum for the next disease cycle.
- **Pathogen:** Pathogens that have virulences that can overcome the resistance genes in a variety are able to establish in that variety.

TABLE 1 Growth stage and leaf emergence

Development Phase	Zadoks Growth Stage	Approximate leaf emergence stage
Stem elongation (GS30-39)	GS32 (second node)	Leaf 3 (F-2, the second leaf underneath the flag) fully emerged on main stem.
	GS33 (third node)	Leaf 2 (F-1, the leaf underneath the flag) fully emerged on main stem.
	GS37	Flag leaf just visible on main stem.
	GS39	Flag leaf fully emerged on main stem.

COURTESY: NICK POOLE, FAR AUSTRALIA

Before sowing

Coming into a season, researchers try to estimate which diseases will be problematic based on a range of conditions.

Growers should assess the disease risk in individual paddocks posed by retained stubbles and be aware of any green bridge threat in the region. Consider the season that is expected, and the short-to-medium term rainfall outlook. Select varieties accordingly.

Understand the likely response of your chosen varieties to each disease threat and have a treatment plan ready, including the right chemicals on hand if disease develops quickly.

Variety selection

Variety choice is arguably the most important aspect of managing foliar diseases. The more susceptible a variety, the more urgent the action required to arrest an epidemic.

Growers should assess potential risk, as stated above, and always try to select the most resistant variety for their circumstances.

In the case of cereal rusts, the minimum level of resistance a northern grower should accept is moderately resistant (MR). Knowing the level of resistance of the chosen variety will help with management decisions.

Resistant (R) varieties are usually resistant from emergence and throughout the life of the plant. On varieties with an MR rating for stripe rust, fungicides rarely deliver a cost-effective response. The further down the resistance rating scale from MR to VS the variety is rated, the more vigilant the grower needs to be and the more critical rapid response becomes to limiting yield loss if disease occurs in-crop.

Monitoring becomes very important during stem elongation. Fungicide use should be based on a risk assessment that includes varietal resistance, yield potential, disease pressure locally and regionally (particularly in warmer districts where disease may be more advanced), and crop growth stage.

Adult plant resistance

Adult plant resistance (APR) provides protection in a crop's post-seedling stages, typically becoming effective between tillering and booting (GS20 to GS49) and becoming increasingly active between GS30 and GS59.

It differs from seedling resistance (also

known as all-stage resistance), which protects the plant at all growth stages.

If a variety has significant APR, it can provide useful levels of late-season protection despite being susceptible as a seedling. While fungicide treatments at sowing in the form of seed, fertiliser or in-furrow treatment can help, spraying may still be required to protect key plant leaves if APR has not 'switched on' when these leaves are developing or if the level of APR is lower.

In these cases, APR complements a fungicide strategy by protecting those parts of the plant that contribute most to yield. However, a resistant plant's response to infection often involves death of the tissue around the site of the pathogen's incursion, resulting in the loss of some green leaf area and potential yield.

Identifying fungal disease

Before making the decision to spray, ensure the disease is correctly identified.

Nitrogen deficiency, for example, may be mistaken for yellow spot, and some symptoms of herbicide phytotoxicity can be mistaken for fungal lesions.

Barley responds to a range of stresses by developing spots – it may not be disease.

Look at the pattern of distribution of symptoms in the crop and consider other management practices before assuming a disease is present. In stubble-borne diseases there will generally be more lesions on the lower leaves and fewer lesions higher up the plant. Lesions or pustules will also tend to be randomly distributed across individual leaves, not concentrated at leaf tips.

If in any doubt, contact the department researcher from your state to have samples tested. Results are usually available quickly if the sample is good and the symptoms are clear. See Useful Resources.

Fungicide modes of action

There are two modes of action available in foliar fungicides used in Australian cereals:

- ▶ Group 3 Demethylation inhibitors (DMIs), including triazoles; and
- ▶ Group 11 Quinone outside inhibitors (QoI), or strobilurins.

All available products contain a group 3 DMI; two products are a mix of groups 3 and 11.

Seed treatments and in-furrow fungicides when applied for control of foliar diseases should also protect against smuts and

bunts, and some are also designed to target root diseases.

Flutriafol is registered for use as a foliar and fertiliser treatment for the control of stripe rust, septoria tritici blotch in wheat, and scald and powdery mildew in barley.

Fungicide timing

Factors that influence spray timing recommendations include:

- ▶ growth stage;
- ▶ level of disease;
- ▶ length of the grain fill period;
- ▶ crop yield expectations;
- ▶ whether the region/season is high or low rainfall and if an early seasonal cut-off is expected;
- ▶ the resistance rating of the variety; and
- ▶ the likelihood of disease.

In drier areas where the season is shorter, there is less time for the flag leaf to contribute to crop yield. As a result, there is a subtle change in emphasis for management of stripe rust, with protection of earlier leaves such as F-1 and F-2 becoming more important. In this situation, a GS32 or GS37 spray will usually give more value than an application at GS39.

Seed treatments and in-furrow fungicides delay the onset of a stripe rust epidemic and may protect the crop for long enough to see varieties with some level of APR through in most seasons. However, if the variety is very susceptible and stripe rust pressure is high, a later in-crop fungicide application may still be needed.

Two sprays – at GS32 and GS39 – may be required to control stripe rust where disease pressure is high and varieties have lower levels of resistance.

An alternative might be to have a longer season seed treatment followed by a GS39 treatment. In very high yield situations, later sprays may also have a role.

Stem rust, although not a big issue in the north due to varietal resistance, does not emerge until later in the season, when the weather is warmer, and moves rapidly once established.

Spraying for stem rust can be economical at much later growth stages than with other diseases. Sprays at GS45 to GS51 (booting to early ear emergence) are more effective on stem rust on the flag leaf sheath, while later sprays, GS55 to GS75, are more effective on disease on the ear and the peduncle. The optimal single spray timing is around GS55 to GS59, however, timing depends on the onset of infection.



PHOTO: McINTOSH, WELLINGS, PARK



PHOTO: HUGH WALLWORK



PHOTO: McINTOSH, WELLINGS, PARK

Leaf rust (left) can be identified by small circular to oval orange brown pustules, mainly on the upper surface of the leaf. **Stem rust (centre)** is characterised by oval, elongated reddish-chestnut-brown pustules with tattered edges. It infects leaves, the leaf sheaths, the stem, the peduncle and the outside of the head. The distinctive appearance of **stripe rust (right)** is caused by small yellow-orange circular pustules arranged in yellow stripes. It mainly infects the upper surface of the leaf, but can also appear on the leaf sheaths, the awns and inside the glumes.

Foliar fungicides are more effective in controlling rusts and mildews than they are in controlling necrotrophic diseases such as yellow spot and net blotches. Control is highly dependent on the timing of application, with product choice and rate of application also important. Higher rates of recommended product will give longer protection and are usually more effective on harder-to-control diseases.

In barley, the flag leaf contributes less to yield than it does in wheat; F-1 and F-2 are more important. However, the flag leaf sheath in barley is a major contributor to yield and it is not fully emerged until around GS49. Therefore protection against diseases such as leaf rust is often best managed using a two-spray strategy. The first spray can be timed for around GS30 to GS32 with a second application at around GS49.

Later sprays always carry a level of risk, so be mindful of withholding periods for harvest and also grazing with applications earlier in the season. Similarly, if spraying twice in a season, ensure that maximum residue limits (MRLs) will not be exceeded.

Fungicide application

Foliar fungicides need to cover a much larger plant area than herbicides. Unlike

herbicides, they are translocated in only one direction (from the point of contact towards the leaf tip) so, in effect, fungicides will protect only the portion of the leaf that is visible at the time of spraying. Therefore, when applying fungicides, a higher carrier volume is needed. A minimum of 70 to 80 litres is recommended.

Any leaf that emerges after spraying is unprotected, although when earlier sprays are applied, inoculum levels will be reduced.

Medium to medium-coarse droplets provide the best coverage. Fine droplets have poorer penetration of the crop canopy and present a greater risk of spray drift. Coarse droplets are not always retained on a waxy leaf surface as they can bounce off.

Tips for optimal fungicide efficacy

- ▶ Ensure thorough boom decontamination.
- ▶ Understand most fungicides have limited translocation. Hence coverage is required where control or protection is needed.
- ▶ Use a minimum of 70 to 80L carrier volume and medium to medium-coarse droplets. In denser canopies, more volume may be

required if the product needs to reach the lower parts of the canopy.

- ▶ Limit speed to less than 20 kilometres per hour. Higher speeds risk spray coverage being concentrated on only one side of the plant.
- ▶ Consider a narrower nozzle spacing (for example, 25 centimetres), with one angled forwards and one backwards, or twin jets. If using this option, limit speed to 16km/h.
- ▶ Use the correct surfactant, if advised, as per label recommendation.
- ▶ Use minimum controller hold settings to avoid pressure loss and under-dosing at the ends of runs where seed and pressure are normally reduced.

Aerial application (in non-controlled traffic systems) is another option for most foliar fungicides and is generally less damaging to the crop because there are no wheel tracks.

Aerial application works well with much lower carrier volumes (around 30 to 40L) for products designed to protect the flag leaf or upper parts of the foliage. However, higher application volumes may be required where deposition is needed in lower parts of large canopies.

However, barriers to aerial application (trees, power lines, proximity to roads/waterways) can be an issue and may leave parts of a paddock unsprayed that would otherwise have been covered with an application using a ground rig. This can cause issues with more rapid reinfection of a paddock once the fungicide protection wanes.

Late-season fungicide use

Some fungal leaf diseases, for example, stripe rust, can also cause infections in the head. These head infections compete with the developing grain for the plant's resources and may have an impact on quality, such as pinched grain and aborted florets.

TABLE 2 Modes of action registered for control of foliar diseases in Australian cereals

Group	Active ingredient	Example product name	Foliar (F), seed (S) or in-furrow (IF)
3 – DMI	Triadimefon	Triad®	F and IF
	Propiconazole	Tilt®	F
	Propiconazole + cyproconazole	Tilt® Xtra	F
	Tebuconazole	Folicur®	F and S
	Flutriafol	Impact®	F and IF
	Tebuconazole + flutriafol	Impact® Topguard	F
	Tebuconazole + prothioconazole	Prosaro®	F
	Epoxiconazole	Opus®	F
	Triadimenol	Baytan®	S
3 + 11 (Strobilurins)	Fluquinconazole	Jockey®	S
	Azoxystrobin + cyproconazole	Amistar® Xtra	F
	Pyraclostrobin + epoxiconazole	Opera®	F

COURTESY: RICHARD OLIVER, CURTIN UNIVERSITY

Late-season fungicide applications to control stripe rust head infection are generally ineffective. If the disease is visible, it is too late to treat it. There is also a higher chance of exceeding maximum residue limits (MRLs), which is a serious industry risk.

Economics

The decision to apply a fungicide for disease control is usually based on economics, that is, will the fungicide application give an economic return greater than the cost of application? Factors to consider in making this decision are:

- ▶ the presence of disease;
- ▶ yield potential;
- ▶ potential loss of yield and quality;
- ▶ commodity prices; and
- ▶ cost of fungicide plus application.

A break-even return suggests that the application is not warranted. Many growers consider a 100 per cent return on the cost of spraying justifies application of a fungicide.

Fungicide resistance

A GRDC-funded project based in Western Australia has recently confirmed triazole resistance in powdery mildew in barley.

This has had a devastating affect in WA causing losses estimated at \$100 million.

The resistance is associated with two mutations, one of which was detected in the northern region, and sends a warning to use fungicides responsibly.

For these reasons, barley growers should limit the use of tebuconazole (Folicur®, Impact® Topguard), flutriafol (for example, Impact®), triadimefon (Triad®) or triadimenol (Baytan®) alone where powdery mildew is the target disease.

Growers should instead consider rotating with fungicides from alternative modes of action (for example Amistar® Xtra, Opera®) and the remaining triazole fungicides (for example Tilt®, Tilt® Xtra, Prosaro®, Opus®). Refer to Table 2 for active ingredients.

GRDC PROJECT CODES

**CUR0010, CUR00015, CUR00016,
DAW00190, DAW00210, GRS10035,
ICN00010, UMU00031, DAS00099**

The GRDC is investing in research to bring new Australian modes of action to manage these risks.

Stewardship

In the absence of diseases or any threat of diseases, it is uneconomical and unnecessary to apply fungicides.

Good management practices such as controlling the green bridge for cereal rusts, attention to potential risk of stubble-borne leaf disease when deciding on crop rotations, and choosing the most resistant variety for the conditions will reduce the reliance on fungicides and disease pressure overall.

PHOTO: RICHARD OLIVER



Powdery mildew has developed resistance to some triazole fungicides in WA. Growers should not use tebuconazole, flutriafol, triadimefon or triadimenol alone for powdery mildew control.

USEFUL RESOURCES

Advancing the management of crop canopies: A cereal crop management guide

GRDC Bookshop; 1800 11 00 44; ground-cover-direct@canprint.com.au

Wheat and barley leaf symptoms Back Pocket Guide

www.grdc.com.au

Ground Cover TV: Adult plant resistance; Fungicide resistance

www.grdc.com.au

Adult plant resistance Fact Sheet

www.grdc.com.au/GRDC-FS-AdultPlantResistance

Cereal disease diagnosis:

Do not send samples in plastic. Samples of infected tissue should be in paper packaging – paper bags, envelopes or wrapped in newspaper – to one of the following researchers: Steven Simpfendorfer, NSW DPI, 4 Marsden Park Rd, Tamworth NSW 2340
Stephen Neate, QDAFF, Leslie Research Centre, PO Box 2282, Toowoomba QLD 4350
Greg Platz, QDAFF, Hermitage Research Facility, 604 Yangan Road, Warwick QLD 4370

Rust samples:

Samples of rust-infected plant tissue should be sent in paper packaging to:
Australian Cereal Rust Survey
Plant Breeding Institute, Private Bag 4011, Narellan NSW 2567

MORE INFORMATION

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- ▶ **Nick Poole, FAR Australia**, 03 5265 1290, poolen@far.org.nz
- ▶ **Steven Simpfendorfer, NSW DPI**, 0439 581 672, steven.simpfendorfer@dpi.nsw.gov.au

Acknowledgments: John Cameron, ICAN Rural; Stephen Neate, QDAFF; Richard Oliver, ACNFP, Curtin University; Robert Park, ACRCF, Sydney University; Greg Platz, QDAFF; Nick Poole, FAR; Steven Simpfendorfer, NSW DPI; Hugh Wallwork, SARDI.

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