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GRDC™ GROWNOTES™

GRDC™ GRAINS RESEARCH & DEVELOPMENT CORPORATION

TRITICALE

SECTION 9

DISEASES

KEY MESSAGES | GENERAL DISEASE-MANAGEMENT STRATEGIES | RUSTS | YELLOW LEAF SPOT (TAN SPOT) | TAKE-ALL | CROWN ROT | COMMON ROOT ROT | SMUT AND BUNT | RHIZOCTONIA ROOT ROT | SCALD | ERGOT | SEPTORIA TRITICI BLOTCH | CEREAL FUNGICIDES | BARLEY YELLOW DWARF VIRUS | DISEASE FOLLOWING EXTREME WEATHER

Diseases

Key messages

- Triticale can be less susceptible to the common fungal diseases of cereals, which makes it suitable for use in rotations where stubble is retained.
- Some varieties have good resistance to stem, leaf and stripe rusts, mildew and *Septoria tritici* blotch as well as both resistance and tolerance to cereal cyst nematode (CCN).
- Soil and stubble testing is essential for diagnosing many cereal diseases.
- Integrated Disease Management strategies are recommended to reduce disease risk and minimise the likelihood of resistance to controls methods.
- Keeping consistent paddock records and implemented crop rotations are some of the most important and simple strategies in fighting crop diseases.

In the early years of triticale in Australia, the crop was relatively free of disease compared with other winter cereals. As the crop expanded in the 1980s, a range of diseases became more important and began to require active management. The main diseases have been the three rusts (leaf, stem and stripe rust), crown rot, Barley yellow dwarf virus (BYDV). Breeders have had to be careful to avoid the release of susceptibility to diseases when releasing new varieties. [1] The potential arrival of stem rust Ug99 plus new races of stem rust has major implications for triticale production, since the genetics of rust resistance is less well documented in triticale than wheat. [2]

Triticale can be sensitive to BYDV, downy mildew, loose smut, yellow leaf spot, scald, rhizoctonia, ergot and some strains of stripe rust. These diseases may cause yield loss in triticale and crops should be monitored closely during seasons when conditions may favour the development of these diseases.

Nevertheless, triticale generally has better disease resistance than its wheat parent, courtesy of the rye component of its genetic make-up, and many growers use it as a disease break in their rotations and value the benefits of triticale for its contribution to soil conservation. Though triticale can have better resistance to some diseases than wheat, it can be a host for disease, so growers should monitor crops carefully and choose rotations based on disease risk.

Triticale has some resistance to take-all (lower susceptibility than wheat) and *Septoria tritici* blotch.

Triticale also assists in maintaining soil health by helping reduce nematodes, such as *Pratylenchus neglectus* and *P. thornei* (root-lesion nematodes) and *Heterodera avenae* (cereal cyst nematode), and a range of fungi and bacteria that build up in the soil and reduce yields when the same crop species is grown repeatedly.

Table 1 shows the reaction to diseases by different varieties of triticale. [3]

1 B McIntosh (1999) Cereal rust corner. Ground Cover. Issue 25. GRDC, https://grdc.com.au/Media-Centre/Ground-Cover/Ground-Cover-Issue-25/CEREAL-RUST-CORNER-with-Bob-McIntosh

2 RS Jessop, M Fittler (2009) Appendix 1. Triticale production manual: an aid to improved triticale production and utilisation. In J Roake, R Trethowan, R Jessop, M Fittler, Improved triticale production through breeding and agronomy. Pork CRC, http://www.apri.com.au/1A-102_Final_Research_Report_.pdf

3 Agriculture Victoria (2016) Triticale [download]. In Victorian winter crop summary. Agriculture Victoria, http://agriculture.vic.gov.au/agriculture/grains-and-other-crops/crop-production/victorian-winter-crop-summary

Table 1: *Triticale variety agronomic guide and disease reaction.*

Variety	Grazing production	Straw strength	Maturity	Resistances					
				Stem rust	Leaf rust	Stripe rust Tobruk pathotype	Stripe rust Yr 17–27 pathotype	Cereal cyst nematode	RLN *P. neglectus*
Dual-purpose									
Breakwell▲	quick–early	very good	mid–late	R	R	S–VS	MR	R	–
Cartwheel	quick–early	very good	mid–late	R	R	–	R	–	–
Crackerjack ▲	quick–early	moderate	mid	R	MR–MS	MS[a]	R–MR	–	–
Endeavour	quick–early	very good	late	R	R	R–MR	R–MR	R	–
Tobruk▲	quick–early	very good	mid–late	R	R	MS–S[a]	MR	–	–
Tuckerbox	quick–early	–	mid	MR	R	MR–MS	MR	R	–
Grain only									
Astute#	NR	very good	early–mid	R–MR	R–MR	–	R–MR	–	–
Berkshire▲	NR	good	early–mid	R	R	MS	MR–MS	–	–
Bison#	NR	good	early–mid	R–MR	R–MR	–	R	R	R
Bogong▲	NR	very good	early–mid	R–MR	R–MR	MS	MR–MS	–	–
Canobolas▲	NR	good	early–mid	R	R	MS–S	MR–MS	–	–
Chopper▲	NR	very good–good	very early	MR	R	MS–S	MR–MS	R	MR
Fusion	NR	medium-good	mid	R	R	MR[b]	R–MR	R	R
Goanna#	NR	good	early–mid	R	R	MR–MS	R–MR	R	–
Hawkeye	NR	good	mid	R–MR	R	MR, MS–S[b]	MR, MS[b]	R	R
Jaywick	NR	good	early–mid	MR–MS	R	MR, MS–MS[b]	R–MR, MS[b]	R	R
KM10#	NR	good	very early	R	MR–MS	–	R	S	–
Rufus▲	NR	good	early–mid	R	R	MS	MR–MS	R	R–MR
Tahara▲	NR	moderate	early–mid	R	R	MS	MR–MS	R	R
Yowie#	NR	good	mid	R	R	MR–MS, MS[b]	MR	R	–
Yukuri	NR	good	mid–late	R	R	R–MR	R–MR	S	–

NR = Not recommended, R = Resistant, R–MR= Resistant to Moderately resistant, MR = Moderately resistant, MR–MS= Moderately resistant to Moderately susceptible, MS = Moderately susceptible, MS–S= Moderately susceptible to Susceptible, S = Susceptible, S– VS=Susceptible to Very susceptible, VS=Very susceptible. V. Tol = Very tolerant, pOutclassed. a Susceptible to head infection. b mixed population, some plants are more susceptible to stripe rust. Where ratings are separated by '&' the first is correct for the majority of situations, but different pathotypes are known to exist at a low level and the latter rating reflects the response to these pathotypes.–Unknown or no data. # Limited data available on Astuteⓓ, Bisonⓓ, Goanna, KM10 and Yowie in NSW.

Source: NSW DPI

MORE INFORMATION

GrownNotes Alert™

9.1.1 GrowNotes Alert™

GrowNotes Alert is a free nationwide system for delivering urgent, actionable and economically important pest, disease weed and biosecurity issues directly to you, the grower, adviser and industry body, the way you want. Real-time information from experts across Australia, to help growers increase profitability.

A GrowNotes Alert notification can be delivered via SMS, email, web portal or via the iOS App. There are also three by dedicated regional Twitter handles–@GNAlertNorth, @GNAlertSouth and @GNAlertWest–that can also be followed.

The urgency with which alerts are delivered can help reduce the impact of disease, pest and weed costs. GrowNotes Alert improves the relevance, reliability, speed and coverage of notifications on the incidence, prevalence and distribution of these issues within all Australian grain growing regions.

9.2 General disease-management strategies

- Use resistant or partially resistant varieties.
- Use disease-free seed.
- Use fungicidal seed treatments to kill fungi carried on the seed coat or in the seed.
- Have a planned crop fungicide regime.
- Conduct disease audits of the crop to determine the severity of the disease. This can also be used as a tool to determine what crop is grown in what paddock the following year.
- Conduct disease audits of fallowed paddocks to determine the severity of the disease, e.g. yellow leaf spot and crown rot. This can also be used as a tool to determine what crop is grown in what paddock the following year.
- Send plant or stubble samples away for analysis (e.g. Plant Science Consulting) to determine the pathogen or strain you are dealing with or the severity of the disease.
- Keep the farm free of weeds, which may carry over some diseases. This includes cereals over summer that may act as a green bridge.
- Rotate crops. [4]

9.2.1 Integrated disease management tactics in triticale

Key points:

- Destroy volunteer triticale plants by Feburary, as they can provide a green bridge for rust carryover.
- Community efforts are required to eradicate volunteers from roadsides, railway lines, bridges, paddocks and around silos.
- Crop rotation is very important in the case of yellow leaf spot.
- Growing resistant varieties is an economical and environmentally friendly way of disease reduction.
- Seed or fertiliser treatment can control stripe rust up to four weeks after sowing, and suppress it thereafter.
- During the growing season active crop monitoring is very important for an early detection of diseases.
- Correct disease identification is very important; you can consult the department's fact sheets, charts, website and experts.
- When deciding if a fungicide spray is needed, consider crop stage and potential yield loss.
- Select a recommended and cost-effective fungicide.
- For effective coverage, the use of the right spray equipment and nozzles is very important.
- Read the label, wear protective gear, be safe to yourself and environment.
- Avoid repeated use of fungicides with the same active ingredient in the same season.
- Always check for withholding periods before grazing and harvesting a crop applied with any fungicide.

4 DAF Qld (2015) Wheat:diseases, physiological disorders and frost. DAF Queensland, http://www.daff.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/wheat/diseases

- If you suspect any severe disease outbreak, especially on resistant varieties, your agronomist or the local representatives of the state agricultural department. [5]

MORE INFORMATION

Ute Guides Online

GRDC, Cereal root and crown diseases: Back pocket guide

Field Crop Diseases Manual online

9.2.2 Tools for diagnosing cereal diseases

Foliar diseases–the Ute guide

GRDC UteGuides App is a mobile information resource for farmers and agronomists working in the Australian Grains Industry. It provides searchable library topics with extensive high resolution images on subjects relevant to grain-growers. It compliments and extends GRDC's paper-based Ute Guide series by linking all resources under a single App.

The GRDC Foliar diseases Ute Guide provides disease descriptions and images relevant to each crop.

Crop Disease Au app

The app Crop Disease Au, developed by the National Variety Trials, allows the user to quickly:

- Identify crop diseases.
- Compare disease-resistance ratings for cereal, pulse and oilseed varieties.
- Potentially, facilitate the early detection of exotic crop diseases.

The app brings together disease-resistance ratings, disease information and also features an extensive library of quality images that make it easier for growers to diagnose crop diseases and implement timely management strategies. Live feeds from the Australian National Variety Trials (NVT) database means the apps is always up to date with the latest varieties.

If a disease cannot be identified there is also a function that allows the user to take a photo of their crop and email it to a friend or an adviser.

The precursor for this app was the Victorian Department of Economic Development, Jobs, Transport and Resources (DEDJTR) Crop Disease app developed by a team of grains pathologists. Crop Disease Au functions similarly to the old app, but provides information for all Australian grain-growing regions.

9.3 Rusts

In Australia, there are three rust diseases of triticale and wheat:

- stripe rust
- stem rust
- leaf rust

They are caused by three closely related fungi all belonging to the genus *Puccinia*. The rusts are so named because the powdery mass of spores which erupt through the plant's epidermis have the appearance of rusty metal. The spores can be spread over considerable distances by wind, and may also spread via clothing and equipment.

Rusts have a number of features in common. They can only infect a limited number of specific host plants (mostly volunteer triticale, wheat and barley) and can only survive on green, growing plant tissue. Biotrophic pathogens (including stem rust, stripe rust and leaf rust) require a living plant host and, since they cannot survive on soil, seed or dead tissue, need a 'green bridge', grassy weeds or overlapping crops to persist. (Plants that facilitate the survival of rust fungi through the summer are components of what is known as the 'green bridge'.) [6]

5 DAF Qld (2015) Integrated disease management of wheat rusts and yellow leaf spot. DAF Qld, https://www.daf.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/wheat/wheat-rusts

6 DAF Qld (2015) Wheat: diseases, physiological disorders and frost. DAF Queensland, https://www.daf.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/wheat/diseases

MORE INFORMATION

Stripe rust pathotype 'Jackie Yr27' detected for the first time

The Rust Bust

Cereal rust situation, September 2016

Given favourable conditions rust can cause large losses in susceptible varieties. However, growers have shown that by planning to manage this disease they can effectively minimise its effects.

During the early 1980s a number of short, early triticales (e.g., Coorong and Satu) became susceptible to a new stem rust pathotype that evolved in southern Australia and moved northwards. As a result of heavy losses, triticale virtually disappeared from northern NSW and Queensland. The resistant varieties, such as Tahara, Muir, Bejon and Abacus, that replaced the older ones are too late for northern areas, and now triticale tends to be a crop for the southern zone, especially in areas with acid soils.

The early-maturing triticales have only six pairs of rye chromosomes, one pair being replaced by an additional pair from bread wheat. It turns out that the most effective genes for stem-rust resistance are located in the rye chromosome that was removed. That chromosome also carries a gene for day-length sensitivity that delays flowering.

In 2007, a new pathotype of stripe rust was detecting in many triticale cultivars. Despite dry conditions, stripe rust infections swept through triticale crops, in particular Jackie. The pathotype was virulent on most triticale varieties. The Jackie pathotype, unlike most new pathotypes, was widespread and affected most triticale cultivars. [7] The Jackie pathotype also had major impacts on the wheat industry.

Stripe rust reached epidemic levels in eastern Australia during 2009, resulting in widespread fungicidal spraying.

The University of Sydney's September 2016 Cereal rust report warned growers to monitor crops carefully. Reports on leaf rust and stripe rust in the eastern states suggested that these diseases are starting to gain momentum in crops. Monitoring of crops for all cereal rusts is advised and samples of all rusts observed in cereal crops should be submitted for pathotype analysis to the Australian Cereal Rust Survey. [8]

In the September 2016 cereal rust report, samples of leaf rust off Sunzell were received from the Queensland areas of Millmerran in mid August and Mirabookain in late August. Pathotype identifications for these two samples were under way in September. Later samples were also received from Warwick, Gatton, and Emerald.

The Rust Bust is an initiative of the Australian Cereal Rust Control Program (ACRCP) Consultative Committee, with support from the GRDC. The Rust Bust aims to raise awareness of rust-management strategies that reduces risk of disease outbreak.

9.3.1 Varietal resistance or tolerance

Some triticale varieties have good resistance to stem, leaf and stripe rusts (Table 2). [9]

7 NSW DPI (2007). New triticale stripe rust pathotype. NSW DPI, http://www.dpi.nsw.gov.au/content/archive/agriculture-today-stories/ag-today-archives/december-2007/triticale-stripe-rust-pathotype

8 W Cuddy, R Park, D Singh (2016) Cereal rust situation, September 2016. Cereal Rust Report (14) 7. University of Sydney, https://sydney.edu.au/content/dam/corporate/documents/sydney-institute-of-agriculture/research/plant-breeding-and-production/cereal_rust_report_2016_14_7.pdf

9 Agriculture Victoria (2016) Triticale [download]. In Victorian winter crop summary. Agriculture Victoria, http://agriculture.vic.gov.au/agriculture/grains-and-other-crops/crop-production/victorian-winter-crop-summary

Table 2: *Triticale resistance ratings to Rust diseases.*

Variety	Resistances			
	Stem rust	Leaf rust	Tobruk pathotype	Stripe rust Yr 17–27 pathotype
Dual-purpose				
Breakwell▲	R	R	S–VS	MR
Cartwheel	R	R	–	R
Crackerjack ▲	R	MR–MS	MS[a]	R–MR
Endeavour	R	R	R–MR	R–MR
Tobruk▲	R	R	MS–S[a]	MR
Tuckerbox	MR	R	MR–MS	MR
Grain only				
Astute#	R–MR	R–MR	–	R–MR
Berkshire▲	R	R	MS	MR–MS
Bison#	R–MR	R–MR	–	R
Bogong▲	R–MR	R–MR	MS	MR–MS
Canobolas▲	R	R	MS–S	MR–MS
Chopper▲	MR	R	MS–S	MR–MS
Fusion	R	R	MR[b]	R–MR
Goanna#	R	R	MR–MS	R–MR
Hawkeye	R–MR	R	MR, MS–S[b]	MR, MS[b]
Jaywick	MR–MS	R	MR, MS–MS[b]	R–MR, MS[b]
KM10#	R	MR–MS	–	R
Rufus▲	R	R	MS	MR–MS
Tahara▲	R	R	MS	MR–MS
Yowie#	R	R	MR–MS, MS[b]	MR
Yukuri	R	R	R–MR	R–MR

NR = Not recommended, R = Resistant, R–MR= Resistant to Moderately resistant, MR = Moderately resistant, MR–MS= Moderately resistant to Moderately susceptible, MS = Moderately susceptible, MS–S= Moderately susceptible to Susceptible, S = Susceptible, S– VS=Susceptible to Very susceptible, VS=Very susceptible. V. Tol = Very tolerant, pOutclassed. a Susceptible to head infection. b mixed population, some plants are more susceptible to stripe rust. Where ratings are separated by '&' the first is correct for the majority of situations, but different pathotypes are known to exist at a low level and the latter rating reflects the response to these pathotypes.–Unknown or no data. # Limited data available on Astute(þ, Bison(þ, Goanna, KM10 and Yowie in NSW.

Source: NSW DPI).

9.3.2 Symptoms

Table 3 outlines the symptoms of common diseases of cereals. [10]

Table 3: *Diagnosing leaf diseases in cereals.*

Disease	Spore colour	Symptoms	Plant part affected
Stripe rust	Yellow-orange	Small closely packed circular pustules during the vegetative stage, becoming stripes along leaves of older plants	Upper surface of leaf, leaf sheaths, awns and inside glumes
Leaf rust	Reddish-orange	Random, circular to oval pustules	Upper surface of leaf and leaf sheaths
Stem rust	Reddish-brown	Random, oblong pustules with torn margins	Both sides of leaf, leaf sheaths, stems and outside of head
Yellow leaf spot	small tan (yellowish-brown) oval spots surrounded by a yellow margin	Spots up to 10 mm, varied shapes and may coalesce	Both sides of leaf, leaf sheaths, stems and outside of head

Source: DAF Qld

9.3.3 Stripe rust

Stripe rust has become more important in recent years owing to new races arriving in eastern Australia.

Stripe rust is caused by the fungus *Puccinia striiformis*. It is easily distinguished from other rusts by the yellow-orange spores, which produce small, closely packed pustules that develop into stripes along the length of the leaf veins. The spores occur on the upper surface of the leaves, the leaf sheaths, awns and inside of the glumes (Photo 1). [11]

Photo 1: *Stripe rust in a cereal plant.*

Source: DAF Qld

Stripe rust requires cool and wet conditions to infect the crop. Free moisture on the leaves and an optimal temperature of 10–15°C are required for infection. Pustules erupt 10–14 days after infection.

10 DAF Qld (2015) Integrated disease management of wheat rusts and yellow leaf spot. DAF Queensland, https://www.daf.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/wheat/wheat-rusts

11 DAF Qld (2015) Integrated disease management of wheat rusts and yellow leaf spot. DAF Qld, https://www.daf.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/wheat/wheat-rusts

VIDEOS

WATCH: GCTV1: Cereal rust

If the weather is conducive to stripe rust, the disease can cause up to 25% yield loss on varieties scoring moderately susceptible = 5 (MR–MS) or lower. This is provided there is inoculum from a neglected green bridge or from an infected crop.

There are several fungicides recommended for the control of stripe rust. Fungicides can be incorporated with the fertiliser or applied as seed dressings to delay the onset of disease. Later on if the 'money' leaves require protection and stripe ruse is present in the district, recommended foliar fungicides can be applied for the control of stripe rust (see Tables 4 and 5 in Section 9.3.6: Managing cereal rusts).

Managing stripe rust

Stripe rust may be a problem in triticale. The key to stripe rust management is variety choice. Avoid growing highly susceptible varieties, and use moderately or highly resistant varieties instead. Growers should check to ensure their current variety has adequate field resistance to both the Jackie and Tobruk(D pathotypes of stripe rust or consider using foliar fungicides to control the disease in the crop if required.

There are now options available to treat seed to provide seedling protection against the disease. [12] Seed treatment should be considered for controlling seedling stripe rust in susceptible varieties, especially those sown early for grazing. [13] Fertiliser can also be treated with fungicides to help aid with rust control.

Newer varieties generally have improved stripe-rust resistance. Varieties with at least an MR–MS (moderately resistant–moderately susceptible) should be used. Usually changing to a more resistant variety also gives a yield advantage. For example, changing from Jackie to Endeavour(D makes good sense. Endeavour(D offers a 15% yield increase over Jackie, has excellent dry-matter production for early grazing, and is resistant to all current strains of stripe rust.

Seek local advice on managing stripe rust in triticale. Remember that just because a variety is rust resistant does not mean it will be completely free of stripe rust.

Under very high disease pressure, isolated leaves of resistant varieties can be infected. This does not automatically mean the resistance has broken down or that the crop needs spraying. [14] In these cases rust samples should be sent to:
Australian Cereal Rust Survey
Plant Breeding Institute
Private Bag 4011
Narellan, NSW 2567

9.3.4 Stem rust

Triticale has good resistance to stem rust. [15] All the present commercial varieties have been screened for the current races of stem rust and they have adequate levels of resistance, although if new races arrive varieties will require screening for them as the levels of resistance to new races are unknown. [16]

Stem rust is caused by the fungus *Puccinia graminis* f. sp. *tritici*. In addition to triticale it can also attack wheat, barley and cereal rye. It produces reddish-brown spore masses in oval, elongated or spindle-shaped pustules on the stems and leaves. Unlike leaf rust, pustules erupt through both sides of the leaves (Photo 2). [17] Ruptured pustules release masses of stem rust spores, which are disseminated by wind and other carriers.

12 Agriculture Victoria (2012) Growing triticale. Note AG0497. Revised. Agriculture Victoria, http://agriculture.vic.gov.au/agriculture/grains-and-other-crops/crop-production/growing-triticale

13 P Matthews, D McCaffery, L Jenkins (2016) Winter crop variety sowing guide 2016. NSW DPI, https://www.dpi.nsw.gov.au/agriculture/broadacre-crops/guides/publications/winter-crop-variety-sowing-guide

14 Waratah Seed Company (2010) Triticale: planting guide. Waratah Seed Company, http://www.porkcrc.com.au/1A-102_Triticale_Guide_Final_Fact_Sheets.pdf

15 KN Adhikar, RA McIntosh (1998). Inheritance of wheat stem rust resistance in triticale. Plant Breeding, 117 (6), 505–513.

16 RS Jessop, M Fittler (2009) Appendix 1. Triticale production manual: an aid to improved triticale production and utilisation. In J Roake, R Trethowan, R Jessop, M Fittler, Improved triticale production through breeding and agronomy. Pork CRC, http://www.apri.com.au/1A-102_Final_Research_Report_.pdf

17 DAF Qld (2015) Integrated disease management of wheat rusts and yellow leaf spot. DAF Queensland, https://www.daf.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/wheat/wheat-rusts

Photo 2: *Stem rust in a cereal plant.*

Source: DAF Qld

Stem rust develops at higher temperatures than the other rusts, within a range of 18–30°C. Spores require free moisture (i.e. dew, rain or irrigation) and take up to six hours to infect the plant. Pustules can be seen 10–20 days after infection.

Inoculum must be present for the disease to develop. Practicing crop hygiene by removing volunteer cereals, which forms a green bridge for the fungus through the summer, can eliminate or delay the onset of stem rust.

Foliar fungicides to control stem rust are presented in Tables 4 and 5 in Section 9.3.6: Managing cereal rusts.

9.3.5 Leaf rust

Triticale response to leaf Rust varies from moderately susceptible to resistant, depending on the variety.

Leaf rust is caused by the fungus *Puccinia triticinia* (previously called *Puccinia recondite* f. sp. *tritici*). The disease can infect triticale, rye and wheat. It produces reddish-orange spores which occur in small, 1.5 mm, circular to oval-shaped pustules. These are found on the top surface of the leaves, distinguishing leaf rust from stem rust (Photo 3). [18]

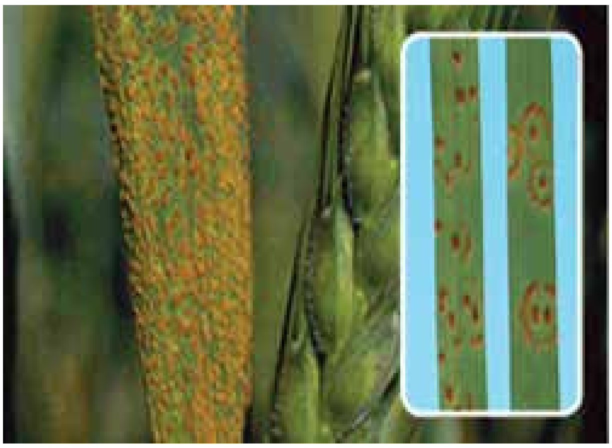


Photo 3: *Leaf rust in a cereal plant.*

Source: DAF Qld

VIDEOS

WATCH: GCTV5: Green bridge control for less stem rust

MORE INFORMATION

Stem rust

Leaf rust

GRDC Foliar Diseases–Ute Guide

18 DAF Qld (2015) Integrated disease management of wheat rusts and yellow leaf spot. DAF Qld, https://www.daf.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/wheat/wheat-rusts

The spores require temperatures of 15–20°C and free moisture (i.e. dew rain, irrigation) on the leaves to successfully infect cereal. The first signs of the disease, sporulation, occur 10–14 days after infection. Removal of volunteer cereal plants, which form a green bridge for the fungus through the summer, can eliminate or delay the onset of leaf rust.

Foliar fungicides to control leaf rust are presented in Tables 4 and 5 in Section 9.3.6: Managing cereal rusts.

9.3.6 Managing cereal rusts

Rust diseases of cereals can be eliminated or significantly reduced by removing the green bridge. This should be done well before the new crop is sown, allowing time for any herbicide to work and for the fungus to stop producing spores.

Wherever possible, sow resistant varieties rated MR (moderately resistant = 6) and above.

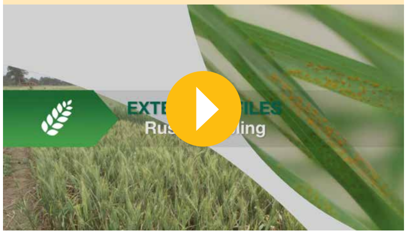
Rust fungi change continuously, producing new pathotypes. They are detected when disease is found on a previously resistant variety. Even if a resistant variety has been sown, the crop should be monitored on a regular basis, starting no later than growth stage (GS) 32, the second-node stage on the main stem, and continue to at least GS 39, the flag leaf. This is because the flag leaf and the two leaves below it are the main factories contributing to yield and quality. It is very important that these leaves are protected from diseases. [19]

Always read product labels carefully and stay up to date with the APVMA website.

There are a number of fungicides recommended for the control of foliar diseases of cereals (Table 4 and Table 5). [20]

VIDEOS

WATCH: GCTV Extension files: rust sampling



MORE INFORMATION

CSIRO, Cereal rusts

The Rust Bust

Table 4: *Fungicides recommended for seed and fertiliser treatment.*

Diseases	Fungicides	
	Fluquinconazole (167 g/L)	**Flutriafol (250 g/L)**
Stripe rust (yellow rust)	Rate of product formulation: 450 mL/100 kg seed	Rate of product formulation: 200 or 400 mL/ha fertiliser
Leaf rust (brown rust)	Rate of product formulation: 450 mL/100 kg seed	
Stem rust (black rust)		
Withholding periods	12 weeks for grazing and harvest	4 weeks for grazing and harvest

Source: DAF Qld

19 DAF Qld (2015) Wheat:diseases, physiological disorders and frost. DAF Qld, https://www.daf.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/wheat/diseases

20 DAF Qld (2015) Integrated disease management of wheat rusts and yellow leaf spot. DAF Qld, https://www.daf.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/wheat/wheat-rusts

Table 5: *Rate of fungicide (product formulation) recommended as foliar sprays for the control of rust diseases of cereals.*

Diseases	Foliar fungicides							
	Epoxi-conazole (125 g/L)	Flutriafol (250 g/L)	Propi-conazole (250 g/L)	Triadime-fon (125 g/L)	Tebuco-nazole (430 g/L)	Prothioconazole (210 g/L) + Tebuconazole (210 g/L)	Azoxystrobin (200 g/L) + Cyproconazole (80 g/L)	Propiconazole (250 g/L) + Cyproconazole (80 g/L)
Stripe rust (yellow rust)	250–500 mL/ha	250–500 mL/ha	250–500 mL/ha	500 or 1000 mL/ha	145 or 290 mL/ha	150–300 mL/ha + Hasten 1% v/v	400 or 800 mL/ha	250–500 mL/ha
Leaf rust (brown rust)	500 mL/ha	250–500 mL/ha	150–500 mL/ha		145 or 290 mL/ha	150–300 mL/ha + Hasten 1% v/v	400 or 800 mL/ha	150–500 mL/ha
Stem rust (black rust)			500 mL/ha		145 or 290 mL/ha	150–300 mL/ha + Hasten 1% v/v		500 mL/ha
Yellow leaf spot (tan spot)			250–500 mL/ha		145 or 290 mL/ha	150–300 mL/ha	400 or 800 mL/ha	250–500 mL/ha
Withholding periods	6 weeks for grazing and harvest	7 weeks for grazing and harvest	4 weeks for harvest, 7 days for grazing	4 weeks for grazing and harvest	5 weeks for harvest, 14 days for grazing	5 weeks for harvest, 14 days for grazing	6 weeks for harvest, 21 days for grazing	6 weeks for harvest, 21 days for grazing

Source: DAF Qld, Last updated 24 April 2015

VIDEOS

WATCH: GCTV18: Adult plant resistance—fungicide

WATCH: GCTV9: Cereal rust—adult plant resistance

WATCH: GCTV18: Triple rust resistance

IN FOCUS

Breeding cereals for rust resistance in Australia

Rust diseases have caused significant losses to Australian cereal crops, and continue to pose a serious threat. Because Australian cereal-crop yields are generally low, genetic resistance remains the most economical means of controlling rust. Resistant cultivars also contribute significantly to reducing over-summer rust survival.

The Australian Cereal Rust Control Program conducts annual pathogenicity surveys for all cereal rust pathogens, undertakes genetic research to identify and characterise new sources of resistance, and provides a germplasm screening and enhancement service to all Australian cereal-breeding groups. These three activities are interdependent and are closely integrated, with particular emphasis on linking pathology and genetics to develop more resistant varieties. Recent changes in the rust pathogens, including the development of virulences for the resistance genes Yr17, Lr24, Lr37 and Sr38, and the introduction of a new pathotype of the stripe rust pathogen, have provided new and significant challenges for rust resistance breeding. Similar challenges exist in breeding barley and oats for rust resistance. In future, as more markers linked to durable rust resistance sources become available, it is likely that the use of marker-assisted selection will become more common-place in rust resistance breeding. [21]

9.4 Yellow leaf spot (tan spot)

Yellow leaf spot, has become a widespread and important disease of cereals in Australia (Photo 4). [22] Its expansion has been supported by stubble retention, intense cereal production in the rotation and widespread cultivation of susceptible varieties. [23]

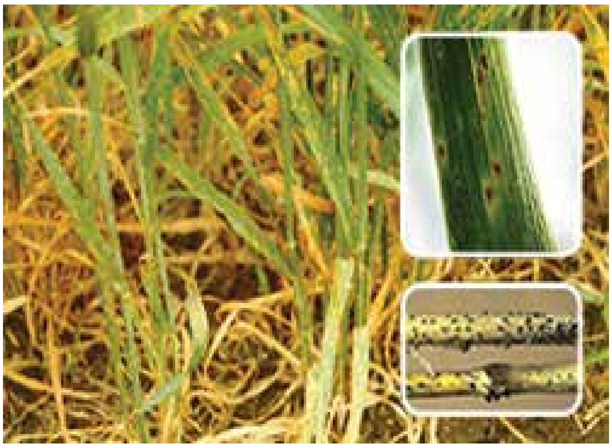


Photo 4: *Yellow leaf spot in cereal crop.*

Source: DAF Qld

21 RF Park (2008) Breeding cereals for rust resistance in Australia. Plant Pathology, 57 (4), 591–602.

22 DAF Qld (2015) Integrated disease management of wheat rusts and yellow leaf spot. DAF Queensland, https://www.daf.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/wheat/wheat-rusts

23 G Holloway (2014) Yellow leaf spot of wheat. Note AG1114. Revised. Agriculture Victoria, http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/plant-diseases/grains-pulses-and-cereals/yellow-leaf-spot-of-wheat

VIDEOS

WATCH: GCTV2: Yellow or tan spot

Yellow leaf spot is caused by the fungus *Pyrenophora tritici-repentis*. It survives in wheat and, occasionally, triticale stubble. In rare cases, the fungus may survive in barley stubble. Wet spores (ascospores) develop in fungal fruiting bodies on stubble, and spread during wet conditions to infect growing plants.

As the crop develops, masses of a second type of spore (conidia) are produced on old lesions and dead tissues. Conidia result in rapid development of the epidemic within a crop and spread of the disease to other crops and areas. Again, wet conditions are necessary for spore production and infection. Strong winds are needed to spread the disease any great distance. [24]

9.4.1 Varietal resistance or tolerance

Most triticale cultivars have moderate resistance to yellow leaf spot (Table 6). [25] Yellow leaf spot, however, it can still carryover the disease into following years. [26]

Table 6: *Triticale variety disease guide for yellow leaf spot.*

Variety	Resistance to yellow leaf spot
Astute(D)	MR–MS
Berkshire(D)	MR
Bison(D)	MR
Canobolas(D)	MR
Chopper(D)	MR
Endeavour(D)	MR
Fusion(D)	MR–MS
Goanna	MR
KM10	MR–MS
Rufus	MR
Tahara	MR
Tobruk(D)	MR
Tuckerbox	MR
Yowie	MR

Maturity: E = early, M = mid-season, L = late, VL = very late Height: M = medium, T = tall Colour: W = white, Br = brown Disease resistance order from best to worst: R > R–MR > MR > MR–MS > MS > MS–S > S > S–VS > VS *p* = provisional ratings—treat with caution, R = resistant, M = moderately, S = susceptible, V = very # Varieties marked may be more susceptible if alternative strains are present

Source: Agriculture Victoria

9.4.2 Damage caused by disease

Yellow leaf spot is most often observed in seedlings, but when conditions are suitable it can progress up the plant where it causes significant yield loss. [27] Grain yield can be substantially reduced and losses of more than 50% may occur in extreme situations. Pink grain with reduced value is also a frequent result of severe yellow leaf spot epidemics. Where cereal follows cereal and some stubble is left on the soil surface, losses may be around 10–15%, and up to 30% in wet seasons.

24 DAF Qld (2015) Wheat: diseases, physiological disorders and frost. DAF Qld, https://www.daf.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/wheat/diseases

25 Agriculture Victoria (2016) Triticale [download]. In Victorian winter crop summary. Agriculture Victoria, http://agriculture.vic.gov.au/agriculture/grains-and-other-crops/crop-production/victorian-winter-crop-summary

26 Birchip Cropping Group (2004) Triticale agronomy 2004. Online Farm Trials, http://www.farmtrials.com.au/trial/13801

27 G Holloway (2014) Yellow leaf spot of wheat. Note AG1114. Revised. Agriculture Victoria, http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/plant-diseases/grains-pulses-and-cereals/yellow-leaf-spot-of-wheat

9.4.3 Symptoms

Yellow leaf spot is characterised by tan-brown flecks turn into yellow-brown oval-shaped spots or lesions surrounded by yellow margins. They may expand to 10–12 mm in diameter. Large lesions coalesce, and develop dark brown centres or cause the tips of leaves to die. Spots develop on both sides of leaves (Photos 5 and 6). Severe yellow leaf spot may result in short, spindly plants with reduced tillering and root development. Where conditions are favourable to the disease, plants may be fully defoliated soon after flowering. [28]

Photo 5: *Yellow leaf spot in triticale.*

Source: Thomas County Ag

28 DAF Qld (2015) Wheat: diseases, physiological disorders and frost. DAF Qld, https://www.daf.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/wheat/diseases

Photo 6: *Yellow spot lesions may coalesce, causing the tip of the leaf to die.*

Source: Thomas County Ag

9.4.4 Conditions favouring development

Yellow leaf spot is likely to develop in wet years in paddocks where triticale residues remain on the soil surface. Temperatures of 15–28°C, with up to 12 hours of leaf wetness, are the optimal condition for infection. [29]

9.4.5 Management of disease

The impact of the disease can be reduced by:

- Planting partially resistant varieties.
- Rotating with resistant crops such as barley, oats or chickpeas.
- Incorporating the stubble into the soil.
- Grazing or burning the stubble late in the fallow period.

Incorporation or burning of stubble is not recommended unless infestation levels are very high. The correct identification of the yellow leaf spot fungus in infected stubble should be carried out before the stubble is removed. Varieties partially resistant to yellow leaf spot offer the only long-term solution and should be considered for planting where yellow leaf spot could be a problem. [30]

If you do not want to be concerned by yellow leaf spot (including at seedling stages) then:

- Do not sow cereal-on-cereal.
- If you are going to sow cereal-on-cereal consider:
- A late (autumn) stubble burn; and/or
- Selecting a triticale variety with some level of resistance to yellow leaf spot (and also note tolerance or resistance to other diseases).

MORE INFORMATION

GRDC Foliar Diseases–Ute Guide

29 GRDC (2011) Management to reduce the risk of yellow leaf spot. Factsheet. GRDC, https://grdc.com.au/Resources/Factsheets/2011/08/Yellow-Leaf-Spot-Fact-Sheet

30 DAF Qld (2015) Wheat:diseases, physiological disorders and frost. DAF Qld, https://www.daf.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/wheat/diseases

MORE INFORMATION

Management of yellow leaf spot in wheat: decide before you sow

- Primary management decisions for yellow leaf spot need to be made before and/or at sowing. Fungicides are a poor last resort for controlling yellow leaf spot as they have reduced efficacy. [31]

In-crop fungicides and timing

Fungicides used against yellow leaf spot in Australia include:

- propiconazole
- tebuconazole
- azoxystrobin + cyproconazole
- propiconazole + cyproconazole

The timing of application of the chosen fungicide is crucial. The most effective time is at 90% flag leaf emergence, with disease levels of less than 10% on the flag leaf (Table 7). [32]

Table 7: *Rate of fungicide (product formulation) recommended as foliar sprays for the control of yellow leaf spot in cereals.*

Disease	Foliar fungicides							
	Epoxi-conazole (125 g/L)	Flutriafol (250 g/L)	Propi-conazole (250 g/L)	Triadimefon (125 g/L)	Tebuco-nazole (430 g/L)	Prothioconazole (210 g/L) + Tebuconazole (210 g/L)	Azoxystrobin (200 g/L) + Cyproconazole (80 g/L)	Propiconazole (250 g/L) + Cyproconazole (80 g/L)
Yellow leaf spot (tan spot)			250–500 mL/ha		145 or 290 mL/ha	150–300 mL/ha	400 or 800 mL/ha	250–500 mL/ha
Withholding periods	6 weeks for grazing and harvest	7 weeks for grazing and harvest	4 weeks for harvest, 7 days for grazing	4 weeks for grazing and harvest	5 weeks for harvest, 14 days for grazing	5 weeks for harvest, 14 days for grazing	6 weeks for harvest, 21 days for grazing	6 weeks for harvest, 21 days for grazing

Source: DAF Qld

MORE INFORMATION

Yellow leaf spot: is it worth spraying?

GRDC factsheet, Yellow leaf spot

The economics and risks of early sprays for yellow leaf spot

The higher rate of application has been shown to provide longer protection under periods of high disease pressure. Fungicide effectiveness is greater on susceptible varieties and is reduced with increasing levels of resistance.

Information on fungicide effectiveness has been gathered from irrigated field trials and does not confirm the economic viability of such applications during the extreme pressure of large-scale epidemics. [33]

Check the Australian Pesticides and Veterinary Medicines Authority (APVMA) website for fungicide updates.

9.5 Take-all

Key points:

- Take-all is a fungal disease of the roots of cereals.
- Though triticale is less susceptible to take-all than wheat, it can still carryover the disease into following years. [34] Early sowing increases the risk. [35]

31 S Simpfendorfer (2013).Management of yellow leaf spot in wheat: decide before you sow. GRDC Update Paper. GRDC, https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2013/03/Management-of-yellow-spot-in-wheat-decide-before-you-sow

32 DAF Qld (2015) Integrated disease management of wheat rusts and yellow leaf spot. DAF Queensland, https://www.daf.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/wheat/wheat-rusts

33 DAF Qld (2015) Wheat: diseases, physiological disorders and frost. DAF Qld, https://www.daf.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/wheat/diseases

34 Birchip Cropping Group (2004) Triticale agronomy 2004. Online Farm Trials, http://www.farmtrials.com.au/trial/13801

35 P Matthews, D McCaffery, L Jenkins (2016) Winter crop variety sowing guide 2016. NSW DPI, https://www.dpi.nsw.gov.au/agriculture/broadacre-crops/guides/publications/winter-crop-variety-sowing-guide

- In early field experiments conducted over six years with a wide range of severity of take-all disease, triticale was intermediate in resistance to take-all, between wheat (susceptible) and rye (resistant). [36]
- Grass-free pastures and break crops minimise *G. graminis* survival, e.g. pulses and canola.
- Monitor rainfall patterns (when and how much?), and adjust sowing times where possible.
- Control weeds during late summer and early autumn.
- Ammonium-based nitrogenous fertilisers decrease take-all incidence through improved crop nutrition.
- In severe take-all outbreaks, grass free cropping may be a management strategy.

PODCAST

GRDC Radio (Northern Update), Crown rot and take-all warning

Take-all is a soil-borne disease of cereal crops and is most severe on crops in southern Australia, particularly in the high-rainfall southern cropping regions and areas closer to the coast. The disease is caused by two variations of the fungus *Gaeumannomyces graminis*: *G. graminis* var. *tritici* (Ggt) and *G. graminis* var. *avenae* (Gga). Control of take-all is predominantly cultural and relies on practices which minimise carry-over of the disease from one cereal crop to the next. [37]

9.5.1 Symptoms

Initial indications of take-all in a crop are the appearance of indistinct patches of poor growth in the crop; these may be from a few metres across to significant areas of crop. Closer inspection of individual plants will show discolouration of the crown, roots and stem base. Blackening of the centre of the roots (stele) is symptomatic of an early take-all infection. Severely infected plants will have a blackened crown and stem base and be easy to pull from the soil, with no attached root system. Any remaining roots are brittle and break off with a square end.

The appearance of whiteheads later in the season is another indicator of a take-all (although frost and micronutrient deficiencies can also cause whiteheads), with severe infections causing the crop to hay-off early. Infected plants will produce pinched grain, with severe infections yielding little harvestable seed in the head (hence take-all) and in some cases infected areas may not be worth harvesting. [38]

What to look for in the paddock

- Patches (up to several metres in diameter and with indistinct and irregular edges) of white-coloured tillers and heads containing shrivelled or no grain (Photo 7). [39]
- Affected plants can be individuals scattered among healthy plants or entire populations of plants over a large area.

36 TW Hollins, PR Scott, RS Gregory (1986).The relative resistance of wheat, rye and triticale to take- all caused by *Gaeumannomyces graminis*. Plant Pathology, 35 (1), 93–100.

37 Soilquality.org (2016) Take-all disease, NSW. Factsheet. Soilquality.org, http://www.soilquality.org.au/factsheets/take-all-disease-nsw

38 Soilquality.org (2016) Take-all disease, NSW. Factsheet. Soilquality.org, http://www.soilquality.org.au/factsheets/take-all-disease-nsw

39 DAFWA (2015) Diagnosing take-all in cereals. DAFWA, https://www.agric.wa.gov.au/mycrop/diagnosing-take-all-cereals

Photo 7: *Patches with irregular edges of white coloured tillers and heads containing shrivelled or no grain.*

Source: DAFWA

What to look for in the plant

- First obvious signs of infection are seen after flowering, with the development of whiteheads.
- Roots of affected plants are blackened and brittle, and break easily. They are black to the core, not just on outer surface (Photo 8).
- Severely affected plants can also have blackened crowns and lower stems.

MORE INFORMATION

GRDC Foliar Diseases–Ute Guide

Photo 8: *Roots of affected plants are blackened, brittle, break easily, and are black to the core (left). Severely affected plants can have blackened crowns and lower stems (right).*

Source: DAFWA

9.5.2 Conditions favouring development

Gaeumannomyces graminis survives the Australian summer in the residue of the previous season's grass host (Figure 1). [40] The arrival of cooler temperatures and rainfall in the autumn encourages the fungus into action, and it is in this period that it infects the roots of the emerging crop. Higher rainfall in winter is likely to increase take-all disease pressure. For this reason, the southern regions of New South Wales are most likely to suffer yield loss in cereal crops due to take-all. While lower soil moisture will decrease the chance of a severe outbreak of take-all, plants that are already infected will find it difficult to cope due to water stress.

Soil at field capacity (fully wet) encourages early season infection of seedlings by both *G. graminis* var. *tritici* and *G. graminis* var. *avenae*. Greatest yield loss occurs on infected plants when moisture is limited post-anthesis.

40 Soilquality.org (2016) Take-all disease, NSW. Factsheet, Soilquality.org, http://www.soilquality.org.au/factsheets/take-all-disease-nsw

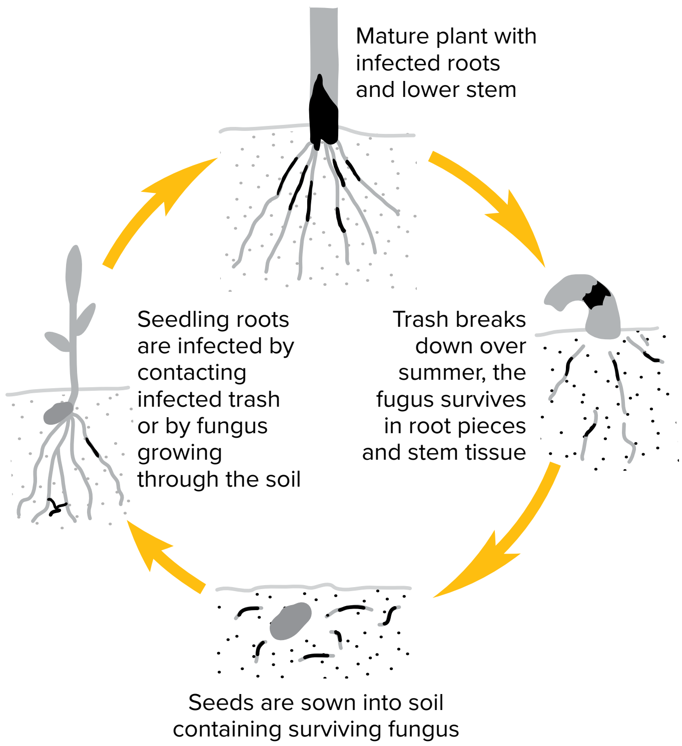


Figure 1: *Common life cycle of the take-all fungus.*

Source: Soilquality.org

Hosts

All annual grasses can be infected by *G. graminis*, although some species are more susceptible than others. While triticale, wheat and barley are the most susceptible crops to take-all, barley grass is also an effective host to the disease. Brome grass, silver grass and ryegrass are all viable host species for take-all, too. Oats is the only cereal crop to offer resistance, although evidence of *G. graminis* strains capable of causing yield loss has been reported in areas where continual oat cropping occurs. The non-cereal crops (e.g. lupins, canola and clover) do not host take-all. [41]

9.5.3 Managing take-all

Key points:

- By far the most effective method of reducing take-all is to remove grasses in the year before the crop with a grass-free pasture or break crop.
- Seed, fertiliser or in-furrow applied fungicides are registered for take-all control.
- Acidifying fertilisers can slightly reduce disease severity; conversely, the severity of take-all may increase following liming.
- Control volunteer grasses and cereals.
- Delay sowing following the opening rains by implementing a short chemical fallow. [42]

The most effective management strategy for take-all is to deny the fungus the ability to survive in the paddock, through the elimination of hosts. This is most effectively done through the use of a non-cereal break crop (i.e. lupin, canola, field peas,

41 Soilquality.org (2016) Take-all disease, NSW. Factsheet, Soilquality.org, http://www.soilquality.org.au/factsheets/take-all-disease-nsw

42 DAFWA (2015) Diagnosing take-all in cereals. DAFWA, https://www.agric.wa.gov.au/mycrop/diagnosing-take-all-cereals

faba beans, chickpeas) and effective grass-weed control during autumn. Pastures containing low levels of grass species will also have reduced take-all carryover the following season. Where minimum tillage is practiced, the time taken for residues to breakdown is increased, and this allows the disease to stay viable for longer. The use of break crops and activities to hasten residue breakdown may be beneficial. While burning does decrease the amount of surface residue infected with the fungus, it is generally not hot enough to affect the infected material below ground.

Fungicides, applied as either fertiliser or seed treatments, are registered for use against take-all, but are generally only economically viable where severe outbreaks have occurred. Registered fungicides provide useful protection in paddocks with low to medium disease risk. In many cases it is more practical to sow non-cereal crops or pasture to reduce take-all carryover.

Competition from other soil organisms decreases the survival of *G. graminis* in the soil. Summer rains or an early break in the season allows for such conditions. The effect of this can be negated by poor weed control during this period. This has a double effect:

- Cereal weeds become infected, thus enabling G. *graminis* to survive until crop establishment.
- Rapid drying of the topsoil due to weeds decreases the survival of competitive soil organisms, therefore slowing *G. graminis* decline.

MORE INFORMATION

PreDicta B

VIDEOS

WATCH: GRDC, Grains research updates: Improving PreDicta B

Soil testing

The DNA-based soil test PreDicta B can be used to detect take-all in the paddock. Soil samples that include plant residues should be tested early in late summer to allow results to be returned before seeding. This test is particularly useful when sowing susceptible varieties, and for assessing the risk after a non-cereal crop. [43]

PreDicta B samples are processed weekly from February to mid-May (prior to crops being sown) to assist with planning the cropping program. The test is not intended for in-crop diagnosis. That is best achieved by sending samples of affected plants to your local plant pathology laboratory. In order to get an accurate result, it is important to follow the PreDicta B sampling protocol precisely. [44]

Take-all decline

Take-all decline is the apparent waning of the incidence of take-all following many years of continuous cereal cropping. It has been shown to occur in South Australia. Decline has been attributed to the build-up of antagonistic micro-organisms in the soil. This occurrence is unlikely to be something growers can rely on, as the economic losses incurred during the build-up appear to be unacceptable.

There have, however, been examples of a reduction in the incidence of take-all due to gradual acidification of soil; this decline is reversed when lime is applied to increase soil pH. [45]

9.6 Crown rot

Key points:

- Triticale is susceptible to crown rot. [46]
- Crown rot survives on infected stubble, from where it is passed onto the following crop.
- Use non-host crops (i.e. pulses, oilseeds and broadleaf pasture species) in rotation sequences to reduce inoculum levels.

43 Soilquality.org (2016) Crown rot, Queensland. Factsheet, Soilquality.org, http://www.soilquality.org.au/factsheets/crown-rot-queensland

44 D Lush (2014) PreDicta B sampling strategy. GRDC, https://grdc.com.au/Media-Centre/Media-News/South/2014/04/PreDicta-B-sampling-strategy

45 Soilquality.org (2016) Take-all disease, NSW. Factsheet, Soilquality.org, http://www.soilquality.org.au/factsheets/take-all-disease-nsw

46 Matthews P, McCaffery D, Jenkins L. (2016). Winter crop variety sowing guide 2016. NSW DPI, https://www.dpi.nsw.gov.au/agriculture/broadacre-crops/guides/publications/winter-crop-variety-sowing-guide

- Control grass-weed hosts to reduce opportunities for *Fusarium* spp. to survive fallow or non-host rotations.
- Sow varieties with partial resistance or improved tolerance where available.

Information concerning the resistances of triticale varieties to *Fusarium* diseases is very limited. For crown rot (*Fusarium psuedograminearum)* most research has been completed in wheat, but data from 2007 included one triticale (Everest). Inoculation with the crown-rot fungus caused the greatest reduction in yield in durum wheat (average of 58%) with less but similar reduction in five wheat varieties (25%) and one triticale (23%). Within the wheat varieties the reductions were in a 10% range and it is likely that a similar position would occur within triticale varieties. This emphasises the importance of crop rotational strategy, e.g. the use of disease break crops such as canola and mustard, within the cropping system. [47]

The crown rot fungus may increase in wet years as rain splash distributes the fungus from lower stem nodes into grain heads.

While all winter cereals host the crown-rot fungus, yield loss due to infection varies with cereal type. The approximate order of increasing yield loss is cereal rye, oats, barley, bread wheat, triticale and durum wheat. [48] Crown rot is a priority cereal disease in the Northern Region. [49]

Crown rot becomes apparent after flowering expressed as whiteheads following periods of moisture and/or heat stress. Crown rot is sometimes first seen in patches or in wheel tracks, but is often not obvious until after heading. Then it becomes obvious with the appearance of dead heads that contain shrivelled or no grain are called whiteheads, although it is important to note that yield loss can occur even without the formation of whiteheads.

Update on the latest research

Key points:

- Managing the impact of crown rot on yield and quality means managing the balance between inoculum levels and the amount of soil water.
- The amount of soil water is the biggest factor in the impact of crown rot on profitability, yet most management strategies focus on combating inoculum, sometimes even to the detriment of soil water. It is more important to maintain good levels of soil water so that triticale is not temperature or water stressed during grainfill.
- For crown rot, cultivation, even shallow cultivation, distributes infected residue more evenly across paddocks and into the infection zones below the ground for crown rot. This is not good!
- Some of the newer varieties appear promising in that they provide improved tolerance to crown rot.
- PreDicta B is a good tool for identifying the level of risk for crown rot (and other soil-borne pathogens) prior to sowing. However, it requires a dedicated sampling strategy and is not a simple add-on to a soil nutrition test.

Crown rot is a significant disease of winter cereals. Infection is characterised by a light honey-brown to dark brown discolouration of the base of infected tillers, and the crown rot-induced production of whiteheads that causes major yield loss is related to the presence of the fungus and moisture stress after flowering. It is critical that growers understand that there are three distinct and separate phases of crown rot, namely survival, infection and expression. Management strategies are different for each phase.

47 RS Jessop, M Fittler (2009) Appendix 1. Triticale production manual: an aid to improved triticale production and utilisation. In J Roake, R Rethowan, R Jessop, M Fittler, Improved triticale production through breeding and agronomy. Pork CRC, http://www.apri.com.au/1A-102_Final_Research_Report_.pdf

48 GRDC (2016) Crown rot in winter cereals: Northern Region. Tips and Tactics. GRDC, https://grdc.com.au/Resources/Factsheets/2016/02/Crown-rot-in-winter-cereals

49 T Dixon (2013) Balancing crown rot and nematodes in wheat. Ground Cover. Issue 104, May–June 2013. GRDC, https://grdc.com.au/Media-Centre/Ground-Cover/Ground-Cover-Issue-104-May-June-2013/Balancing-crown-rot-and-nematodes-in-wheat

- Survival—the crown-rot fungus survives as mycelium (cottony growth) inside winter cereal and grass-weed residues, which it has infected. The fungus will survive as inoculum inside the stubble for as long as the plant material remains intact, which varies greatly with soil and weather conditions as decomposition is a very slow process.
- Infection—given some level of soil moisture, the crown-rot fungus grows out of stubble residues and infects new winter cereal plants through the coleoptile, sub-crown internode or crown tissue, which are all below the soil surface. The fungus can also infect plants on the soil surface through the outer leaf sheaths. However, whatever the points of infection, direct contact with the previously infected residues is required. Infections can occur throughout the whole season, given the necessary moisture. Hence, wet seasons favour greater infection by the crown-rot fungus, especially when combined with the production of greater stubble loads, which significantly build up inoculum levels.
- Expression—yield loss is related to moisture and temperature stress around flowering and through grainfill. This stress is believed to trigger the crown rot fungus to proliferate in the base of infected tillers, restricting water movement from the roots through the stems, and producing whiteheads. The expression of whiteheads in plants infected with crown rot (i.e. they will still have basal browning) is restricted in wet seasons and increases greatly with increasing moisture and temperature stress during grainfill. Focus attention to crops around trees in a paddock or along tree lines. Even in good years, whiteheads associated with crown-rot infection are likely to be seen around trees. This is due to the extra competition for water.

9.6.1 Damage caused by crown rot

The presence of crown rot in the plant stem limits water movement, which can result in premature death of the tiller and the presence of whiteheads (or deadheads) (Photo 9). Crown rot survives from one season to the next on infected stubble, from where it is passed onto the following crop. The impact of a bad crown-rot season can make or break a crop, with bread-wheat yield losses of up to 55% possible at high inoculum levels, and losses in durum up to 90%.

Triticale can see similar yield losses from crown rot as wheat (average yield loss).

Photo 9: *Scattered whiteheads in cereal crop.*

Source: DAFWA

9.6.2 Symptoms of crown rot

If the leaf bases are removed from the crowns of diseased plants, a honey-brown to dark-brown discolouration will be seen. In moist weather, a pinkish-purple fungal growth forms inside the lower leaf sheaths and on the lower nodes.

The infection of plants with crown rot occurs at the base of the plant and spreads up the stem during the growing season. The onset of crown rot is often not obvious until after heading, when whiteheads appear with the onset of water stress. Plants infected with crown rot display a number of symptoms, including:

- Brown tiller bases, often extending up 2–4 nodes (Photo 10). [50] This is the most reliable indicator of crown rot, with browning often becoming more pronounced from mid to late grainfilling through to harvest.
- Whitehead formation, particularly in seasons with a wet start and dry finish (Photo 11). These are usually scattered throughout the crop, and do not appear in distinct patches. These may first appear in wheel tracks where crop-available moisture is more limited.
- A cottony fungal growth that may be found around the inside of tillers, and a pinkish fungal growth that may form on the lower nodes, especially during moist weather (Photo 12).
- Pinched grain at harvest. [51]

Photo 10: *Honey-brown discolouration of stem bases.*

Source: DAFWA

50 DAFWA (2016) Diagnosing crown rot of cereals. DAFWA, https://www.agric.wa.gov.au/mycrop/diagnosing-crown-rot-cereals

51 Soilquality.org (2016) Crown rot, Queensland. Factsheet, Soilquality.org, http://www.soilquality.org.au/factsheets/crown-rot-queensland

Photo 11: *Scattered single tillers and whiteheads.*

Source: DAFWA

Photo 12: *Pinkish-purple discolouration often forms around or in the crown or under leaf sheaths.*

Source: DAFWA

9.6.3 Conditions favouring development

The effects of crown rot on yield tend to be most severe when there are good crop conditions in the first part of the season followed by a dry finish. This is because the moist conditions at the beginning of the season enable the fungus to grow from infected stubble to an adjacent seedling, while the dry conditions during flowering and grainfilling cause moisture stress, allowing rapid growth of the pathogen within the plant. A wet finish to the season can reduce the damage caused by crown rot, but will not prevent yield loss in all cases. [52]

Cultivation can also have a huge impact. Crown rot is a stubble-borne disease and for a plant to become infected it must come into contact with inoculum from previous winter cereal crops. So by cultivating soil, growers are actually helping to spread the crown rot inoculum to next year's crop. The best thing a grower can do with infected stubble is leave it alone. [53]

Interaction with root-lesion nematodes

Root-lesion nematodes (RLNs) are also a widespread constraint to cereal production across the region. RLNs feed inside the root systems of susceptible winter cereals and create lesions that reduce lateral branching. This reduces the efficacy of the root system to extract soil water and nutrients, which can subsequently exacerbate the expression of crown rot. Varieties with reduced tolerance to *Pratylenchus thornei* can suffer significantly greater yield loss from crown rot if both of these pathogens are present within a paddock.

See Section 8.3 Nematodes and crown rot in Section 8: Nematodes for more information.

9.6.4 Management

Key points:

- Rotate crops—this is the most important management tool. A grass-free break from winter cereals is the best way to lower crown-rot inoculum levels.
- Test—a pre-sowing PreDicta B soil test will identify paddocks at risk of crown rot.
- Sow winter cereals into paddocks where the risk is lowest.
- Choose more resistant crop varieties, but variety choice needs to be combined with effective management.
- Observe—check plants for browning at the base of infected tillers as this is the most reliable indicator of crown rot. Don't rely solely on whiteheads as an indicator (Figure 2).
- Keep crown rot inoculum at low levels is the most effective way to reduce yield loss from this disease. [54]

52 Soilquality.org (2016) Crown rot: Qld. Factsheet, Soilquality.org, http://www.soilquality.org.au/factsheets/crown-rot-queensland

53 T Dixon (2013) Balancing crown rot and nematodes in wheat. Ground Cover. No. 104, May–June 2013. GRDC, https://grdc.com.au/Media-Centre/Ground-Cover/Ground-Cover-Issue-104-May-June-2013/Balancing-crown-rot-and-nematodes-in-wheat

54 GRDC (2016) Crown rot in winter cereals, southern region. Tips and Tactics. GRDC, https://grdc.com.au/Resources/Factsheets/2016/02/Crown-rot-in-winter-cereals

Figure 2: *The GRDC's 'Stop the crown rot' campaign.*

Source: GRDC

Crown rot may be controlled through planting more resistant varieties and by using crop rotation. If the disease is severe, rotation to a non-susceptible crop for at least two and preferably three years is recommended. A winter crop such as chickpea, oats or any summer crop may be used as a disease-free rotation crop. [55]

Crop rotation

The most effective way to reduce crown rot inoculum is to include non-susceptible crops in the rotation sequence. The crown rot fungus can survive for two to three years in stubble and soil. Growing a non-host crop for at least two seasons is recommended to reduce inoculum levels. This allows time for decomposition of winter cereal residues that host the crown rot fungus. Stubble decomposition varies with the type of break crop grown: canopy density and rate of the canopy closure as well as row spacing, the amount of soil water they use and seasonal rainfall.

Because crown rot survives from one season to the next on infected stubble, the use of break crops can give stubble a chance to decompose and thus reduce soil inoculum levels. The use of break crops with dense canopies, such as canola, can be particularly effective, as these help to maintain a moist soil surface, which further promotes the breakdown of cereal residues.

The number or break crops required to sufficiently reduce crown rot levels will vary, depending on rainfall in the break year. In dry years, when residue breakdown is

55 DAF Qld (2015) Wheat: diseases, physiological disorders and frost. DAF Qld, https://www.daf.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/wheat/diseases

slower, a two-year break crop may be required to reduce crown rot to acceptable levels. In wetter seasons, a one-year break may be sufficient.

It should be noted that incorporating plant residues into the soil by cultivation during the break period can increase the rate of decay of residue. However, it also spreads infected residue, which may increase plant infection rates in following crops, thus counteracting any benefits from increased rate of breakdown.

Baling, grazing and/or burning crop residues are not effective solutions for the removal of crown rot, either. The majority of the crown rot inoculum is below ground and in the bottom 7 cm of the stem. Thus, the crown rot fungus can survive in below-ground tissue even if above-ground material is removed.

Variety selection

All winter cereal crops host the crown-rot fungus. Yield loss varies between crops and the approximate order of increasing loss is oats, barley, triticale, bread wheat and durum.

Where growers are aware their paddocks are infected with crown rot, tolerant varieties can be used to limit yield loses (Figure 3). Growers need to be aware of the levels of crown rot disease in their paddocks, as even the most tolerant crops can suffer yield loss under high levels of the disease. At intermediate levels of disease, the grower can take a calculated risk about returns versus yield loss by growing only tolerant varieties. However, where high levels of disease are present even tolerant varieties may be affected, and a break crop may be required.

VIDEOS

WATCH: GRDC, Grains research updates: Crown rot tolerance in new cereal cultivars

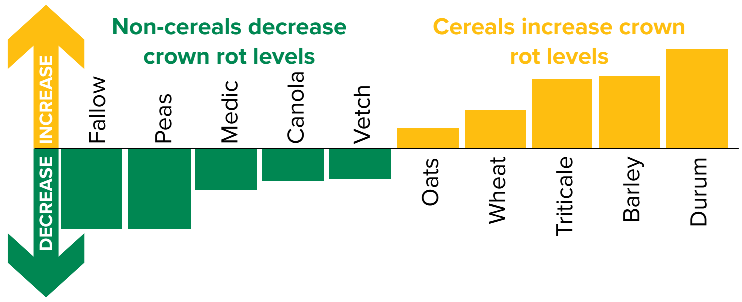


Figure 3: *Rotation effects on crown rot levels in the soil in the following year.*

Source: GRDC.

NSW DPI trials at 23 sites in 2013–14 indicate that susceptibility can represent a yield benefit of around 0.50 t/ha in the presence of high levels of crown rot infection. However, variety choice is NOT a solution to crown rot with even the best variety still suffering up to 40% yield loss from crown rot under high infection levels and a dry/hot seasonal finish. [56]

MORE INFORMATION

Tips and Tactics: Crown rot in winter cereals, southern region

Understanding crown rot underpins effective management, southern and western regions

Crop management

Stressed plants are most susceptible to the effects of crown rot. Thus the use of management practices to optimise soil water and ensure good crop nutrition can help reduce the impacts of crown rot. Effective strategies include:

- Reducing moisture stress in plants through good fallow management and avoiding excessively high sowing rates.
- Matching nitrogen fertiliser inputs to available soil water to avoid excessive early crop growth.
- Ensuring good crop nutrition. Zinc nutrition can be particularly important as the expression of whiteheads can be more severe in zinc-deficient crops.

56 S Simpfendorfer (2015) Crown rot: an update on latest research. GRDC Update Paper. GRDC, https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2015/07/Crown-rot-an-update-on-latest-research

Cultivation

The effect of cultivation on crown rot is complex, as it potentially impacts on all three phases of the disease cycle.

- Survival—stubble decomposition is a microbial process driven by temperature and moisture. In theory, cultivating stubble increases the rate of decomposition as it reduces particle size of stubble, buries the particles in the soil where microbial activity is greater, and puts the stubble below the soil surface, where it is maintained in better moisture and temperature conditions than at the surface or above ground. However, this is generally not sufficient: cultivating also dries out the soil in the cultivation layer, which immediately slows down decomposition. Full decomposition of cereal stubbles is a slow process that requires adequate moisture for an extended time. One summer fallow, even if extremely wet and stubble has been ploughed in, is *not* long enough!
- Infection—the cultivation of winter cereal stubble harbouring the crown-rot fungus breaks the inoculum into smaller pieces and spreads them more evenly through the cultivation layer across the paddock. Consequently, the fungus has a much greater chance of coming into contact with seedlings when the next winter cereal crop germinates and starts to grow. In a no-till system the crown-rot fungus becomes confined to the previous cereal rows and is more reliant on infection through the outer leaf sheaths at the soil surface, thus greatly reducing infection. Cultivating or harrowing negates the option of inter-row sowing as a crown rot management strategy.
- Expression—extensive research has shown that cultivation dries out the soil to the depth of cultivation and reduces the water infiltration rate due to the loss of structure (e.g. macropores). The lack of cereal stubble cover can also increase soil evaporation. With poorer infiltration and higher evaporation, fallow efficiency is reduced for cultivated systems compared to a no-till stubble retention system. Greater moisture availability has the potential to provide buffering against the expression of crown rot late in the season.

Stubble burning

Stubble burning removes the above-ground portion of crown rot inoculum but the fungus will still survive in infected crown tissue below ground, burning is **not** a ‘quick fix’ for high-inoculum situations. The removal of stubble by burning increases evaporation from the soil surface and makes fallow less efficient. A cooler autumn burn is preferable to an earlier hotter burn as it minimises the loss of soil moisture while still reducing inoculum levels.

Reducing water loss

Inoculum level is important in limiting the potential for yield loss from crown rot, but the factor that most dictates the extent of yield loss is moisture and temperature stress during grainfill. Any management strategy that limits the storage of soil water or creates constraints that reduce the ability of roots to access this water will increase the probability and/or severity of moisture stress during grainfill and exacerbate the impact of crown rot.

Grass-weed management

Grass weeds should be controlled in fallows and in crops, especially in break crops, as they host the crown-rot fungus and can also significantly reduce soil-moisture storage. In pasture situations, grasses need to be cleaned out well in advance of a following cereal crop as they serve as a host for the crown-rot fungus.

Sowing time

Earlier sowing within the recommended window for a given variety and region can bring the grainfill period forward and reduce the probability of moisture and temperature stress during grainfill. Earlier sowing can increase root length and depth and provide greater access to deeper soil water later in the season, which buffers against the expression of crown rot. This has been shown in NSW DPI research across seasons to reduce yield loss from crown rot. However, earlier sowing can place a crop at risk of frost damage during its most susceptible time.

Sowing time is a balancing act between the risk of frost and heat stress. However, when it comes to crown rot, increased disease expression with delayed sowing can have just as big an impact on yield as frost. The big difference from NSW DPI trial work is the additional detrimental impact of later sowing on grain size in the presence of crown rot infection.

IN FOCUS

The incidence of crown rot on cultivars sown on two dates in northern NSW

Researchers assessed 13 bread-wheat cultivars, a durum wheat, a barley, and a triticale cultivar in the paddock for their reaction to crown rot, based on the incidence of basal browning. Plots were sown in May and again in July at two sites in northern New South Wales where the incidence of crown rot had been high in the previous year. The incidence of infected plants and the incidence of plants with basal browning tended to be higher in all cultivars when sown in May. There was a mean loss in potential yield at one site of 35%, and at the other site of 18%. However, the mean loss in potential yield was unaffected by sowing date. [57]

Row placement

In a no-till system, the crown rot fungus becomes confined to the previous cereal rows and is more reliant on infection through the outer leaf sheaths at the soil surface. This is why inter-row sowing with GPS guidance has been shown to provide around a 50% reduction in the number of plants infected with crown rot when used in a no-till cropping system.

Research conducted by NSW DPI has also demonstrated the benefits of row placement in combination with crop rotation and the placement of break crop rows and winter cereal rows in the sequence to limit disease and maximise yield. Sowing break crops between standing cereal rows, which are kept intact, then sowing the following crop directly over the row of the previous year's break crop, ensures four years between cereal rows being sown in the same row space. This substantially reduces the incidence of crown rot in crops, improves establishment of break crops (especially canola), and chickpeas will benefit from reduced incidence of virus in standing cereal stubble.

Soil type

The soil type does not directly affect the survival or infection phases of crown rot. However, the water-holding capacity of each soil type does affect the expression of crown rot by the degree to which it buffers triticale plants against moisture stress late in the season. Hence, yield loss can be worse on red soils than black soils due to the generally lower water-holding capacity of red soils. On top of this, other sub-soil constraints, e.g. sodicity, salinity or shallower soil depth, can also reduce the level of plant-available water, which can increase the expression of crown rot.

57 TA Klein, LW Burgess, FW Ellison (1989) The incidence of crown rot in wheat, barley and triticale when sown on two dates. Animal Production Science, 29 (4), 559–563.

MORE INFORMATION

PreDicta B

GRDC Tips and Tactics, Crown rot in winter cereals: Northern Region

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WATCH: GRDC, Grains research updates: Improving PreDicta B

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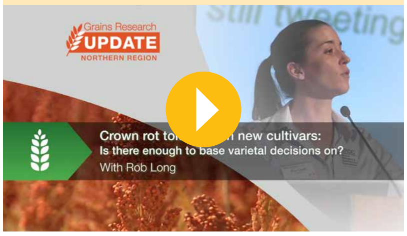

Interaction with root-lesion nematodes

Root-lesion nematodes (RLNs) are also a widespread constraint to cereal production across the region. RLNs feed inside the root systems of susceptible winter cereals and create lesions that reduce lateral branching. This reduces the efficacy of the root system to extract soil water and nutrients, which can subsequently exacerbate the expression of crown rot. Varieties with reduced tolerance to Pt can suffer significantly greater yield loss from crown rot if both of these pathogens are present within a paddock.

Soil testing

In addition to visual symptoms, the DNA-based soil test PreDicta B can be used to assess the level of crown rot in the paddock. Soil samples that include plant residues should be tested early in late summer to allow results to be returned before seeding. This test is particularly useful when sowing susceptible varieties, and for assessing the risk after a non-cereal crop. [58]

The test is not intended for in-crop diagnosis. In order to get an accurate result, it is important to follow the PreDicta B sampling protocol precisely (Photo 13). [59]

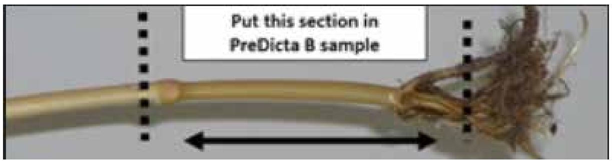

Photo 13: *It is important to follow the PreDicta B sampling protocol precisely.*

Source: GRDC.

Crown Analytical Services has the first Australian commercial test for crown rot. It is based on five years of laboratory research.

Testing involves carrying out a visual assessment on stubble, followed by a precise plating test. This is the only way of accurately testing for the disease. Results are provided to the grower and consultant within approximately four weeks of receiving the sample.

Crown Analytical Services provides sample bags and postage-paid packs. Go to the service's Protocol web page to better understand the process.

9.7 Common root rot

Common root rot (*Bipolaris* spp.) is a soil-borne fungal disease which attacks cereals. It survives from one sveason to the next through fungal spores that remain in the cultivated layer of the soil. The disease increases in severity with continuous cereal sequences. The symptoms of common root rot are:

- a dark-brown to black discolouration of the stem just below the soil surface
- black streaks on the base of stems
- slight root rotting

9.7.1 Damage caused by disease

Common root rot can cause yield losses of between 10–15% in susceptible wheat varieties.

58 Soilquality.org (2016) Crown rot, Queensland. Factsheet, Soilquality.org, http://www.soilquality.org.au/factsheets/crown-rot-queensland

59 D Lush (2014) PreDicta B sampling strategy. GRDC, https://grdc.com.au/Media-Centre/Media-News/South/2014/04/PreDicta-B-sampling-strategy

9.7.2 Symptoms

What to look for in the paddock

- Affected plants tend to be scattered over a paddock, and they may be slightly stunted, have fewer tillers and produce smaller heads.

What to look for in the plant

- Browning of roots and sub-crown internode (the piece of stem emerging from the seed to the crown) (Photo 14). [60]
- Blackening of sub-crown internode in extreme cases.

Photo 14: *Blackening of sub-crown internode in an extreme case of common root rot.*

Source: DAFWA

9.7.3 Conditions favouring development

The disease can occur from tillering onwards, but is most obvious after flowering.

There are no distinct paddock symptoms, although the crop may lack vigour. Severe infections can lead to stunting of plants.

Common root rot appears to be more prevalent in paddocks that are N deficient. When N is not limiting, yield loss occurs through a reduction in tillering due to poor N use efficiency.

Affected plants are usually scattered through the crop. The disease is widespread through the grain belt, and is often found in association with crown rot.

60 DAFWA (2015) Diagnosing common root rot of cereals. DAFWA, https://www.agric.wa.gov.au/mycrop/diagnosing-common-root-rot-cereals

The fungus that causes common root rot survives on the roots of grasses and as dormant spores in the soil. It can build up to damaging levels in continuous cereal rotations. [61]

Infection is favoured by high soil moisture for six to eight weeks after planting.

9.7.4 Management

The disease may be controlled by planting the more resistant varieties and by crop rotation. Where the disease is severe, rotation to non-susceptible crops for at least two years is recommended. Summer crops such as sorghum, sunflower, or white French millet can be used for this purpose. [62] It is important to:

- Reduce levels of the fungus in your paddocks by rotating with crops such as field peas, faba beans, canola, mustard, mungbeans, sorghum or sunflower.
- Keep susceptible crops and pasture grass-free.
- Sow more resistant varieties.
- If moisture permits, reduce sowing depth to limit the length of the sub-crown internode (SCI).
- Ensure adequate nutrition, especially of phosphorus, which reduces severity.
- Reconsider stubble burning, as it does not decrease spore levels in the soil. [63]

9.8 Smut and bunt

Triticale is not usually prone to infection from smuts and bunt. However, it is good insurance for better yields to apply a seed dressing to the grain when it is being graded. [64]

9.8.1 Bunt or stinking smut

Bunt or stinking smut (*Tilletia* spp.) affects ears of mature triticale, durum and wheat. A mass of black fungal spores replaces the interior of a grain with what is known as a bunt ball. Compared with healthy plants, infected plants are shorter and have darker green ears and gaping glumes (Photo 15). [65] Bunt is usually only noticed at harvest when bunt balls and fragments are seen in the grain. It is important to manage this disease, as receival sites will not accept grain deliveries with traces of bunt balls.

61 K Moore, B Manning, S Simpfendorfer, A Verrell (n.d.) Root and crown diseases of wheat and barley in northern NSW. NSW DPI. http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0019/159031/root-crown-rot-diseases.pdf

62 DAF Qld (2015) Wheat: diseases, physiological disorders and frost. DAF Queensland, https://www.daf.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/wheat/diseases

63 K Moore, B Manning, S Simpfendorfer, A Verrell (n.d.) NSW DPI. Root and crown diseases of wheat and barley in northern NSW. NSW DPI, http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0019/159031/root-crown-rot-diseases.pdf

64 Agriculture Victoria (2012) Growing triticale. Note AG0497. Revised. Agriculture Victoria, http://agriculture.vic.gov.au/agriculture/grains-and-other-crops/crop-production/growing-triticale

65 DAFWA (2016) Smut and bunt diseases of cereal: biology, identification and management. DAFWA, https://www.agric.wa.gov.au/autumn/smut-and-bunt-diseases-cereal-biology-identification-and-management?page=0,1

Photo 15: *Common bunt in cereal head showing glumes containing bunt balls.*

Source: DAFWA

The spores germinate with the seed when it is planted, and infect the young seedling. The fungus then grows inside the developing plant, finally replacing each normal grain with a mass of spores. If a bunt ball is crushed, a putrid, fishy odour is released. Spores released during harvest will contaminate sound grain.

Managing bunt

- Seed that is sown to provide the following season's seed should be treated with a fungicidal seed dressing.
- Seed obtained from plants grown from untreated seed should be treated with a fungicidal seed dressing before planting.
- All seed should be treated with a fungicidal seed dressing which will control bunt.
- Grain from a crop with bunt should not be used for seed.
- On farms where a crop has been affected by bunt, all seed should be treated with fungicidal seed dressing for at least six years.

These recommendations could be adopted in one of two ways:

- Treat all seed with a fungicidal seed dressing every second year.
- Treat a small quantity of seed of each variety with a fungicidal seed dressing every year, and use only the grain from this seed as planting seed in the following year. [66]

9.8.2 Loose smut

Triticale is susceptible to loose smut, [67] though it does not usually occur to a degree where control is warranted.

MORE INFORMATION

GRDC Foliar Diseases–Ute Guide

66 DAF Qld (2015) Wheat: diseases, physiological disorders and frost. DAF Qld, https://www.daf.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/wheat/diseases

67 P Matthews, D McCaffery, L Jenkins (2016) Winter crop variety sowing guide 2016. NSW DPI, https://www.dpi.nsw.gov.au/agriculture/broadacre-crops/guides/publications/winter-crop-variety-sowing-guide

Loose smut is a fungal disease that becomes evident at head emergence. A loose, powdery mass of fungal spores is formed in the head; these are readily blown away leaving a bare, ragged stalk (Photo 16). [68]

Photo 16: *Barley heads affected by loose smut.*

Source: DAFWA

If the spores settle on healthy flowers, they may germinate and infect the embryo of the developing seed. When the seed is planted, the smut grows inside the plant until flowering, when the disease appears. Because loose smut is carried inside the seed, systemic seed dressings are needed to control it. These are more expensive than the others and should be used only when a high incidence of loose smut is expected. [69]

Managing smut

The disease is controlled by pickling seed in a systemic fungicide which penetrates the developing seedling to kill the internal infection. Seed-dressing fungicides for cereals differ in their efficacy for smut management with trial research demonstrating that some seed dressings can reduce the incidence of loose smut in heavily infected seed to nearly zero. The correct application of seed dressings is critical to ensuring adequate control. In-furrow and foliar fungicide applications are not effective. [70]

9.9 Rhizoctonia root rot

Key points:

- The presence of *Rhizoctonia* fungal disease is most evident as bare patches in a young crop. Close inspection of infected seedlings shows brown discolouration or rotting of the roots and evidence of 'spear tips'.
- In cereals, oat is most tolerant, followed by triticale, wheat and then barley, which is the most intolerant. [71]

MORE INFORMATION

GRDC Foliar Diseases–Ute Guide

68 DAFWA (2016) Smut and bunt diseases of cereal: biology, identification and management. DAFWA, https://www.agric.wa.gov.au/autumn/smut-and-bunt-diseases-cereal-biology-identification-and-management?page=0,1

69 DAF Qld (2015) Wheat: diseases, physiological disorders and frost. DAF Queensland, https://www.daf.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/wheat/diseases

70 DAFWA (2016) Smut and bunt diseases for cereal. DAFWA, https://www.agric.wa.gov.au/autumn/smut-and-bunt-diseases-cereal-biology-identification-and-management?page=0%2C0

71 GRDC (2008) What is Rhizoctonia bare patch? Factsheet. GRDC, https://grdc.com.au/__data/assets/pdf_file/0014/222143/rhizoctonia-factsheet.pdf.pdf

- Adequate nutrition during crop emergence gives the crop a better chance of getting ahead of the disease.
- Fast-growing roots will push past the infected topsoil before *Rhizoctonia* infects the root tip.
- Poor weed management prior to seeding allows *Rhizoctonia solani* to 'prime' itself for infection of the upcoming crop.
- In severe paddock infections cultivation following late summer–early autumn rains can help to reduce infection by the fungus.

Rhizoctonia root rot is a fungal disease caused by *Rhizoctonia solani AG8*. It affects a wide range of crops and has become more prevalent in light soils in recent years following the introduction of minimum tillage. The traditional practice of tilling prior to planting encouraged the breakdown of the fungus in the soil before seedlings emerged. Minimum tillage decreases the rate of organic-matter breakdown, thereby providing a habitat for *Rhizoctonia solani* over summer. The disease affects most major crops to varying degrees, with barley being most susceptible and oat crops are least susceptible. Bare patch and root rot of cereals, and damping off and hypocotyl rot of oilseeds and legumes are all caused by different strains of *R. solani*. [72]

Yield losses in crops affected by Rhizoctonia can be over 50% and crops with uneven growth may lose up to 20%. The disease fungus grows on crop residues and soil organic matter and is adapted to dry conditions and lower fertility soils. The fungus causes crop damage by pruning newly emerged roots (spear-tipped roots) which can occur from emergence to crop maturity. The infection results in water and nutrient stress to the plant, as the roots have been compromised in their ability to translocate both moisture and nutrients.

Key factors influencing Rhizoctonia occurrence and severity

While *Rhizoctonia solani AG8* fungus is likely to be present in many soils, it is not necessarily going to cause a problem. One reason for this is that beneficial soil micro-organisms and high microbial activity have been shown to suppress the expression of the disease and reduce the level of disease. In cereals, *R. solani AG8* inoculum builds up from sowing to crop maturity and generally peaks at crop maturity, while rain post-maturity of a crop and over the summer fallow causes a decline in inoculum (Figure 4).

72 Soilquality.org (2016) Rhizoctonia, NSW. Factsheet, Soilquality.org, http://www.soilquality.org.au/factsheets/rhizoctonia-nsw

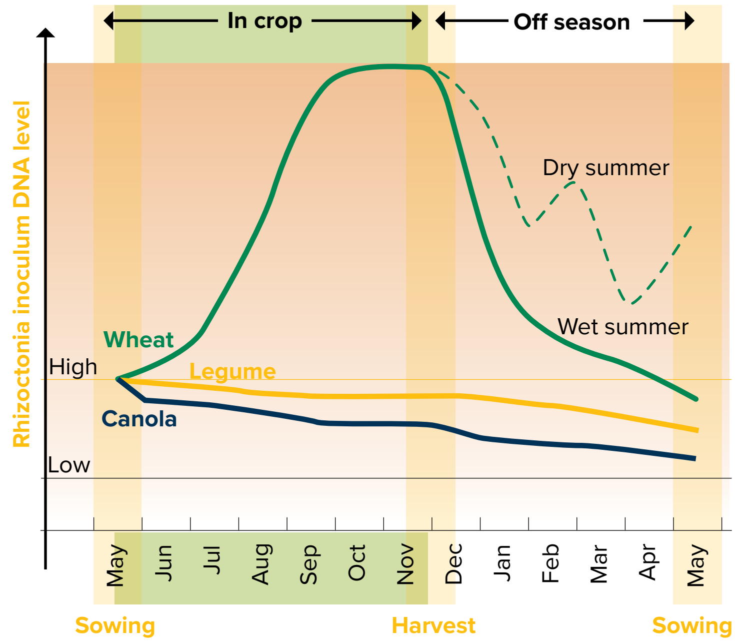

Figure 4: *R. solani AG8 inoculum levels in soil build-up in-crop but decline during summer following rainfall under wheat, while under grass-free canola and legume crops inoculum levels decline in-crop and over summer.*

Source: GRDC.

Crown root infection late into the crop season results in the build-up of inoculum in cereal crops. In the absence of host plants including weeds, summer rainfall events of more than 20 mm in a week can substantially reduce the level of inoculum. Dry spells, on the other hand, offer little opportunity for pathogen inoculum breakdown, with disease levels likely to remain stable if a host, or stubble, are present. Cropping systems with stubble retention, suppressive activity has been shown to increase over a five to eight-year period. GRDC funded CSIRO research showed suppressive soils generally contained higher populations of specific fungi and bacterial groups capable of antibiosis, mycoparasitism, plant growth promotion, nutrition and improved plant defenses. [73]

9.9.1 Symptoms

The characteristic symptom of Rhizoctonia root rot is clearly defined bare patches in the crop. The reason these patches are clearly defined relates to the susceptibility of young seedlings, and the placement of the fungus within the soil profile. *Rhizoctonia solani* tends to reside in the upper layers of soil, but not in the surface, and only infects seedlings through the root tip soon after germination. Older plants have a more developed root epidermis that does not allow the penetration of fungal hyphae into the root. For this reason, once the crop is fully established, plants have either perished due to seedling infection or are reasonably healthy. Some yield loss may be associated with plants on the margins of the bare patch. Roots of a plant infected with *R. solani AG8* will typically be shorter and have a brown 'spear tip' where they have rotted. Plants within a patch remain stunted with stiff, rolled leaves and can be darker green than those outside the patch. [74]

MORE INFORMATION

Karoonda break crops trails: soil biology and rhizoctonia diseasev

VIDEOS

WATCH: Over the Fence: improving soil health helps fight against Rhizoctonia

73 GRDC (2016) Tips and Tactics: Rhizoctonia Southern region. https://grdc.com.au/resources-and-publications/all-publications/factsheets/2016/02/rhizoctonia

74 Soilquality.org (2016) Rhizoctonia, NSW. Factsheet, Soilquality.org, http://www.soilquality.org.au/factsheets/rhizoctonia-nsw

What to look for in the paddock

- Severely stunted plants occur in patches with a distinct edge between diseased and healthy plants.
- Patches vary in size from less than half a metre to several metres in diameter.
- Patches of uneven growth occur from mid-winter when seminal roots have established (Photo 17). [75]

Photo 17: *Patches vary in size from less than a metre to several metres in diameter. Patches have a distinct edge.*

Source: DAFWA

What to look for in the plant

- Affected plants are stunted with stiff, rolled leaves and are sometimes darker green than healthy plants (Photo 18).
- Roots of affected plants are short with characteristic pinched ends called 'spear tips' (Photo 19).

75 DAFWA (2016) Diagnosing rhizoctonia root rot in cereals. DAFWA, https://www.agric.wa.gov.au/mycrop/diagnosing-rhizoctonia-root-rot-cereals

Photo 18: *Affected plants are stunted with stiff, rolled leaves which are sometimes darker than those of healthy plants.*

Source: DAFWA

Photo 19: *Roots of affected plants are short with characteristic pinched ends or 'spear tips'.*

Source: DAFWA

VIDEOS

WATCH: [How to diagnose Rhizoctonia root rot]

MORE INFORMATION

[GRDC Foliar Diseases–Ute Guide]

9.9.2 Conditions favouring development

Rhizoctonia solani survives best in organic matter just below the surface of undisturbed soil. The fungus benefits from summer rainfall by infecting and multiplying in weeds, and has a limited ability to survive on the residue of previous seasons crops. The break of season initiates the development of the fungus in soil, where it lies primed to infect germinating seeds. Infection by the pathogen is encouraged by factors that restrict root growth, such as low soil fertility and sulfonylurea herbicides (including residues). If there is a delay between the season break and seeding, it is imperative that weeds are controlled to minimise proliferation of the fungus. Good nitrogen nutrition helps to minimise the effects of the disease; bare patches are smaller and less severe.

In general, Rhizoctonia root rot is most likely to be a severe problem where the plant is under stress from factors other than the disease, for example, low rainfall or poor nutrition.

There are certain soil conditions that favour the development of the root rot during and after seeding.

Soil nutrition

The disease is most common in soils of poor fertility. Crops with access to sufficient nutrients for growth have a better ability to 'get ahead' of *Rhizoctonia solani* infections.

Soil disturbance

Rhizoctonia solani is sensitive to cultivation, with cultivation after rain and before sowing most effective at reducing infection. Disturbing the soil prevents the fungus from 'priming' itself for infection of the emerging crop.

Soil moisture

When it is moisture stressed the crop becomes more susceptible to *R. solani* infection and is less able to get ahead of the disease.

Weeds

Poor weed management following late summer and early autumn rain allows *R. solani* to infect grass weeds, thereby allowing the fungus to multiply in preparation for the crop.

Herbicides

Sulfonylurea herbicides can sometimes worsen Rhizoctonia root rot, and this is attributed to minor herbicidal effects on the crop. [76]

9.9.3 Managing Rhizoctonia root rot

Key points:

- Management of Rhizoctonia requires an integrated approach to reduce inoculum and control infection and impact on yield (Table 8).
- Rhizoctonia inoculum levels will be greatest following cereals, particularly barley.
- Grass-free canola is the most effective in reducing inoculum levels.
- Legumes can also help reduce inoculum loading.
- Disturbance below the seed at sowing promotes rapid root growth away from the Rhizoctonia and disrupts hyphal networks. The ideal depth is 5–10 cm.
- Fungicides applied through in-furrow liquid banding can provide useful suppression of Rhizoctonia disease.
- Herbicides that slow root growth can increase the risk of Rhizoctonia root rot. [77]

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76 Soilquality.org (2016) Rhizoctonia, NSW. Factsheet, Soilquality.org, http://www.soilquality.org.au/factsheets/rhizoctonia-nsw

77 GRDC (2016) Tips and Tactics: Rhizoctonia Southern region. https://grdc.com.au/resources-and-publications/all-publications/factsheets/2016/02/rhizoctonia

Table 8: *Management strategies to reduce Rhizoctonia root rot.*

Year 1 (Sept-Nov)	Summer (Dec-April)	Season break (April-May)	Year 2 crop (May-August)
Check for inoculum build-up	Facilitate inoculum decline	Select appropriate crop	Manage infection and disease impact through management practices
Paddocks can often be identified in the previous spring by estimating the area of bare patches and/or zones of uneven growth during spring– verify that poor plant growth is due to Rhizoctonia disease	In wet summers, early weed control will reduce inoculum. In dry summers, inoculum levels do not change Adopt practices that prolong soil moisture in the upper layers (e.g. stubble retention and no cultivation) which helps maintain higher microbial activity Consider soil testing for pathogen inoculum level (PreDicta B™ test in FebMarch), to identify high disease risk paddocks, if disease is not confirmed in the previous cereal crop, especially if planning to sow cereals back on cereals	Select a non-cereal crop (e.g. canola or pulses) if you want to reduce inoculum levels Remove autumn 'green bridge' before seeding with good weed control	Sow early; early-sown crops have a greater chance of escaping infection Use soil openers that disturb soil below the seed to facilitate root growth–knife points reduce disease risk compared to discs Avoid pre-sowing SU herbicides Supply adequate nutrition (N, P and trace elements) to encourage healthy seedling growth Avoid stubble incorporation at sowing to minimize N deficiency in seedlings Consider seed dressings and banding fungicides to reduce yield loss Remove grassy weeds early Apply nutrient/ trace elements, foliar in crop, if required

Source: GRDC)

Summer weed control

Summer weed control will reduce inoculum levels and the disease in the following winter by decreasing the living host plants for the disease. This complements the moisture and nitrogen conservation benefits of summer weed control.

Crop choice rotations

Cereals and grassy fallows promote the build-up of Rhizoctonia inoculum, with barley being the worst of these. Crop rotation with a grass-free non-cereal crop is one of the best available management strategies to reduce the impact of Rhizoctonia disease. Trials across the lower rainfall cropping region of southern Australia indicated that grass-free oilseeds, pulses, pasture legumes and fallow can result in significant reductions in Rhizoctonia inoculum in a cropping sequence. Non-cereal crops can be infected by Rhizoctonia, however, most do not allow the build-up of inoculum. Lupins may be a less effective break crop and can suffer from yield damage in the presence of Rhizoctonia. The beneficial effect of rotation on reducing Rhizoctonia inoculum generally lasts for one cereal crop season.

Fungicide treatments

Fungicide treatments need to be used as part of an integrated management strategy. Yield responses can vary between seasons with the greatest responses occurring when spring rainfall is above average. In GRDC funded trials in southern Australia and Western Australia, on average seed treatments gave 5% (0 to 18%) yield responses in cereals. Several products have been registered for liquid banding. GRDC funded research has shown that: Product(s) registered for dual banding, in-furrow 3–4 cm below the seed and on the surface behind the press wheel, gave the most consistent yield and root health responses across seasons. Seed treatment combined with in-furrow application can provide intermediate benefit between seed treatment alone and a split application.

Nitrogen

Nitrogen-deficient crops are more susceptible to Rhizoctonia. Intensive cropping with cereals and stubble retention result in very low levels of mineral nitrogen over summer as soil microbes temporarily utilise all available nitrogen while breaking down the low nitrogen stubble residues. Application of adequate N fertiliser at sowing is necessary to ensure early seedling vigour so plants can push through the layer of inoculum concentrated in the top 10 cm. Ensure good nitrogen nutrition is present. Crops with adequate N will be less affected by the disease.

Disease suppression

Biological disease suppression can help control Rhizoctonia disease occurring in grower's crops. • Disease suppression is a function of activity and diversity of the microbial community. A management regime that increases Carbon inputs and turnover over a number of years (five to seven years) may improve suppressive activity. Management practices which encourage suppression include reduced tillage and stubble retention, controlling weed hosts, no grazing or stubble burning and avoiding bare fallows. [78]

Cultivation practices

Where reduced tillage is practiced, Rhizoctonia root rot is best controlled by effectively managing weeds and maintaining adequate nutrition for the establishing crop. Spraying weeds with a fast-acting knockdown herbicide will minimise the development of the fungus in the ground prior to seeding, and good nutrition gives the crop a better chance of getting ahead of the disease.

Best-tillage practices involve deep cultivation and shallow sowing, with minimal time between the two. In no-till systems the use of modified sowing points that provide some soil disturbance 5–10 cm below the seed can be useful in controlling the disease.

In the past, tilling was the most effective method of reducing the impact of *Rhizoctonia solani*. The establishment of the fungus in the topsoil late in autumn was negated as cultivation broke the network of fungal hyphae, and it did not have time to recover before seedling establishment. In severely infected paddocks, cultivation may be an important management strategy.

Currently there are no resistant crop varieties, but there are products on the market for the control of Rhizoctonia root rot. Consult your local adviser for specific information.

In areas where the disease is known or suspected, the best practice is to clean knife points once the seeding is complete, to eliminate movement of the fungus from one paddock to the next. In general, maintaining adequate nutrition (especially

78 GRDC (2016) Tips and Tactics: Rhizoctonia Southern region. https://grdc.com.au/resources-and-publications/all-publications/factsheets/2016/02/rhizoctonia

MORE INFORMATION

GRDC factsheet, Tips and Tactics: Rhizoctonia

Management to minimise Rhizoctonia disease in cereals

nitrogen) during crop establishment is the best way to reduce the chance of *R. solani* infection. [79]

9.10 Scald

Scald is caused by the fungus *Rhynchosporium commune* (formerly known as R. *secalis*) and is considered a minor disease of the traditional GRDC Northern region (north of Dubbo). However, in the southern part of the Northern region, and in seasons when environmental and epidemic conditions are particularly favourable the economic impact of this disease can be quite serious. Scald can cause yield loss in triticale (Photo 20).

Photo 20: *Scald infection on a triticale plant.*

Photo: H Wallwork.

Its severity varies between crops and seasons, being more prevalent in high rainfall areas and wet seasons. Scald is also favoured by an early break to the season. Grain yield losses due to scald are estimated to be between 10–30% in susceptible varieties, while individual losses as high as 45% have been recorded.

While scald can be common in cereals in the Southern cropping region (and also the southern part of the Northern cropping region), it has been over a decade since scald occurred at damaging levels in the Northern region, north of Dubbo.

Scald has been detected at levels that reduce yield as far north as Toowoomba but this is a rare occurrence. It was present at damaging levels in several crops in the Tamworth area in 2003 and at interest levels in 2005 and 2006. Though the 2016

79 Soilquality.org (2016) Rhizoctonia, NSW. Factsheet. Soilquality.org, http://www.soilquality.org.au/factsheets/rhizoctonia-nsw

experience is unlikely to be a frequent occurrence, it is a reminder that given the right conditions, minor diseases can rapidly increase and cause significant yield loss.

Most cereal varieties developed for the Northern region are susceptible (S) to very susceptible (VS) to scald, because resistance to the disease in this region is not seen as a breeding priority. This not only provides a susceptible host in areas where scald might over-season and infect any one variety; but it also provides large areas of other susceptible varieties, making an easy target for spores to be deposited and infect. Therefore, a high proportion of spores released by the pathogen will find a target host, infect and establish the disease in new areas.

Scald is a highly variable fungus and many pathotypes have been identified. It is claimed that numerous pathotypes can be isolated from just one square metre of infected crop. Consequently, virulent pathotypes are omnipresent.

The pathogen survives on barley stubble, on barley grass (*Hordeum leporinum, H. glaucum*) and can be seed-borne. Barley stubble is most likely the major source of inoculum in 2016. The disease has probably been present in crops at low levels in most seasons and has persisted over summers on crop residues. Winter environments in recent years have not suited the development and spread of scald in crop; so it has persisted at only low levels. It is unlikely that seed-borne infection played a major role in the recent epidemic.

Once infection occurs, scald can proliferate at an alarming rate. A single scald lesion can produce up to 1 million conidia.

The over-seasoning phases have implications for future disease management. Stubble from crops of barley, heavily infected in 2016, will be a major source of inoculum in 2017. Stubble could be removed but if this is not an option, do not sow barley back into those paddocks for at least two seasons. Stubble has been shown to support sporulation over a 10-month period.

Furthermore, if growers harvested seed from heavily infected crops in 2016 intending to save some for planting seed in 2017, it is recommended that they either buy in seed from non-infected crops or alternatively treat seed with a recommended fungicide. Transmission of scald from infected seed to seedlings can be as high as 86%.

The reappearance of scald in 2016 was a new experience for many Northern growers and agronomists. Consequently, it was easy to overlook the disease early in the season and later to underestimate the potential for epidemic increase. By the time scald was recognized as an issue, the optimal time for fungicide application had passed. No doubt the disease reduced yield in heavily infected crops. [80]

9.10.1 Symptoms

Scald causes lesions of the leaf blades and sheaths. At first, scald appears as water-soaked, grey- green lesions, which change to a straw colour with a brown margin that are ovate to irregular in shape, (Photo 21). In severe infections, the disease may virtually cause defoliation by coalescing of the lesions.

80 G Platz, L Snyman, R Fowler (2017) GRDC Update Papers: What we learnt in 2016 about scald and other wet season diseases. https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2017/02/What-we-learnt-in-2016-about-scald-and-other-wet-season-diseases

MORE INFORMATION

GRDC Foliar Diseases–Ute Guide

Photo 21: *Scald of barley. Early water-soaked, grey- green symptoms compared to later straw colour lesions with a distinctive brown margin.*

Source: CropPro.

Scald blotches may look similar to herbicide damage, however herbicide damage is often seen as more evenly-spread droplet-sized lesions.

9.10.2 Conditions favouring development

Scald requires free moisture for sporulation and infection and relies on rain splash to move spores up the plant and within the crop. Frequent rain periods therefore promote sporulation, disseminate conidia and favour infection. These conditions also promote crop growth; so that in dense crops leaf tissue can remain wet for 24 hours per day. Serious losses to scald occur in seasons with frequent rain.

The optimal temperature for spore production is 15–20°C which also favours infection. No doubt environmental conditions that promoted spore production, spore dissemination and infection occurred repeatedly in the problem areas in 2016 and played a major role in the development of epidemics. [81]

9.10.3 Management of Scald

Wet weather can be a trigger for disease control. If growers are in an area that has experienced diseases like scald before, be suspicious that these diseases may reappear. Monitor crops for the presence of the regular diseases but also with a purpose to detect other diseases that have appeared in previous wet seasons.

Usually minor diseases do not command routine procedures to control the disease. Although once detected in a favourable season, they demand close monitoring and timely fungicide intervention to minimize yield losses. Foliar fungicides are quite effective on scald and will give protection for 3–4 weeks depending on product and rate applied. In a season like 2016, application of fungicide at GS31-32 and again at GS39-41 may have been required to give an adequate level of control. [82]

81 G Platz, L Snyman, R Fowler (2017) GRDC Update Papers: What we learnt in 2016 about scald and other wet season diseases. https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2017/02/What-we-learnt-in-2016-about-scald-and-other-wet-season-diseases

82 G Platz, L Snyman, R Fowler (2017) GRDC Update Papers: What we learnt in 2016 about scald and other wet season diseases. https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2017/02/What-we-learnt-in-2016-about-scald-and-other-wet-season-diseases

Cultural Practices

Carry-over of scald inoculum can be reduced by grazing, burning or cultivation of stubble, volunteers and barley grass, however, these practices do not eliminate the disease altogether as scald will survive on small amounts of remaining residue. Rotations that avoid consecutive barley crops and ideally a two year or more break between suscpetible crops is recommended to allow residue to sufficiently breakdown. Scald is also more severe in early sown crops, so avoiding early sowing of susceptible varieties, especially in high rainfall areas will reduce the loss caused by scald.

Resistant Varieties

Cultivation of resistant varieties gives the best control of scald, with the risk of grain yield and quality loss being greatly reduced by avoiding growing susceptible and very susceptible rated varieties. Unfortunately, *R. commune* is highly variable pathogenically and able to overcome resistances rapidly, meaning that variety ratings may also change frequently. It is important to check up to date cereal disease guides for the resistance status of varieties.

Fungicides

There are a range of fungicides available that will provide suppression of scald. Fertiliser and seed applied fungicides provide effective suppression during the seedling stages of crop development, while foliar fungicides are most effective when applied between the beginning of stem elongation (GS31) and flag leaf emergence (GS39). Two applications of fungicide are generally required to minimise grain yield and quality loss where disease pressure is sustained during the season. Application that coincide with the early stages of scald development are more effective than later applications as scald can rapidly cause damage when conditions are favourable. Crop monitoring if very important during seasons of risk of scald development. [83]

MORE INFORMATION

New fungicides and disease management strategies for wheat and barley

9.11 Ergot

Triticale, like rye, is susceptible to ergot, a fungal disease, caused by *Claviceps purpurea*, that can ruin a year's crop. Careful crop rotation, the use of a clean seedbed, and diligent maintenance of field edges will minimise this chance, but triticale intended for human or animal consumption should be tested for toxins. Ergot can make grain less palatable to livestock, as well as causing serious health problems. [84]

9.11.1 Damage caused by disease

Ergot bodies contain alkaloid chemicals that can cause lameness, gangrene of the extremities and nervous convulsions (staggers) that can lead to death in both humans and other animals. Symptoms begin to occur after long periods of low level ingestion as toxins accumulate in the body. Yields of crops affected by ergot are generally not much diminished yield losses, but economic losses can be quite severe, because grain tendered by growers is likely to be rejected at receival. [85]

Gangrenous ergotism of humans and cattle

In humans, gangrenous ergotism causes blockages of circulation to the extremities resulting first in tingling and then in gangrene in the fingers and toes, as well as vomiting, diarrhoea, and ulceration of the mouth. It is a dry form of gangrene, and limbs may fall off.

83 CropPro (2014) Scald of Barley. http://www.croppro.com.au/crop_disease_manual/ch02s17.php

84 UVM Extension Crops and Soils Team (2011) Triticale. University of Vermont, http://northerngraingrowers.org/wp-content/uploads/TRITICALE.pdf

85 AWB (n.d.) Ergot. Factsheet. AWB, https://www.awb.com.au/NR/rdonlyres/BFA96F0A-1967-4B8D-8B6C-631A00F15478/0/ERGOT_factsheet.pdf

In cattle there is lameness, especially in the hindquarters, gangrene of feet, ears and tail. Pregnant cows may abort. There is a characteristic band where the gangrenous tissue ends.

Convulsive ergotism

Symptoms are similar to those of gangrenous ergotism, and are followed by painful spasms of the limbs, epilepsy-like convulsions and delirium in humans. Cattle become excitable and run with a swaying, uncoordinated gait. [86]

9.11.2 Symptoms

What to look for in the plant

Characteristically ergot pieces have a purple–black surface with a white to grey interior (Photo 22). They are usually horn-like in shape and replace one or more grains in the heads of cereals and grasses. These ergot bodies can be up to four times larger than normal grain.

- Hard, dry purple–black fungal bodies (ergots) that replace the grain in the seed head.
- Yellow droplets of sugary slime in infected heads during flowering. [87]

Photo 22: *Ergot bodies in cereal grain head.*

Photo: C Wolinsky

What to look for in stock

Producers are encouraged to keep an eye on animals that may have eaten ergot-infected grain, especially in hot or sunny weather (Photo 23). Signs of ergot poisoning include animals seeking shade, being reluctant to move, and panting and distress following any exercise. Animals may also drool, have an increased respiratory rate, and reduced feed intake. [88]

86 HerbiGuide (n.d.) Rye. HerbiGuide, http://www.herbiguide.com.au/Descriptions/hg_Rye.htm

87 DAFWA (2015) Diagnosing ergot. DAFWA, https://www.agric.wa.gov.au/mycrop/diagnosing-ergot

88 DAFWA (2015) Look out for ergots when selecting stock feed. DAFWA, https://www.agric.wa.gov.au/news/media-releases/look-out-ergots-when-selecting-stock-feed

Photo 23: *Producers need to be aware that even a small amount of ergot in grain can cause serious illness to their stock.*

Photo: Michael Raine

9.11.3 Conditions favouring development

Key points:

- Ergots survive in the soil for up to one year, producing spores that infect plants during flowering.
- Infection is more likely when there is cool, wet weather at flowering.
- It is spread by rain splash or by insects attracted to the sugary droplets.
- High levels of grass-weed contamination can increase ergot infection in cereals, or ergots produced in grasses can contaminate grain samples. [89]

The development of ergot is promoted by moist soil surfaces during spring and early summer. In addition, wet conditions during the flowering of cereals and grasses increases the period of infection. The disease cycle of ergot consists of two stages. It begins in spring when the ergot bodies germinate in wet soils after winter and develop fruiting bodies that contain spores (ascospores). The spores can be spread to neighbouring, susceptible plants by wind and rain. To infect these plants, the spores must land on the florets. Within five days the second stage commences; this is referred to as the 'honeydew stage'. The infected florets exude a sugary slime that contains spores of a second type (conidia). These can infect other florets via insect vectors, rain splash and/or wind. This period of infection lasts for as long as the susceptible plants are in flower. The infected ovary in the floret then enlarges and is replaced by the purple–black ergot body, which can survive in soil for up to one year.

Crops are generally perceived to be at greatest risk when grass weed populations are high. Infected grasses usually produce slender ergots and in some cases can be fully responsible for the contamination of grain samples. [90]

Ongoing periods of spring and summer rain can increase occurrence of ergots in ryegrass; therefore, ergots in crops are more likely to develop in years of above-average rain when ryegrass is flowering. [91]

9.11.4 Management of disease

Key points:

89 DAFWA (2015) Diagnosing ergot. DAFWA, https://www.agric.wa.gov.au/mycrop/diagnosing-ergot

90 AWB (n.d.) Ergot. Factsheet. AWB, https://www.awb.com.au/NR/rdonlyres/BFA96F0A-1967-4B8D-8B6C-631A00F15478/0/ERGOT_factsheet.pdf

91 DAFWA (2015) Look out for ergots when selecting stock feed. DAFWA, https://www.agric.wa.gov.au/news/media-releases/look-out-ergots-when-selecting-stock-feed

- Give contaminated paddocks a one-year break without cereals or grasses.
- Manage grass-weed contamination in crops.
- Clean seed. [92]

For grain that is contaminated, grain-cleaning equipment can be used to remove the majority of ergot bodies (Photo 24). However, the grower will need to determine whether this is economically viable.

Photo 24: *Ergot-contaminated seed.*

Source: DAFWA

To avoid the development of ergot in subsequent cereal crops, effective farm-management practices are required. One option available to growers is the use of crop rotations away from cereals for at least one year to reduce the number of viable ergot pieces in the soil to negligible levels.

During planting, clean seed must be used, as there are currently no effective treatments against ergot. For growers using conventional tillage, ergot pieces need to be buried to a minimum depth of 4–5 cm. This prevents the fruiting bodies that are produced by the ergot from reaching the soil surface and releasing spores. This may have an effect on the usual sowing operations and guidance should be sought.

Finally, to eliminate the development of host reservoirs, growers may be able to mow or spray grass pastures to prevent flowering. [93]

92 DAFWA (2015) Diagnosing ergot. DAFWA, https://www.agric.wa.gov.au/mycrop/diagnosing-ergot

93 AWB (n.d.) Ergot. Wheat quality factsheet. AWB, https://www.awb.com.au/NR/rdonlyres/BFA96F0A-1967-4B8D-8B6C-631A00F15478/0/ERGOT_factsheet.pdf

Control of grasses within cereal crops will help prevent cross-infection. This is best achieved by preventing seedset in the season before cropping, by clear fallowing, hard grazing or hay cutting, together with the use of selective herbicides. [94]

The only practical control is to sow clean, year-old seed on land that hasn't grown cereal rye for at least a year. Mowing roadside and headland grass prior to seedset will reduce or eliminate this major source of ergot re-infestation. [95]

Strategies to reduce the risk of ergot infection:

- Use ergot-free seed if possible.
- Rotate with crops resistant to ergot, such as canola and legumes.
- As the source of ergot infection is often the grass in headlands or ditches, mowing this grass before flowering or seedset will greatly reduce or eliminate the chances of ergot infection.
- Ergots germinate at or near the soil surface. To prevent them from germinating, work the paddock to a depth greater than 4–5 cm to bury the ergot bodies.
- Seed at a uniform depth as shallow as possible for adequate moisture to obtain a uniform early emergence.
- Separate the seed collected from the first few header rounds to prevent contamination of the entire lot, as most of the ergot infested grain will likely be concentrated in this region. [96]

9.12 *Septoria tritici* blotch

Key points:

- Triticale has vastly superior tolerance over wheat to *Septoria tritici* blotch. [97]
- The disease spends 14–21 days living inside leaves without causing visible symptoms. Then the pathogen transitions to causing visible disease symptoms including necrotic lesions in which the characteristic black fruiting structures are observed.
- An integrated approach that incorporates variety selection, cultural practices, crop rotation and fungicides is the most effective way to manage *Septoria tritici* blotch.
- The disease is starting to show resistance to some fungicide treatments used in Australia, so Integrated Disease Management strategies are increasingly important.

Septoria tritici blotch (STB) is an important stubble-borne foliar disease of cereals in southern parts of the Northern cropping region. This disease has increased in importance in the high-rainfall cropping regions recently, even though it has been well controlled in southern Australia for the last 30 years through the use of partially resistant varieties. The increase in STB in the high-rainfall zone has been favoured by stubble retention, intensive cereal production, susceptible cultivars and favourable disease conditions.

When susceptible and very susceptible varieties are grown, *Septoria tritici* blotch is likely to cause annual average losses of up to 20%, with much higher losses possible in individual crops.

STB is prone to developing resistance to fungicides. Resistance to some triazole (Group 3) fungicides was detected in 2013/2014. To minimise the chance of further resistance developing it will be important pay careful attention to fungicide strategies and use an integrated approach to management.

94 R Clarke (1999) Ergot of pasture grasses. Note AG0721. Revised. Agriculture Victoria, http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/plant-diseases/grains-pulses-and-cereals/ergot-of-pasture-grasses

95 Alberta Agriculture and Forestry (2016) Fall rye production. Agdex 117/20–1. Revised. Alberta Government,. http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex1269/$file/117_20-1.pdf

96 Alberta Agriculture and Forestry (2016) Fall rye production. Agdex 117/20–1. Revised. Alberta Government,. http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex1269/$file/117_20-1.pdf

97 P Matthews, D McCaffery, L Jenkins (2016) Winter crop variety sowing guide 2016. NSW DPI, https://www.dpi.nsw.gov.au/agriculture/broadacre-crops/guides/publications/winter-crop-variety-sowing-guide

9.12.1 Symptoms

The fungus causes pale grey to dark brown blotches on the leaves, and to a lesser extent stems and heads. The diagnostic feature of *Septoria tritici* blotch is the presence of black fruiting bodies (pycnidia) within the blotches (Photo 25). [98] These tiny black spots give the blotches a characteristic speckled appearance. When the disease is severe, entire leaves may be affected by disease lesions (Photo 26).

In the absence of the black fruiting bodies, which are visible to the naked eye, similar blotching symptoms may be caused by yellow leaf spot or nutritional disorders such as aluminium toxicity or zinc deficiency.

The only other disease that has black fruiting bodies within the blotches is *Septoria nodorum* blotch, but this disease is rare.

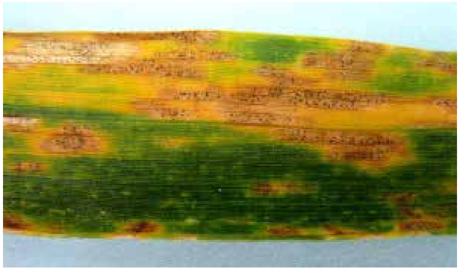

Photo 25: *The presence of black fruiting bodies within the blotches is a diagnostic feature of Septoria tritici blotch.*

Source: Agriculture Victoria

Photo 26: *Septoria tritici blotch can cause complete death of leaves.*

Source: Agriculture Victoria

98 G Hollaway (2014) Septoria tritici blotch of wheat. Note AG1336. Revised. Agriculture Victoria, http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/plant-diseases/grains-pulses-and-cereals/septoria-tritici-blotch-of-wheat

9.12.2 Varietal resistance or tolerance

Table 9 lists the resistance of different varieties to Septoria tritici blotch. [99]

Table 9: *Triticale variety resistance ratings to Septoria tritici blotch.*

Variety	*Septoria tritici*
Astute⫿	MR-MS
Berkshire⫿	R–MR
Bison⫿	MR
Canobolas⫿	R–MR
Chopper⫿	R–MR
Endeavour⫿	R
Fusion⫿	MR
Goanna	MR
KM10	MR
Rufus	R–MR
Tahara	R–MR
Tobruk⫿	R
Tuckerbox	R–MR
Yowie	R–MR

Maturity: E = early, M = mid-season, L = late, VL = very late Height: M = medium, T = tall Colour: W = white, Br = brown Disease resistance order from best to worst: R > R–MR > MR > MR–MS > MS > MS–S > S > S–VS > VS *p* = provisional ratings––treat with caution. R = resistant, M = moderately, S = susceptible, V = very. # Varieties marked may be more susceptible if alternative strains are present

Source: Agriculture Victoria

9.12.3 Conditions favouring development

Septoria tritici blotch, also called Septoria leaf spot or speckled leaf blotch is caused by the fungus *Mycosphaerella graminicola* (asexual stage *Zymoseptoria tritici*, synonym *Septoria tritici*).

The blotch survives from one season to the next on stubble. Following rain or heavy dew in late autumn and early winter, wind-borne spores (ascospores) are released from fruiting bodies (perithecia) embedded in the stubble of previously infected plants. The spores can be spread over large distances.

Early ascospore infections cause blotches on the leaves. Within these blotches a second type of fruiting body, pycnidia, are produced. Asexual spores ooze from pycnidia when the leaf surface is wet and spores are dispersed by rain splash to other leaves where they cause new infections. This phase of disease development depends on the rain splash of spores; therefore, *Septoria tritici* blotch will be most severe in seasons with above-average spring rainfall. A combination of wind and rain provides the most favourable conditions for spread of this disease within crops.

9.12.4 Management

An integrated approach that incorporates variety selection, cultural practices, crop rotation and fungicides is the most effective way to manage *Septoria tritici* blotch.

Variety selection

The majority of commercially grown varieties now have partial resistance (i.e. they are moderately susceptible) to *Septoria tritici* blotch. This resistance has to date been durable, and sufficient to effectively control this disease in Victoria.

99 Agriculture Victoria (2016) Triticale [download]. In Victorian winter crop summary. Agriculture Victoria, http://agriculture.vic.gov.au/agriculture/grains-and-other-crops/crop-production/victorian-winter-crop-summary

MORE INFORMATION

Victorian Cereal Disease Guide

It is important to avoid very susceptible varieties as they will build up inoculum levels. This will cause yield loss in that variety, and in adjacent moderately susceptible crops.

Cultural practices

Following an outbreak of *Septoria tritici* blotch do not sow cereal into infected stubble and avoid early sowing as a high number of ascospores are released early in the season. If this is not possible, destroying stubble by grazing or cultivation will reduce the number of spores available to infect the new season's crop. Such practices will have more effect if undertaken on a district basis. This practice is not, however, practicable in light soil areas where stubble must be kept to prevent erosion.

Crop rotations

Crop rotations are important to ensure triticale is not sown into paddocks with high levels of stubble-borne inoculum. A one-year rotation out of cereals is generally effective to provide disease break. However, the fungus may survive for over 18 months on stubble during very dry seasons.

Fungicides

Some seed-applied fungicides can suppress early infection and should be used in areas where *Septoria tritici* blotch is known to occur.

Effective foliar fungicide sprays are available if necessary. However, it is important to correctly identify *Septoria tritici* blotch before spraying with a fungicide as nutritional disorders such as aluminium toxicity or zinc deficiency can be confused with *Septoria tritici* blotch.

In high-risk areas, the timing of fungicides will be important to achieve adequate disease control. In early sown susceptible varieties, a fungicide application at growth stage 31–32 may be required to suppress the disease and protect emerging leaves. Once the flag leaf has fully emerged, at GS39, another fungicide application may be required to protect the upper canopy.

Since STB is prone to developing resistance to fungicides, and resistance has been detected in Australia, it is important that fungicide strategies to reduce the likelihood of resistance developing are adopted.

Fungicide resistance

Increasing resistance of *Zymoseptoria tritici* to some triazole (Group 3) fungicides was detected in Victoria in 2013/2014. Two mutations of *Septoria tritici* blotch giving resistance to triazole fungicides were identified. These mutations reduce the effectiveness of fungicides, rather than making them completely ineffective. However, continued use of triazole fungicides will put further selection pressure on the pathogen, and potentially new mutations will be selected.

Fungicides with reduced effectiveness against *Septoria tritici* blotch include triadimefon, triadimenol, tebuconazole, propiconazole and epoxiconazole. Epoxiconazole is not registered for control of *Septoria tritici* blotch in Australia.

Dr Milgate found that resistance may not be causing reduced spray efficacy at present, but a strategy to prolong fungicide effectiveness will prolong the life of this fungicide group.

Managing fungicide resistance

There are a few methods that are thought to reduce the selection rate for further mutations.

The first method is to alternate different triazoles, as not all triazole fungicides are affected equally by mutations of the *Septoria tritici* blotch fungus. This means not using the same traizole fungicide more than once in a crop, if multiple sprays are required during the season.

The second is to used fungicides that combine triazoles, such as Tilt Xtra® (propiconazole and cyproconazole) or Impact Topguard® (tebuconazole and flutriafol), which are registered for use on *Septoria tritici* blotch.

The third is to use fungicides with different modes of action. However, in Australia there is a limited choice in this regard. Products that combine a strobilurin (Group 11) fungicide with a triazole fungicide may reduce the risk of resistance development.

Strobilurins on their own are considered to be at high risk of developing resistance due to their single site mode of action. In the United Kingdom, resistance to strobilurins is so widespread in *Septoria tritici* blotch populations they are no longer effective, even in mixtures. Resistance of *Septoria tritici* blotch to strobilurins has been recently detected in New Zealand, too. While not yet registered in Australia, SDHI (Group 7) carboxamide fungicides mixed with triazole (Group 3) fungicides are being used in New Zealand and the United Kingdom to manage *Septoria tritici* blotch.

When using fungicides, it is important that growers always follow label guidelines and ensure maximum residue limits are adhered to.

Biosecurity

As resistant mutations of the *Septoria tritici* blotch fungus have been identified in other countries, including New Zealand, the United Kingdom and mainland Europe, it is important to take great care that these are not accidentally introduced into Australia after travelling overseas.

The risk of introducing exotic diseases or new mutations of a pathogen into Australia can be minimised by having a biosecurity hygiene plan, and implementing it following overseas travel. Basic biosecurity hygiene includes washing clothes and cleaning footwear before returning to Australia. If high-risk areas have been visited, consider leaving clothing and footwear behind. Remind family members, employees or others travelling to also take these precautions. [100]

IN FOCUS

Septoria fungicide update–2017

Genetic mutations in the Septoria tritici blotch (STB) pathogen *Zymoseptoria tritici* can differentially influence the performance of triazole fungicides in the laboratory.

There should continue to be a focus on integrated disease management (IDM) to control STB, using rotation, cultivar resistance, later sowing, and other aspects of cultural control to complement fungicide control.

New research on foliar fungicides indicates that the principal fungicides still give good in-field control of STB up to 30 days after application when applied at full label rates.

There are significant differences in disease control amongst the different fungicide products and rates of application when monitored leaves are assessed more than 30 days after application.

In this study, single spray timings of foliar fungicide for control of STB made during the late tillering phase gave less effective disease control than applications made at first node (GS31). Spray application delayed until flag leaf gave the poorest control of STB but gave superior leaf rust control later in the season.

There was evidence of significantly better curative control of STB on the lowest leaf (flag -3) from Opus 125® (epoxiconazole) and Prosaro® 420 SC (tebuconazole and prothioconazole), though it should be emphasised that

100 G Hollaway (2014) Septoria tritici blotch of wheat. Note AG1336. Revised. Agriculture Victoria, http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/plant-diseases/grains-pulses-and-cereals/septoria-tritici-blotch-of-wheat

though these products are approved for use in wheat, there is currently no label recommendation for STB control.

STB is a stubble borne disease with the majority of the spore release from the stubble taking place in the autumn and winter under wet humid conditions. This initial spore release from the stubble is airborne and gives rise to the characteristic STB symptoms on the lower leaves of the crop later in the winter/spring. Further infection from these blotch lesions takes place under wet conditions with secondary spores spread up the plant by rain splash or the rubbing of wet leaves in the wind. These secondary spores are unable to travel long distances which means that the infection base in spring is likely to be the source of further infection. This raises the question as to when foliar fungicides should be sprayed in the spring to secure the best disease control and greatest economic response. To help answer that question, single applications of fungicide were applied at late tillering GS25 (17th August), pseudo stem erect GS30 (1 Sept), first node GS31 (16 September) and flag leaf emergence GS39 (13 October). Spraying early should control the disease at an early stage of the epidemic, although the leaves protected will be less important to grain fill. Spraying later allows greater early infection on the lower leaves, but applies fungicide to the first of the physiologically more important leaves for grain fill (flag-2 and flag-1).

Results revealed that sprays applied at GS31 gave the optimum control of STB on the top four leaves when assessed at the ear emergence stage. This disease control was principally evident on flag-2 and flag-3. These two leaves emerged in the early September window. [101]

MORE INFORMATION

Septoria fungicide update and latest developments in rust management

9.13 Cereal fungicides

All of the diseases addressed so far are caused by different fungi. Fungal disease is a major disease threat to all Australian crops, and keeping paddocks (and farms) healthy and disease loads low requires thoughtful management.

- Fungicides are only one component of a good management strategy.
- Correct identification of the cause of plant symptoms is essential, and an understanding of the growth and spread of any pathogen will assist in any decision making.
- Cultivar resistance is the best protection against fungal diseases. Ideally, when suitable varieties are available, opt for moderately resistant (MR) to resistant (R) varieties in disease-prone environments.
- 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 to prevent rusts from over-seasoning.
- Monitor crops throughout the season.
- 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.

101 N Poole, T Wylie (2017) GRDC Update Papers: Septoria fungicide update and latest developments in rust management. https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2017/02/Septoria-fungicide-update-and-latest-developments-in-rust-management

VIDEOS

WATCH: GCTV9: Banding fungicide in cereals

MORE INFORMATION

GRDC factsheet, Cereal fungicides

- Fungicide resistance is a major emerging issue. Do not use tebuconazole-based products on triticale if there is any chance of powdery mildew occurring, and select varieties that are resistant to powdery mildew. [102]

9.13.1 Fungicide stewardship

There have been a number of pathogens, including *Septoria tritici* blotch, which have recently developed a level of fungicide insensitivity or resistance in Australia. The occurrence of these highlights the important role all growers play in fungicide resistance.

To help achieve fungicide-resistance management and disease management, there are three important steps growers need to implement.

1. Remove the source of infection:

- For many pathogens, stubble is the source of the infection each year. By removing stubble before sowing, there is a substantial reduction of pathogen population size.
- This reduces all forms of the pathogen irrespective of resistance, and reduces the initial establishment of disease.
- To avoid rapid disease build up, do not sow cereal on cereal.

2. Choose more resistant varieties:

- Under high disease pressure, a variety rated MR–MS can reduce the leaf area loss substantially. Where possible, choose a more resistant variety.
- Host resistance reduces all forms of the pathogen irrespective of resistance, and reduces the need for multiple canopy fungicide applications.
- But resistance ratings do change, so crops must still be monitored in season for higher than expected reactions and check each year for updates to disease ratings.

3. Follow best practice when choosing and using fungicides:

- Do not use the same triazole active ingredient more than once in a season.
- Aim for early control of necrotrophic diseases, such as Yellow Leaf Spot, in high-rainfall years. Reducing the disease in the lower canopy slows the upward movement of disease and ultimately the leaf area lost.
- Follow label instructions at all times.

The timing of application in a disease epidemic is critical to getting the most out of fungicides. [103]

9.14 Barley yellow dwarf virus

Key points:

- Barley yellow dwarf virus (BYDV) infects cereal crops such as triticale, wheat, barley, oats, rye and grasses.
- It is transmitted by aphids which can pass the disease onto plants within 15 minutes of feeding.
- The virus only survives in living tissues. It does not survive in stubbles or soils and is not airborne.
- It is most damaging in higher rainfall zones, including the northern Tablelands in NSW, where permanent grasses and pastures act as a reservoir for the virus and aphids over summer.
- The earlier the infection the more severe the damage. Leaves turn yellow from the tips and develop yellow stripes extending towards the base. Some reddening or purpling of the leaves may occur along the edges.

102 GRDC (2013) Managing cereal fungicide use, Northern Region. Factsheet. GRDC, https://grdc.com.au/Resources/Factsheets/2013/05/Cereal-fungicides

103 A Milgate (2016) Cereal disease update and risks for southern NSW crops in 2016. GRDC Update Paper. GRDC, https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2016/07/Cereal-disease-update-and-risks-for-southern-NSW-crops-in-2016

- Growers should have a management plan which includes selecting resistant varieties, continual crop monitoring, managing the green bridge, presowing seed dressing and spraying foliar insecticides if required (noting correct label usage).

The yellow dwarf diseases of cereals have now been divided into two groups: Barley yellow dwarf virus (BYDV) and Cereal yellow dwarf virus (CYDV). They are the most important virus diseases of cereals worldwide. They have a wide host range which includes triticale, wheat, barley, oats and over 150 non-commercial grass species.

The virus is usually spread by aphids from infected grasses to crops. Wet summers and autumns promote growth of host grasses and build up of aphid vectors, resulting in early crop infection, severe symptoms and yield losses. Yellow dwarf viruses (YDVs) tend to be more serious in the high-rainfall cropping regions in southern Australia, but can occur in all cropping regions.

All early BYDV infections of cereal plants will mean they have less above-ground biomass and a less extensive root system. Grain size can be smaller or it can become shriveled, which causes lower yields, higher screenings and reduced marketing options. Victorian Department of Primary Industries Field Crops Pathology Group (Horsham, 1984) research found yield losses of between 9% and 79% occurred when plants were infected early in the growing season (before the end of tillering) and losses of 69% may occur when plants are infected after tillering.

Growers in high rainfall zones should be proactive and develop a Barley Yellow Dwarf Virus (BYDV) management plan which includes crop monitoring, green bridge management, foliar pesticide sprays and pre-sowing seed treatment. These actions will control aphid populations which spread BYDV. The virus is best controlled by monitoring and spraying for aphids early in the season. [104]

9.14.1 Symptoms

After infection, symptoms take at least three weeks to appear. They usually appear as patches of yellow or red stunted plants. The symptoms first appear where aphids have landed. Flying aphids may infect individuals or groups of plants dotted throughout the crop. If the aphids colonise the crop, rings or patches develop which increase in size with time (Photo 27). [105] If crawling aphids move into the crop from adjoining pastures or crops then symptoms will appear along the fence line first.

104 GRDC (2013) Barley yellow dwarf virus factsheet. https://grdc.com.au/resources-and-publications/all-publications/factsheets/2013/09/barley-yellow-dwarf-virus

105 DAFWA (2015) Managing barley yellow dwarf virus and cereal yellow dwarf virus in cereals. DAFWA, https://www.agric.wa.gov.au/barley/managing-barley-yellow-dwarf-virus-and-cereal-yellow-dwarf-virus-cereals?page=0,1

Photo 27: *Patches where aphids have landed and transmitted the virus.*

Source: DAFWA

The symptoms of the yellow dwarf virus (YDV) can be variable and can differ with host species, cultivar and time of infection. Sometimes, infection of cereals may occur without visible symptoms. Distinct symptoms usually occur on cereals although many infected grasses are symptomless. [106]

Infected triticale plants develop a slight to severe yellowing or pale striping between veins (interveinal chlorosis) in young leaves (Photo 28). Leaf tips can also die (necrosis). Reddening of the leaf tips (particularly of the flag leaf) can often be seen and is the most characteristic symptom of virus infection in triticale. If a sensitive variety is infected before tillering, the plant is usually stunted, has fewer tillers and more sterile ones. Grain matures early, yield is greatly reduced and grain is shrivelled. Effects are milder with a late infection. [107]

Photo 28: *Barley yellow dwarf virus infection of a cereal plant.*

Source: DAFWA

MORE INFORMATION

GRDC Foliar Diseases–Ute Guide

106 Agriculture Victoria (2011) Barley yellow dwarf virus. Note AG1113. Revised. Agriculture Victoria, http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/plant-diseases/grains-pulses-and-cereals/barley-yellow-dwarf-virus

107 DAFWA (2015) Managing barley yellow dwarf virus and cereal yellow dwarf virus in cereals. DAFWA, https://www.agric.wa.gov.au/barley/managing-barley-yellow-dwarf-virus-and-cereal-yellow-dwarf-virus-cereals

9.14.2 Conditions favouring development

The prevalence of BYDV depends on environmental conditions, host-pathogen dynamics and aphid populations. The virus is generally worse in seasons with a wet summer (which allows for significant volunteer or green bridge growth) followed by a mild autumn and winter. However, the aphids are able to survive in hot summers in perennial grasses–such as perennial ryegrass, kikuyu, paspalum, couch and African love grass–in permanent or irrigated pasture areas and along waterways. Winged aphids are able to migrate around the southern grain growing region regardless of summer conditions. Growers should not be complacent in dry summers. BYDV can be caused by relatively few infected aphids if they arrive early in the growing season and are very mobile through the crop. [108]

There are five species of aphids that transfer different types of BYDV, including oat aphid (*Rhopalosiphum padi*), the corn aphid (*R. maidis*), the English grain aphid (*Sitobian miscanthi*) and the rose-grain aphid (*Metopolophium dirhodum*). The viruses are not transmitted by any other insects and are not transmittable through seed, soil or sap. The aphids need to feed on an infected plant for at least 15 minutes, which is followed by a latent period of 12 hours, before the virus will transmit to a healthy plant. Aphids remain infected for the rest of their life.

See Section 7: Insect control for more information on aphids.

Outbreaks of YDV are likely to be worse in years when wet, cool summers allow larger than normal numbers of aphids and alternate hosts to survive summer, followed by a mild winter which favours the build-up of aphid numbers. Early sown crops or long season crops sown in high rainfall areas are particularly vulnerable to this disease. [109]

9.14.3 Management

Key points:

- Control summer weeds (the green bridge) as weeds, volunteer cereals and annual grasses can act as hosts for aphids. Growers in irrigated areas and with forage crops should be aware that these can harbour aphids over the summer.
- Choose varieties which have appropriate ratings. Refer to your local cereal variety disease guide for information on variety ratings.
- Investigate sowing time. Crops sown later in low rainfall regions may avoid being colonised by the major autumn aphid flight. However, this needs to be carefully considered against the risk of frost. The crop may still be infected by aphids from another source.
- Trials results have led to the recommendation that sprays should be applied three and seven weeks after crop emergence. These applications will enable aphid populations to be managed before the problem has spread.
- Communicate with your neighbour if BYDV is gound. This will enable a faster response to management and help to decrease aphid outbreaks.
- Record all spray applications, use appropriate safety equipment and follow label rates and directions at all times. [110]

Resistant varieties, when available, are the preferred option for management. Where it is not possible to grow resistant varieties, BYDV can be reduced by controlling aphid activity in crops, especially early in the season to prevent the spread of the disease, and or delayed sowing to avoid the main aphid flights in the autumn. Later sowing will reduce the incidence of BYDV, but this needs to be weighed up against possible yield reduction from delayed sowing.

108 GRDC (2013) Barley yellow dwarf virus factsheet. https://grdc.com.au/resources-and-publications/all-publications/factsheets/2013/09/barley-yellow-dwarf-virus

109 Agriculture Victoria (2011) Barley yellow dwarf virus. Note AG1113. Revised. Agriculture Victoria, http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/plant-diseases/grains-pulses-and-cereals/barley-yellow-dwarf-virus

110 GRDC (2013) Barley yellow dwarf virus factsheet. https://grdc.com.au/resources-and-publications/all-publications/factsheets/2013/09/barley-yellow-dwarf-virus

It is vital to prevent spread of the virus by aphids during the first 8–10 weeks after crop emergence by using insecticides. In situations where aphids are likely to be a problem in the first few weeks after sowing, a seed treatment containing imidacloprid could be used for protection. [111]

For grain growers who decide to manage aphids, it is critical to plan the control strategy and have it in place before sowing starts. Do not wait until aphids are found because infection or damage will have already occurred. Growers in high risk areas should treat each year as a 'BYDV year' unless there has been low rainfall over summer and autumn. Waiting until aphids or BYDV symptoms are found is too late.

Seed dressings

Seed dressings with imidacloprid have been shown to reduce aphids in cereal crops at the early stage of growth when cereals are most susceptible to BYDV. Do not graze treated cereal crops within nine weeks of sowing. In high risk areas, a top-up spray (see insecticides section) is recommended at six to eight weeks after sowing.

Insecticides

Growers must work to prevent the spread of BYDV early after crop emergence because this is when plants are most vulnerable. In high risk areas, such as the long season areas which have received high summer rainfall, growers can apply insecticides before aphids and/or BYDV symptoms are evident. This is considered a risk-based application. The insecticides will help kill and repel the aphids, leading to increased yields, particularly when plants are young and small. Growers can utilise a range of approved insecticides to manage the aphids. As well as pyrethroids, there are spray options which can have less impact on non-target insects. These may suit farmers trying to incorporate integrated pest management into their system. Advice prior to spraying is essential.

Trial results have led to the recommendation that sprays are applied three and seven weeks after crop emergence. This is because BYDV symptoms are usually not obvious until three weeks after the aphids have fed on plants. These applications will enable aphid populations to be managed before the problem has been noticed and the aphids have spread even further. Considerable BYDV spread can occur even when aphid numbers are low. Symptoms can be hard to see in winter. Consultation with an agronomist or crop pathologist is recommended. In years conducive to aphid build-up, a follow-up insecticide application in spring, with both the early foliar or seed treatment strategies, may be required to limit feeding damage. The effect of late BYDV infection by itself is generally not sufficient to warrant spraying in spring so the decision should be purely based on aphid pressure. [112]

Foliar sprays can be used soon after crop emergence if aphids are easily found. There are a number of products registered for control of aphids in cereals. The active ingredient pirimicarb only effects aphids, and will have less effect on any beneficial insects present at the time of spraying. Synthetic pyrethroids are also registered for use on aphids in cereals, but will have a detrimental effect on many beneficial insects. Consult a local agronomist to determine the most suitable treatment. [113]

Delayed sowing

Delayed sowing avoids the main autumn peak of aphid flights and can reduce the incidence of BYDV. However, other yield penalties associated with late sowing make this option generally considered a poor choice over using insecticides. Growers in the late sown high rainfall areas should note that late sowing may coincide with peak spring flights of aphids resulting in more severe damage.

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111 DAFWA (2015) Managing Barley yellow dwarf virus and cereal yellow dwarf virus in cereals. DAFWA, https://www.agric.wa.gov.au/barley/managing-barley-yellow-dwarf-virus-and-cereal-yellow-dwarf-virus-cereals

112 GRDC (2013) Barley yellow dwarf virus factsheet. https://grdc.com.au/resources-and-publications/all-publications/factsheets/2013/09/barley-yellow-dwarf-virus

113 Agriculture Victoria (2011) Barley yellow dwarf virus. Note AG1113. Revised. Agriculture Victoria, http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/plant-diseases/grains-pulses-and-cereals/barley-yellow-dwarf-virus

MORE INFORMATION

Barley yellow dwarf virus Fact Sheet

Control during the green bridge

Management of the green bridge (volunteer cereals and grass weeds) through appropriate herbicides is important for managing BYDV, not to mention the associated benefits of moisture/nutrient conservation. On top of summer weed control, spraying out perennial grasses near and around cereal paddocks at least three weeks before sowing may reduce aphid numbers. [114]

9.15 Disease following extreme weather

9.15.1 Cereal disease after drought

Drought reduces the breakdown of plant residues. This means that inoculum of some diseases does not decrease as quickly as expected, and will carry over for more than one growing season, such as with crown rot. The expected benefits of crop rotation may not occur or may be limited. Inversely, bacterial numbers decline in dry soil. Some bacteria are important antagonists of soil-borne fungal diseases such as common root rot. These diseases can be more severe after drought.

During a drought year, inoculum of some diseases favoured by a wet season may not increase as expected.

Large amounts of seed produced in abandoned crops, or seed pinched as a result of drought stress, will fall to the ground. If there are summer rains, large numbers of volunteers will provide a summer green bridge and autumn green ramp. Low stock numbers make it difficult to control volunteers, which provide a green bridge for rusts, viruses and virus vectors, and many other pathogens.

Weeds that harbour diseases are harder to kill.

Soil water and nitrogen may be unbalanced and these are likely to impact on diseases. [115]

9.15.2 Cereal disease after flood

For disease to occur, the pathogen must have virulence to the particular variety, inoculum must be available and easily transported, and there must be favourable conditions for infection and disease development.

The legacy of the floods and above average rain include the transport of inoculum (e.g. of crown rot, nematodes, leaf spots through movement of infected stubble and soil) (Photo 29), development of sexual stages (e.g. in leaf spots, head blights), survival of volunteers (unharvested material and self-sown plants in double-crop situations), and weather-damaged seed. [116]

114 GRDC (2013) Barley yellow dwarf virus factsheet. https://grdc.com.au/resources-and-publications/all-publications/factsheets/2013/09/barley-yellow-dwarf-virus

115 G Murray, T Hind-Lanoiselet, K Moore, S Simpfendorfer, J Edwards (2006) Crop diseases after drought. Primefacts. No. 408. NSW DPI,

116 DAF Qld (2013) Winter cereals pathology. DAF Queensland,

Photo 29: *Yellow leaf spot-infected stubble following flood.*

Photo: Rachel Bowman, Seedbed Media