MAY 2013

CEREAL FUNGICIDES FACT SHEET

GRDC
Grains Research & Development Corporation
Your GRDC working with you

WESTERN REGION

MANAGING CEREAL FUNGICIDE USE

Understanding foliar fungal diseases of cereals and how to manage them is in the interests of both the individual 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. Ideally, when agronomically suitable varieties are available, opt for moderately resistant (MR) to resistant (R) varieties in disease-prone environments.
- 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.
- For cereal rusts and mildew, remove the green bridge between crops.
- Spray if disease threatens key plant parts (flag to flag-2) of varieties that are moderately susceptible (MS) or susceptible (S).
- Fungicides do not increase yield; they protect yield potential and cannot retrieve lost yield if applied after infection is established.
- Fungicide resistance is a major emerging issue. Do not use tebuconazole-based products on barley if there is any chance of powdery mildew occurring, and select varieties that are resistant to powdery mildew.

Key cereal growth stages

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

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 through the crop canopy, so it is important to protect the top three (final) leaves from fungal disease as they emerge: the flag, flag-1 (F-1) and flag-2 (F-2).

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, protecting 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', grassy weeds or overlapping crops.

Necrotrophic pathogens kill the host tissue and draw nutrient from the dead cells. These include yellow spot (also known as yellow leaf spot or tan spot), net blotches, scald and stagonospora nodorum blotch (SNB). 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 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:** Source of pathogen inoculum is present (for example, green bridge or infected stubble). The pathotype present is virulent on resistant genes in a variety, allowing disease to establish.

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) emerges on main stem.
	GS33 (third node)	Leaf 2 (F-1, the leaf underneath the flag) emerges on main stem.
	GS37	Flag leaf just visible on main stem.
	GS39	Flag leaf fully emerged on main stem.

COURTESY: NICK POOLE, FAR AUSTRALIA

Level 1, Tourism House | 40 Blackall Street, Barton ACT 2600 | PO Box 5367, Kingston ACT 2604 | **T** +61 2 6166 4500 | **F** +61 2 6166 4599 | **E** grdc@grdc.com.au | **W** www.grdc.com.au

Before sowing

Growers should assess the disease risk in individual paddocks posed by retained infected stubbles, and review previous rotations.

Consider the season that is expected, the likelihood of disease (rotation, potential green bridge development) and the short-to-medium-term rainfall outlook. Select varieties accordingly.

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

Manage the factors within your control well and deal with others as they arise.

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 grower should accept when disease is a high risk for their region is moderately resistant to moderately susceptible (MR-MS). 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 and will not require fungicide protection. Varieties rated MS through to MR have some degree of resistance and may require fungicide protection depending on the level of disease pressure.

The more susceptible a variety is, 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 is important throughout the crop's growth; it allows early detection of disease. 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) to rust diseases 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. Fungicide treatments at sowing on seed or with fertiliser (in-furrow treatment) can help with early crop protection. However, if APR has not 'switched on' when key plant leaves are developing, or if the level of APR is lower, spraying the crop at a later growth stage may still be required.

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 involves killing off 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 necessarily 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 about the cause of a disorder or identification of cereal disease, contact your agronomist or local diagnostic service to have samples tested (AgWest Plant Laboratories, DAFWA).

Rust-infected plant tissue should be sent to the Australian Cereal Rust Survey (ACRS). Necrotrophic disease samples should be sent to the Australian Centre for Necrotrophic Fungal Pathogens (ACNFP), who will carry out DNA-based diagnosis and fungicide resistance testing. Survey samples sent to the ACRS and the ACNFP are not chargeable.

Any sample being posted should be sent in dry paper packaging: paper bags, envelopes or wrapped in newspaper. 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 mixture of groups 3 and 11.

Seed treatments and in-furrow fungicides should always protect against smuts and bunts, and some seed-dressing fungicides 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.

A permit for Prosper® (spiroxamine) is in place for barley powdery mildew in Western Australia from 2013 to 2016. Prosper® has performed well in tests and is a different mode of action.

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 the management of diseases such as 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 one delayed until GS39.

For stripe and leaf rusts, longer-acting seed treatments might also delay an epidemic and protect the crop for long enough to see varieties with some level of APR through.

Two sprays, one at GS30 to GS32 and the other at GS39, would usually be sufficient for control of most of the foliar diseases in higher rainfall areas with higher disease pressure seasons, where varieties display 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.

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 will infect both sides of the leaf, 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 along 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.*

Stem rust is a disease that 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 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. Application before disease becomes severe is essential.

Unlike diseases such as the rusts, necrotrophic diseases such as spot net blotch, yellow spot and the barley net blotches are difficult to control with fungicides. Results are highly dependent on the rate and timing of application. High label rates are advisable.

In barley, the flag leaf contributes less to yield than it does in wheat. F-1 and F-2 are more important to yield, so the first spray can be timed for around GS30 to GS32. This is the key timing for controlling wet weather diseases such as scald and other diseases such as powdery mildew and rust.

The flag leaf sheath in barley, however, is a major contributor to yield and it does not emerge until around GS49, so in a high-rainfall area, a spray should be timed accordingly.

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.

Application

Foliar fungicides need to cover a much larger 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.

New emerging leaf material is unprotected, although the earlier spray will mean inoculum levels are lower. When applying fungicides, a higher carrier volume is needed. A minimum of 70 to 80 litres is recommended.

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 (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 by 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, such as stripe rust and SNB, 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 a higher number of aborted florets.

However, late-season fungicide applications for diseases that affect mainly plant leaves and photosynthetic material are generally ineffective at these late timings. If the disease

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
	Fluquinconazole	Jockey®	S
3 + 11 (Strobilurins)	Azoxystrobin + cyproconazole	Amistar® Xtra	F
	Pyraclostrobin + epoxiconazole	Opera®	F
5 (Amines)	Spiroxamine*	Prosper®	F

*APVMA PERMIT (PER14012) ISSUED FOR WA ONLY AND EXPIRES MARCH 2016.

COURTESY: RICHARD OLIVER, CURTIN UNIVERSITY

is visible, it is often too late to treat it. There is also a higher chance of exceeding 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 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 in Western Australia has recently confirmed triazole resistance in powdery mildew in barley.

The findings mean that barley growers should not use tebuconazole alone (Folicur®, Impact® Topguard), flutriafol (for example, Impact®), triadimefon (Triad®) or triadimenol (Baytan®) if there is any chance at all of powdery mildew occurring in that season. In addition to the issue of resistance, their efficacy is questionable under powdery mildew disease pressure.

Growers should instead consider rotating with fungicides from alternative modes of action (for example Amistar® Xtra, Opera®), Prosper® containing spiroxamine (a permit (PER14012) has been issued for WA only and expires at the end of March 2016) and the remaining triazole fungicides (for example Tilt®, Tilt® Xtra, Prosaro®, Opus®). Refer to Table 2 for active ingredients.

Resistance to triazoles typically manifests as a reduction in efficiacy rather than a complete failure. Each different triazole is affected to a different extent.

Fungicides aren't mutagenic; they select less sensitive individuals that are capable of growing in the presence of that fungicide.

The process of mutation to resistance to each of the triazoles occurs in steps. Two mutations (one of which is already present in the eastern states) are linked to selection by tebuconazole. These mutations reduce efficacy to tebuconazole, flutriafol and triadimefon. Experience in Europe suggests that further mutations on top of the existing two might threaten currently effective triazoles such as prothioconazole epoxiconazole and propiconazole. Therefore use of tebuconazole on barley in mildew-prone areas, even for other diseases, threatens the usefulness of other triazoles.

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

Stewardship

In the absence of disease or any threat of disease, 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.

MORE INFORMATION

Ciara Beard, DAFWA, Geraldton
08 9956 8504
ciara.beard@agric.wa.gov.au

Kith Jayasena, DAFWA
08 9892 8477
kithsiri.jayasena@agric.wa.gov.au

Richard Oliver, Curtin University
08 9266 7872
richard.oliver@curtin.edu.au

Nick Poole, FAR Australia
03 5265 1290
poolen@far.org.nz

Geoff Thomas, DAFWA
08 9368 3262
geoff.j.thomas@agric.wa.gov.au

Acknowledgments: Ciara Beard, DAFWA; John Cameron, ICAN Rural; Kith Jayasena, DAFWA; Richard Oliver, ACNFP; Robert Park, ACRS; Nick Poole, FAR; Geoff Thomas, DAFWA; Hugh Wallwork, SARDI.

PHOTO: RICHARD OLIVER

The recent confirmation of triazole resistance in powdery mildew means that barley growers should not use tebuconazole, flutriafol, triadimefon and triadimenol if there is any likelihood of mildew occurring.

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 (APR) Fact Sheet
www.grdc.com.au/GRDC-FS-AdultPlantResistance

Cereal disease diagnosis:
AgWest Plant Laboratories, DAFWA
3 Baron-Hay Court
South Perth WA 6151

Send rust samples to:
Australian Cereal Rust Survey
Plant Breeding Institute
Private Bag 4011
Narellan NSW 2567

Send nectrotrophic diseases samples:
ACNFP, Curtin University
GPO Box U1987
Perth WA 6845

GRDC PROJECT CODES

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

DISCLAIMER
Any recommendations, suggestions or opinions contained in this publication do not necessarily represent the policy or views of the Grains Research and Development Corporation.
No person should act on the basis of the contents of this publication without first obtaining specific, independent, professional advice.
The Corporation and contributors to this Fact Sheet may identify products by proprietary or trade names to help readers identify particular types of products.
We do not endorse or recommend the products of any manufacturer referred to. Other products may perform as well as or better than those specifically referred to.
The GRDC will not be liable for any loss, damage, cost or expense incurred or arising by reason of any person using or relying on the information in this publication.
CAUTION: RESEARCH ON UNREGISTERED PESTICIDE USE
Any research with unregistered pesticides or of unregistered products reported in this document does not constitute a recommendation for that particular use by the authors or the authors' organisations.
All pesticide applications must accord with the currently registered label for that particular pesticide, crop, pest and region.
Copyright © All material published in this Fact Sheet is copyright protected and may not be reproduced in any form without written permission from the GRDC.

PRODUCED BY **WWW.CORETEXT.COM.AU**