WESTERN
MAY 2018

GRDC GROWNOTES™

GRDC GRAINS RESEARCH & DEVELOPMENT CORPORATION

TRITICALE

SECTION 9

DISEASES

TOOLS FOR DIAGNOSING CEREAL DISEASE | RUST | LEAF SPOT | TAKE-ALL | CROWN ROT | RHIZOCTONIA | SMUT AND BUNT | COMMON ROOT ROT | ERGOT | CEREAL FUNGICIDES | BARLEY YELLOW DWARF VIRUS (BYDV) | DISEASE FOLLOWING EXTREME WEATHER EVENTS

Diseases

Key messages

- Triticale can be less susceptible to the common fungal diseases of cereals which make 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). [1]
- Soil testing is essential for diagnosing many cereal diseases.
- Keeping consistent paddock records and implemented crop rotations are some of the most important and simple strategies in fighting crop diseases.
- Soil-borne diseases, cost Western Australian grain growers an estimated average of $105 million per year in yield and quality losses.

In the early development stages of triticale in Australia, the crop was relatively free of disease compared with other winter cereals. As the crop expanded in the 1980's, a range of fungal and other diseases became more important and required management. The main diseases have been the three rusts (leaf, stem and stripe rust), crown rot, barley yellow dwarf virus (BYDV), and nematodes. The likely 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 compared with wheat. [2]

Many growers use triticale as a disease break in their rotations and value the benefits of triticale for its contribution to soil conservation. Thus, triticale assists in maintaining soil health by the reduction of nematodes, such as *Pratylenchus neglectus* and *thornei* (root lesion nematodes) and *Heterodera avenae* (cereal cyst nematode), and a range of fungi and bacteria that build up in the soil, reducing yields when the same crop species is grown repeatedly. Other favoured characteristics of triticale are its resistances to barley yellow dwarf virus, mildew and rusts, which may cause significant yield reductions in wheat, barley and oats. [3]

Triticale is thought to be tolerant to rusts, *Septoria tritici*, smuts, bunt, powdery mildew, take all, root rots, barley yellow dwarf virus, wheat mosaic virus and barley stripe mosaic virus. [4] Triticale has vastly superior tolerance over wheat to *Septoria tritici* blotch. [5]

1 Agriculture Victoria. (2012). Growing Triticale. http://agriculture.vic.gov.au/agriculture/grains-and-other-crops/crop-production/growing-triticale

2 Jessop RS, Fittler M. (2009). Triticale production Manual – an aid to improved triticale production and utilisation. http://www.apri.com.au/1A-102_Final_Research_Report_.pdf

3 Cooper KV, Jessop RS, Darvey NL in Mergoum, M., & Macpherson, H. G. (2004). *Triticale improvement and production* (No. 179). Food & Agriculture Org. http://www.fao.org/docrep/009/y5553e/y5553e00.htm

4 Varughese, Pfeiffer and Pena (1996) in Mergoum, M., & Macpherson, H. G. (2004). *Triticale improvement and production* (No. 179). Food & Agriculture Org. http://www.fao.org/docrep/009/y5553e/y5553e00.htm

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

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

Variety	Maturity	Height	Head colour	Stem rust	Stripe rust	Leaf rust	Yellow leaf spot	Septoria tritici	CCN resistance	*Pratylenchus neglectus* resistance	*Pratylenchus thornei* resistance
Astute(D	M	M-T	W	RMR	RMR#	RMR	MRMS	-	R	RMR	MS
Berkshire(D	E-M	T	W	R	MRMS#	R	MR	RMR	-	MR	MS
Bison(D	M	T	W	RMR	R#	RMR	MR	MR	R	MR	RMR
Canobolas(D	E-M	M-T	W	R	MRMS#	RMR	MR	RMR	-	MR	MSS
Chopper(D	E	S-M	W	MR	MRMS#	R	MR	RMR	R	MRMS	MSS
Endeavour(D	L		W	R	RMR#	R	MR	R	-	MR	SVS
Fusion(D	M	M-T	W	R	RMR#	R	MRMS	R	R	RMR	MS
Goanna	E-M	T	W	R	RMR#	R	MR	R	R	MRMS	SVS
KM10	E-M			R	R#	MRMS	MRMS	MR	-	MR	MSp
Rufus	M	T	W	R	MRMS#	R	MR	RMR	R	MSS	MSS
Tahara	M	T	W	R	MRMS#	R	MR	RMR	R	MR	S
Tobruk(D	M-L	-	W	R	MR#	R	MR	R	-	MR	SVS
Tuckerbox	M	T	W	MR	MR#	R	MR	RMR	-	MRMS	S
Yowie	M	M-T	W	R	MR#	R	MR	RMR	R	MR	MSS

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 > RMR > MR > MRMS > MS > MSS > S > SVS > 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

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 in-crop fungicide regime.
- Conduct in-crop disease audits to determine the severity of the disease. This can be used as a tool to determine what crop is grown in what paddock the following year.
- Conduct in-fallow disease audits 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 to determine the pathogen or strain you are dealing with or the severity of the disease
- Keep the farm free from weeds, which may carry over some diseases. This includes cereals over summer that may act as a green bridge.
- Rotate crops. [6]
- Stay up to date with local disease guides.

6 DAFF (2012) Wheat—diseases, physiological disorders and frost. Department of Agriculture, Fisheries and Forestry Queensland, http://www.daff.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/wheat/diseases

9.1.1 Tools for diagnosing cereal disease

Crop Disease Au App

ANDROID APP ON Google play | Available on the App Store

The Australian Field Crop Disease Guide app allows the user to quickly identify crop diseases; compare disease-resistance ratings for cereal, pulse and oilseed varieties; and, 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 advisor.

The new Crop Disease Au app functions similarly to the previous DEDJTR app but provides information for all Australian grain growing regions.

MyCrop

ANDROID APP ON Google play | Available on the App Store | Web-based

Released by DAFWA and funded by the GRDC, MyCrop is a collection of interactive tools that can be accessed online or via apps that enable users to diagnose **cereal** production constraints while in the field.

The main feature is an intuitive diagnostic key, which quickly diagnoses a range of possible constraints based on real-time crop and paddock symptoms. Covering a broad range of disease, pest and other agronomic issues, MyCrop can help users to accurately identify constraints and determine possible management solutions. Key features include:

- Extensive image library and constraint factsheets.
- Selecting paddock and plant clues to easily identify the likely cause of cropping problems.
- Over 150 constraints ranging from pests and diseases to soil deficiencies, environmental and management factors.
- Online diagnostic tools

CropPro

DEDJTR and GRDC's newly released online tool CropPro has diagnostic and economic features that allow growers to efficiently identify and manage constraints to both crop productivity and profitability. The core functions of CropPro are to diagnose the cause of wheat and canola crop problems, support risk analysis and provide evidence-based information for management of crop constraints. It combines paddock and crop symptoms in one resource, enabling users to work through a simple process of elimination. CropPro also has an economic feature allowing growers to compare return-on-investment outcomes for different management options and an Agronomist Toolkit that includes an extensive list of resources, online decision support tools and apps. For the first time the Field Crop Diseases Manual is available online! This provides an all-in-one resource for disease identification, biology and management information for cereal, pulse and oilseed crops. The manual is written and maintained by leading subject experts from DEPI and Marcroft Grains Pathology, and provides a detailed exploration of diseases and the influence of pest and abiotic factor. A series of economic videos also feature on CropPro, providing growers with clear information about how management decisions might influence their profitability.

MORE INFORMATION

MyCrop

GRDC Cereal root and crown diseases: Back pocket guide.

9.2 Rust

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. These spores can be spread over considerable distances by wind but may also be spread on 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 cannot survive on soil, seed or dead tissue and need a 'green bridge', grassy weeds or overlapping crops to persist. Plants facilitating the survival of rust fungi through the summer are known as the 'green bridge'. [7]

Stripe rust and leaf rust can be a significant threat to crops in Western Australia in some seasons. [8]

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.

The University of Sydney's recent Cereal rust report warns growers to monitor crops carefully. Wheat leaf rust, barley leaf rust, oat crown rust and oat stem rust are all being detected across a wide area of Western Australia. Samples of wheat leaf rust off Mace from Western Australia were received in mid-July (2016) from Coomalbidgup; late August from Grass Patch; and early September from Nabawa. Pathotype identifications are underway. Recent weather conditions across large areas of the cereal growing regions are likely to favour rust development. 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. [9]

New wheat leaf rust pathotype detected in WA – 2015

A new leaf rust pathotype of *Puccinia triticina*, known as 104–1, 3, 4, 6, 7, 8, 10, 12 +Lr37 was first detected in WA in September 2015. The airborne disease was discovered in South Australia in 2014 and has since been detected in several crops in WA.

The new pathotype differs from those detected previously in WA in being fully virulent on the complementary resistance genes Lr27+Lr31, the adult plant resistance gene Lr12, and in combining virulence for Lr1 with Lr13, Lr17a, and Lr26. As a result wheat varieties dependent on these resistance genes will become more vulnerable to leaf rust infection by this strain.

This find follows the detection in 2013 of another new leaf rust pathotype, which was the first occurrence of virulence for the resistance genes Lr13, Lr17a, Lr17b, and Lr26 in WA.

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

8 DAFWA. (2016). Managing stripe rust and leaf rust in wheat in Western Australia. https://www.agric.wa.gov.au/grains-research-development/managing-stripe-rust-and-leaf-rust-wheat-western-australia

9 Cuddy W, Park R, Singh D. (2016). Cereal rust situation, September 2016.

MORE INFORMATION

[The Rust Bust](#)

[How to manage rust – The Rust Bust WA](#)

[Cereal rust report – September 2016](#)

[WA rust resistance ratings - wheat](#)

What should grain growers do now?

The find of a second new leaf rust pathotype in WA in recent years has serious implications for growing wheat crops in WA and serves as a warning for growers to carefully consider management options each season:

- Be vigilant and destroy green bridge (volunteer cereals and weeds) at least four weeks prior to seeding.
- In high risk areas, where varieties rated S to MS haven't been replaced with more resistant options consider a registered seed dressing or in-furrow fungicide or budgeting for foliar fungicide application is advisable. An effective strategy is to delay general seed dressing or in-furrow treatment of susceptible varieties until autumn. Where 'green bridge' cereals survive through autumn in local districts there is an increased likelihood that stripe or leaf rust could establish early in young susceptible crops.
- Keep up to date with variety disease rating changes, new ratings should be available in the 2016 Variety Sowing Guide.
- Report rust finds to PestFax and take samples to submit to the Australian Cereal Rust Control Program for pathotype testing.

Further information on strategies to manage leaf rust in wheat is available on the Managing leaf rust and stripe rust page or Implications of the known leaf rust pathotypes in WA page. [10]

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

9.2.1 Varietal resistance or tolerance

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

Table 2: *Triticale variety Rust disease susceptibility ratings.*

Variety	Stem rust	Stripe rust	Leaf rust
Astute⍉	RMR	RMR#	RMR
Berkshire⍉	R	MRMS#	R
Bison⍉	RMR	R#	RMR
Canobolas⍉	R	MRMS#	RMR
Chopper⍉	MR	MRMS#	R
Endeavour⍉	R	RMR#	R
Fusion⍉	R	RMR#	R
Goanna	R	RMR#	R
KM10	R	R#	MRMS
Rufus	R	MRMS#	R
Tahara	R	MRMS#	R
Tobruk⍉	R	MR#	R
Tuckerbox	MR	MR#	R
Yowie	R	MR#	R

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 > RMR > MR > MRMS > MS > MSS > S > SVS > 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

10 Beard C, Thomas G. (2015). 2015 New wheat leaf rust pathotype detected in WA. DAFWA. https://www.agric.wa.gov.au/grains-research-development/implications-known-wheat-leaf-rust-pathotypes-wa

9.2.2 Symptoms

Table 3: *Diagnosing leaf diseases in wheat.*

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	orange/brown	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 spot	small tan (yellow 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: DAFF

9.2.3 Stripe rust

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

Photo 1: *Stripe rust in wheat.*

Source: DAFF

Stripe rust is caused by the fungus *Puccinia striiformis*. It is easily distinguished from other wheat rusts by the orange-yellow spores, which produce small, closely packed pustules developing 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).

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

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

MORE INFORMATION

Stripe rust

onset of disease. Later on if 'money' leaves require protection, recommended foliar fungicides can be applied for the control of stripe rust (see section 1.2.6 Managing cereal Rusts, below).

In 2007, a new pathotype of stripe was detecting in many triticale cultivars. Despite dry conditions, stripe rust infections have swept through triticale crops, in particular Jackie. The pathotype was virulent on most triticale varieties. The Jackie pathotpye, unlike most new pathotypes, has been widespread and affected most triticale cultivars. Greenhouse trials found that Everest, Tickit and Tahara still had effective resistance to Jackie. Results on Crackerjack and Treat showed some level of intermediate resistance, which means that some plants in these varieties were resistant while others are susceptible. Seedling resistance for all other varieties changed from resistant or intermediate to susceptible. This included varieties such as Breakwell⒫, Speedee, Kosciusko and Prime322. Some newly released varieties of triticale were more resistant to the new pathotype. [11]

Managing stripe rust

Stripe rust may be a problem in triticale and there are now options to treat seed to provide seedling protection against stripe rust. [12]

The key to stripe rust management is variety choice. Avoid growing highly susceptible varieties; i.e. replace susceptible varieties with a moderately or highly resistant variety.

Growers should check to ensure their current variety has adequate field resistance to both the Jackie and Tobruk⒫ pathotypes of stripe rust or consider using foliar fungicides to control the disease in-crop if required.

Seed treatment should be considered for controlling seedling stripe rust in susceptible varieties, especially those sown early for grazing. [13]

MORE INFORMATION

Managing stripe rust and leaf rust in wheat in Western Australia

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 stripe rust resistant variety also gives a yield advantage. For example changing from Jackie to Endeavour⒫ makes good sense. Endeavour⒫ 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.

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

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

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

nder 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

9.2.4 Stem rust (black rust)

Triticale is thought to have good resistance against 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. The possible arrival of newer races of stem rust requires further screening for these races. The levels of resistance to new races are unknown. [16]

Photo 2: *Stem rust in wheat.*

Source: DAFF

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.

Stem rust 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). Ruptured pustules release masses of stem rust spores, which are disseminated by wind and other carriers.

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

Some cereal varieties have reasonable resistance to stem rust (rating 5 or higher). However, in the past, stem rust has had the ability to cause significant economic damage (50–100% of yield). This has happened when conditions are conducive for the disease and susceptible varieties are grown, or a new stem rust pathotype has developed, which has overcome the wheat's resistance.

Inoculum must be present for the disease to develop. Practicing crop hygiene by removing volunteer wheat, 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 available, see section 9.2.6 Managing cereal Rusts, below.

VIDEOS

WATCH: GCTV5: Green Bridge control for less stem rust.

MORE INFORMATION

Stem rust

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

15 Adhikari, K. N., & McIntosh, R. A. (1998). Inheritance of wheat stem rust resistance in triticale. *Plant breeding*, *117*(6), 505–513.

16 Jessop RS, Fittler M. (2009). Triticale production Manual – an aid to improved triticale production and utilisation. http://www.apri.com.au/1A-102_Final_Research_Report_.pdf

9.2.5 Leaf rust (brown rust)

The current commercial triticale varieties have good resistance to leaf rust and newer varieties should maintain this attribute. [17]

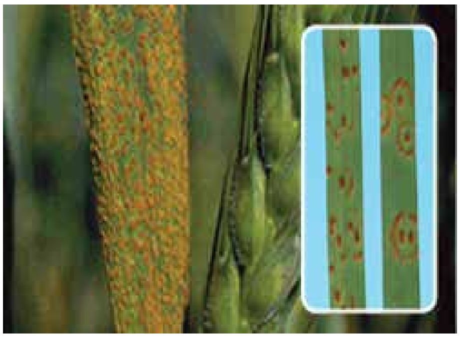


Photo 3: *Leaf rust in wheat.*

Source: DAFF

Leaf rust is caused by the fungus *Puccinia triticinia* (previously called *Puccinia recondita* f. sp. *tritici*). The disease can infect triticale, rye and wheat.

Leaf rust produces reddish-orange coloured 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 which is found on both surfaces of the leaf (Photo 3).

In most parts of Australia leaf rust is effectively controlled with resistant varieties, but it can cause problems in areas where susceptible varieties are grown (Figure 1). Cereal varieties mostly have reasonable resistance (rating of MR-MS - 5 or higher).

The spores require 15 to 20°C temperature and free moisture (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 forms a green bridge for the fungus through the summer, can eliminate or delay the onset of leaf rust.

Foliar fungicides to control stem rust are available, see section 1.2.6 Managing cereal Rusts, below.

17 Jessop RS, Fittler M. (2009). Triticale production Manual – an aid to improved triticale production and utilisation. http://www.apri.com.au/1A-102_Final_Research_Report_.pdf

MORE INFORMATION

Leaf rust

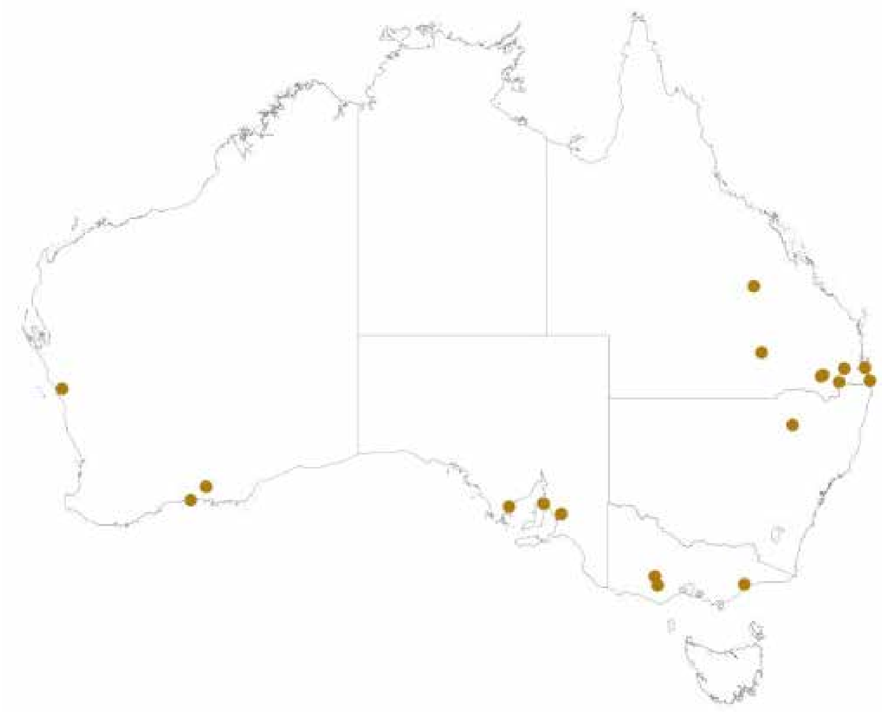


Figure 1: *Reported detections of leaf rust in 2016.*

Source: USYD

9.2.6 Managing cereal rust

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.

Rust fungi continuously change, producing new 'pathotypes'. These pathotypes 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 31 (1st node detectable) and continue to at least growth stage 49 (first awns visible). This is because the 'money' leaves (the flag, fleg -1, -2 and -3 leaves) are the main factories contributing to yield and quality. It is very important that these leaves are protected from any diseases. [18]

Foliar fungicide guidelines

Fungicide timing

- Apply fungicide as soon as possible after the first detection of stripe or leaf rust taking into consideration the stage of crop development and variety susceptibility.
- Economic responses are reduced with later fungicide application.
- Spraying after crop flowering is normally not economic for stripe or leaf rusts. Late rust infection should be carefully inspected to check it is not stem rust. For more information refer to Managing stem rust of wheat.
- Optimise control of stripe rust on leaves is important to reduce risk of infection of heads by applying fungicide at or before crop heading. Although spores may adhere to seed, they rarely induce grain discolouration and do not become seed bourne. Head infection will shrivel grain, so screenings will increase with severe infections.

18 DAFF QLD. Wheat – diseases, physiological disorders and frost. https://www.daf.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/wheat/diseases

Fungicide rate

Use high rates of fungicide if application is delayed or if infection is advanced. Use high rates of fungicide for longer duration of protection, for example, when season conditions favouring infection are likely to persist or for more susceptible varieties. Cost should be tuned to crop yield potential and crop season length.

Fungicide products

A list of registered foliar fungicides including registered rates is available. Consider what other diseases are present or the crop is at potential risk of when choosing which fungicide product to use.

Green bridge proximity

Summer rains permit the development of volunteer cereal hosts and autumn rains permit the early build-up of rust on these volunteers known as the 'green bridge'. This happens readily after wet summers. Cropping areas that receive summer rain resulting in self-sown green bridge cereals are at risk of early infection with stripe or leaf rusts. Wheat regrowth is the primary risk for carryover of both wheat leaf rust and wheat stripe rust. The amount of rust present in the previous season also determines the risk of leaf and stripe rusts. The more rust in a given year means there is more chance of carryover into the next season.

Weather

While resistance will influence individual crop risk, the overall risk of serious rust outbreaks is influenced by summer and winter weather factors (rainfall and temperature) which can be considered in your region each season. Both stripe and leaf rusts require moisture (rain or heavy dew) or high humidity for spores to germinate and infect leaves. Usually 4–6 hours of leaf wetness are required at optimum temperatures (warm days and dewy nights). Each rust has an optimum temperature for infection and growth (Table 4). Rust outlooks are provided as part of the plant pathology group's seasonal Crop diseases: forecasts and management page.

A stripe or leaf rust epidemic is more likely if the winter and/or spring is suitably wet. Seasonal outlooks are available on the Seasonal Climate Information page. Leaf rust has a warmer mean daily temperature optimum than stripe rust (Table 6). The mild winters in Western Australia result in leaf rust being relatively active in winter and into spring, particularly in the northern agricultural areas. Early sown crops, on which infections establish prior to the cooler winter months, are more at risk from early leaf rust which can develop rapidly in spring. The lower temperature optimum for stripe rust results in the disease being relatively more active in winter than later in the season. Warm spring conditions, particularly in the northern agricultural areas, can increase the time taken between infection and resultant new spores being produced (the latent period). Rust spores easily spread on wind.

Table 4: *The approximate time taken for an infection to result in new spores (latent period) and indicative optimal temperature ranges for rust foliar diseases in wheat*

Disease	Latent period (days)	Optimal daily temperature (°C)
Stem rust	7–10	20–35
Stripe rust	10–14	12–20 (dormant >23)
Leaf rust	7–10	15–25

Biosecurity measures

Because there are different strains of leaf, stem and stripe rusts, care must be taken when travelling interstate or receiving interstate or overseas visitors, since spores carried on clothing could introduce new strains of rusts. Implement biosecurity measures to minimise rust becoming established or spreading on your farm. Rust spores are small, light and may survive for several days without a host. Rust spores can spread long distances by wind, on machinery/vehicles, on tools, clothing and footwear. Remember that if you walk through an infected crop, follow biosecurity protocols and thoroughly clean your boots, hands and trousers before entering another paddock or travelling as rust spores can be unknowingly transferred via people locally and also from overseas. Also check biosecurity measures taken by your visitors and agronomists.

Be particularly vigilant when returning from eastern Australia or internationally, as rust pathotypes with different virulences exist outside WA.

If entering a paddock suspected to be infected with rust, biosecurity suggestions include:

- Wear protective overalls and rubber boots
- After crop inspection clean any material off boots with a brush. Prepare footbath of bleach (10% household bleach, 90% water) and spray bottles of methylated spirits brew (95% metho, 5% water) for use to disinfect footwear, pants and hands
- Decontaminate vehicles, tools and machinery
- Walk instead of driving through crops
- Ask visitors/agronomists to leave their vehicle at the gate and only travel on your property in your vehicle.

Utilise variety resistance

Resistance to one rust is normally independent of resistance to other rusts. Varieties may express a range of resistance to stripe or leaf rust in three broad categories:

- Resistant at all plant stages from seedling to adult (MR-R). Fungicide is not required. Normally based on a single gene resistance, experience around the world has shown this resistance can be rendered ineffective (break down) through rust mutation.
- Partially resistant (MRMS), susceptible at young crop stages and gradually increasing in resistance as the crop develops during late stem elongation, expressing maximum adult plant resistance around heading/flowering. Varieties usually develop rust slowly unless they become infected early.
- Very susceptible to susceptible (VS-S) throughout all stages, rapid rusting causing significant yield losses. Promotes epidemic development and pathogen mutation.
- Variety ratings are available. There have been some recent changes due to the presence of two new leaf rust pathotypes in WA (one in 2013 and one in 2015). For further information see Implications of the known wheat leaf rust pathotypes in WA.

Destroy green bridge well in advance of seeding

The overlap of summer volunteer or autumn sown susceptible wheat with conventional wheat plantings in winter is a crucial factor in establishing early severe infection of stripe or leaf rust. Destroy self-sown wheat (particularly the most susceptible varieties) well in advance of seeding (4–6 weeks recommended) as occurrence of rain leading into a cropping season increases susceptible regrowth and allows very early sowing opportunities. Further information on green bridge managment is available at Control of green bridge for pest and disease management.

Early season fungicide protection is important in high risk situations

For S-MRMS varieties, if there is an increased risk of localised rust carryover associated with green bridge cereals in your region, use of a seed dressing or in-furrow fungicide at seeding or fungicide spray at stem elongation can limit early prior to flag leaf emergence. Risk of early season infection cannot be assessed until autumn. If possible, delay general seed treatment of susceptible to intermediate varieties until autumn to determine the risk of rust associated with high early rainfall and regional green bridge cereals. Highly effective options include long-acting seed dressings or in-furrow fungicides that can provide protection until around flag leaf emergence stage depending on rate of application and disease pressure. Expenditure decisions (including product choice) should be made according to risk, yield potential and presence of other diseases. For details on registrations refer to the Seed dressing and in-furrow fungicides for cereals in WA page.

Foliar fungicides can also protect from early infection. In the absence of fungicide at seeding, crops at high risk of early infection can be treated with a foliar fungicide spray at first node (Z31) to protect the crop from early infection until around flag leaf emergence. This strategy is applicable to varieties with ratings S-MRMS and can be used instead of fungicide at seeding. This can delay and sometimes avoid costs if the disease risk does not eventuate. This early spray will only protect the leaves which are emerged at the time of the foliar application and may require a follow up spray if seasonal conditions favour continued rust development. For details on registrations refer to the Seed dressing and in-furrow fungicides for cereals in WA page.

Trials in 2014 with Mace and Lr 76–1, 3, 5, 7, 9, 10, 12 +Lr37 pathotype showed infection and yield losses were greatest when disease was present from Z31, infection after Z39 had less impact.

Control late infection in susceptible to intermediate varieties with fungicide

Foliar fungicide retards disease development for about 3–6 weeks after application, depending on product and rate. These diseases can be controlled effectively and economically if fungicide is applied shortly after infection commences but follow-up application will probably be required in long season environments or on very susceptible varieties. If crops have not received early fungicide, commence monitoring for stripe or leaf rust at first node stage, Z31 and apply foliar fungicide at the first sign of infection according to the stage of crop development and variety susceptibility. If crops have received early fungicide, commence monitoring for stripe or leaf rust at early to full flag leaf emergence and apply fungicide at the first sign of infection according to the stage of crop development and variety susceptibility. When taken up by the leaf, the fungicide can stop development of early infections but more established infections can continue such that rust pustules may persist for several days after fungicide application. A list of registered foliar fungicides is available to assist choosing a product.

How to monitor crops

The aim of crop monitoring is to detect infection at the earliest stage feasible. Inspect the most susceptible and earliest sown crops carefully over a wide area of the paddock. Examine leaves at the top and bottom of the canopy for scattered light infections. In green bridge areas also look for infrequent heavily-infected hot spots. Crops prone to infection at young stages (rated very susceptible to moderately resistant) should be inspected at seven to 10 day intervals from early stem elongation (growth stage Z31) or from early flag leaf emergence (growth stage Z37) if seeding fungicide treatments registered to control rust diseases have been used.

A chargeable service is available to assist with disease diagnosis, send ~10 infected leaves to:

DAFWA Diagnostic Laboratory Services (DDLS)
Department of Agriculture and Food, Western Australia
Locked Bag 4, Bentley Delivery Centre WA 6983

Post in a paper envelope (no plastic) with date, location, name and contact details. Broadacre diagnostic submission forms are available from your local office or from the DAFWA Diagnostic Laboratory Services (DDLS) page.

Rust pathotype testing

Leaf rust and stripe rust occur as different strains because they can readily mutate and strains can easily move around the country and the world on the wind or people's clothing. Possible new strains need to be continuously monitored in order

VIDEOS

WATCH: GCTV Extension Files: Rust Sampling.

VIDEOS

WATCH: Adult plant resistance – fungicide.

WATCH: Cereal Rust – Adult plant resistance.

MORE INFORMATION

CSIRO Cereal rusts

Rust Bust.

to understand the implications for existing varieties and to assist wheat breeders in developing new resistant varieties.

To monitor rust strains in Western Australia, growers and consultants are encouraged to send rust samples at no cost to the Australian Rust Survey, particularly from varieties showing unusually high levels of rust. Post leaf samples in paper envelopes to: University of Sydney, Australian Rust Survey, Reply Paid 88076, Narellan NSW 2567. Further instructions on submitting samples and printable dispatch forms are available from the University of Sydney website.

Reporting to PestFax

For the benefit of industry; growers, agronomists and consultants are encouraged to submit samples of rust finds to their local DAFWA office or directly to the National Cereal Rust Survey and to PestFax. Reports to PestFax can be made online to PestFax Reporter or PestFax map. To receive the weekly PestFax newsletter of disease and pest finds across the Western Australian wheatbelt, subscribe by emailing pestfax@agric.wa.gov.au. You can access past newsletters at the PestFax newsletter archive.

9.2.7 Integrated disease management of rusts and yellow spot

Key points

- Destroy volunteer wheat plants by March, 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 spot and *Fusarium* head blight.
- 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.
- If you suspect any severe disease outbreak, especially on resistant varieties, your agronomist or local DPI.

Rust diseases occur throughout the cereal growing regions, frequently causing economic damage.

Wherever possible, sow resistant varieties MR (Moderately Resistant = 6) and above.

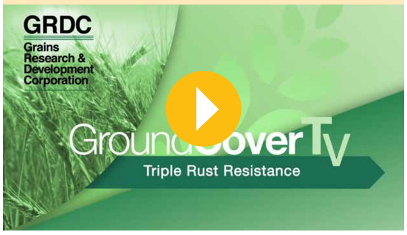
IN FOCUS

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 rust control. 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 characterize 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 ensure breeding outcomes. Recent changes in the wheat rust pathogens, including the development of virulences for *Yr17*, *Lr24*, *Lr37* and *Sr38* resistance genes, and the introduction of a new pathotype of the wheat stripe rust pathogen, have provided new and significant challenges for wheat rust resistance breeding. Similar challenges exist in breeding barley and oats for rust resistance. Examples are discussed to illustrate the ways in which rust isolates are providing information that can be used in breeding 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. [19]

VIDEOS

WATCH: GCTV18: Triple Rust Resistance.



9.3 Leaf spot

Leaf spot diseases affecting wheat in WA are yellow spot (*Pyrenophora tritici-repentis*), septoria nodorum blotch (*Parastagonospora nodorum; previously Phaeosphaeria nodorum,* synonyms *Stagonospora nodorum, Septoria nodorum*), and septoria tritici blotch (*Mycosphaerella graminicola*). They are caused by three different fungal pathogens but the disease symptoms and biologies are similar.

Septoria nodorum blotch and yellow spot may occur throughout the WA wheatbelt and frequently occur together. They have the capacity to significantly reduce yield and grain quality. Septoria tritici blotch has become less common throughout the WA wheatbelt and currently losses from this disease are rare.

Impacts from leaf spot diseases vary greatly from season to season and between locations. They are particularly a problem in continuous wheat crops in stubble retention farming systems. Yield loss will depend on the disease resistance of the variety and the presence and severity of the disease throughout the life of the crop. For susceptible varieties, when the disease development is continuous due to favourable conditions throughout the season, losses around 30% have been measured. When disease development is only favourable for part of the season, either before or after flag leaf emergence, losses around 20% can occur. Severe disease will cause grain quality reductions such as increased screenings and lower hectolitre weights that can add to high yield loss impacts. [20]

19 Park, R. F. (2008). Breeding cereals for rust resistance in Australia. *Plant Pathology*, *57*(4), 591–602.

20 Beard C, Jayasena K, Thomas G, Galloway J. (2016). Managing yellow spot and septoria nodorum blotch in wheat. https://www.agric.wa.gov.au/grains-research-development/managing-yellow-spot-and-septoria-nodorum-blotch-wheat?page=0%2C2

Septoria nodorum blotch and yellow spot often occur together and are generally impossible to distinguish by the naked eye. Septoria tritici blotch is considered rare in WA. [21]

9.3.1 Damage caused by disease

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. [22] 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 leaf spot epidemics. Where wheat follows wheat and some stubble is left on the soil surface, losses may be around 10–15%, and up to 30% in wet seasons.

9.3.2 Symptoms

Leaf spot diseases appear as irregular or oval-shaped spots that initially are small and often yellow (sometimes blackish-brown), but enlarge to form brown dead centres, with yellow edges (Photo 4). Typically, a badly affected leaf will die back from the tip as lesions merge, reducing the photosynthetic area and causing premature leaf death. Differentiation of septoria nodorum blotch, septoria tritici blotch, and yellow spot on the basis of symptoms is difficult even to a trained eye. Some physiological or nutritional yellowing symptoms can be confused with yellow spot and septoria so it is important to get a correct diagnosis. [23]

Photo 4: *Small tan-brown spots with yellow margins that become more elongated with age indicate the presence of yellow leaf spot. Yellowing of the leaf without lesions is not a symptom.*

Photo: Hugh Wallwork, Source: GRDC

Spot develops on both sides of leaves. Severe leaf spot may result in short, spindly plants with reduced tillering and root development (Photo 5). Where conditions are favourable, plants may be fully defoliated soon after flowering. [24]

21 Beard C. (2016). Yellow spot of wheat. DAFWA https://www.agric.wa.gov.au/grains-research-development/managing-yellow-spot-and-septoria-nodorum-blotch-wheat?nopaging=1

22 Holloway G. (2014). Yellow leaf spot of wheat. http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/plant-diseases/grains-pulses-and-cereals/yellow-leaf-spot-of-wheat

23 Beard C, Jayasena K, Thomas G, Galloway J. (2016). Managing yellow spot and septoria nodorum blotch in wheat. https://www.agric.wa.gov.au/grains-research-development/managing-yellow-spot-and-septoria-nodorum-blotch-wheat?page=0%2C2

24 DAFF QLD. Wheat – diseases, physiological disorders and frost. https://www.daf.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/wheat/diseases

Photo 5: *Spot form of net blotch causing dead leaves in susceptible variety.*

Photo Mike Ford, Source: GRDC

What to look for

Paddock

- Yellowing leaves, dying back from tips and scattered through a paddock.

Plant

- Lower leaves affected in young crops.
- Yellow-tan oval spots or lesions on leaves that become tan-brown in their centre with a yellow edge as lesions grow.
- Lesions near leaf tips cause leaf yellowing and withering.
- Look for small black fruiting bodies on stubble which have short, black hair-like projections and feel rough to touch. [25]

What else could it be?

Condition	Similarities	Differences
Septoria nodorum blotch	Tan blotches with yellow margins	Oval to irregular blotches. Tiny brown fruiting bodies in blotches, however these may not be evident to the naked eye. Frequently attacks heads and glumes.
Septoria tritici blotch	Tan blotches often without yellow margins	Blotches irregular, often interveinal, not oval. Tiny black fruiting bodies in blotches, typically visible to the naked eye.

See 'Disease diagnosis' section for diagnosis assistance that is available through DDLS - Plant pathology services.

MORE INFORMATION

Yellow spot,

Septoria nodorum blotch

Septoria tritici blotch.

25 Beard C. (2016). Yellow spot of wheat. DAFWA https://www.agric.wa.gov.au/grains-research-development/managing-yellow-spot-and-septoria-nodorum-blotch-wheat?nopaging=1

9.3.3 Varietal resistance or tolerance

Most triticale cultivars have moderate resistance to yellow spot (Table 5). Though triticale has moderate resistance to yellow spot, it can carryover the disease into following years. [26]

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

Variety	Yellow leaf spot	Septoria tritici
Astute⟏	MRMS	-
Berkshire⟏	MR	RMR
Bison⟏	MR	MR
Canobolas⟏	MR	RMR
Chopper⟏	MR	RMR
Endeavour⟏	MR	R
Fusion⟏	MRMS	R
Goanna	MR	R
KM10	MRMS	MR
Rufus	MR	RMR
Tahara	MR	RMR
Tobruk⟏	MR	R
Tuckerbox	MR	RMR
Yowie	MR	RMR

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 > RMR > MR > MRMS > MS > MSS > S > SVS > 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

9.3.4 Conditions favouring development

Primary infection of leaf spot diseases is from infected wheat stubble. The fungi that cause leaf spot diseases survive from one season to the next as fruiting bodies on wheat stubble (pseudothecia or pycnidia) or as mycelium in living, volunteer plants. Yellow spot pseudothecia on wheat stubble appear as black raised specks and feel like braille dots when rubbed between the thumb and index finger.

With the onset of winter rains, the over-summering fruiting bodies on stubble release ascospores. Ascospores of septoria nodorum blotch and septoria tritici blotch are readily airborne and result in wide dispersal (over kilometres) while those of yellow spot are larger in size and are dispersed over shorter distances (over metres). Once wheat plants are infected, secondary disease spread occurs — conidia are produced from the leaf infections and these spores are then water dispersed or wind blown through the crop canopy. During the growing season, several cycles of both primary and secondary infection can occur.

DAFWA research has found that the timing of yellow spot spore maturation on stubble differs at different locations in the wheat belt. The release of spores from the fruiting bodies on the stubble is dependent on temperature and rainfall conditions. The wetter, cooler conditions on the south coast for example (around Albany) favour the release of spores before wheat crops are sown or have emerged. On the other hand, the temperature and moisture conditions at Northam and Eradu favour ascospore development from May through to September which coincides with the crop growing season. This provides some explanation why yellow spot is usually more prevalent in the northern agricultural regions compared with the southern agricultural regions. [27]

MORE INFORMATION

Is yellow spot affected by location?

26 Triticale agronomy. (2004). Online farm trials. http://www.farmtrials.com.au/trial/13801

27 Beard C, Jayasena K, Thomas G, Galloway J. (2016). Managing yellow spot and septoria nodorum blotch in wheat. https://www.agric.wa.gov.au/grains-research-development/managing-yellow-spot-and-septoria-nodorum-blotch-wheat?page=0%2C2

Double wheat cropping

As they are stubble-borne, these diseases (but particularly yellow spot) will be most serious in continuous wheat cropping under stubble retention systems. Varieties rated as susceptible to these diseases are particularly vulnerable to infection when sown on wheat stubble and in the absence of fungicide they can sustain significant yield losses.

The fungi that cause these diseases survive on wheat stubble very well for six months between continuous wheat crops but relatively poorly after 18 months, such as wheat grown in one-year rotation with other crops or pasture. Use crop rotation to reduce risk from these stubble-borne diseases.

Weather

While rotation and variety will influence individual crop risk, risk of disease outbreaks that will significantly reduce yield is influenced by rainfall (in autumn, winter and spring). The causal pathogens of the various leaf spot diseases have different environmental conditions that are conducive to disease spread.

For yellow spot, primary infection of wheat leaves (from stubble) requires at least six hours of leaf wetness with temperatures of 15–28°C and periods of dew. Secondary infection (leaf to leaf) is favoured by leaf wetness (dew, fog or rain), high relative humidity and temperatures above10°C.

Septoria nodorum blotch development is favoured by warm weather (such as 20–25°C) in association with heavy and frequent rain; infection depends on leaves remaining wet for more than six hours.

Analysis of rainfall information collected at experimental sites between 1997 and 2004 has demonstrated that an economic response to fungicide (in terms of disease impacts) is more likely when the crop receives approximately 100 mm rainfall or more in the eight weeks following flag leaf emergence. The likelihood of meeting this criterion is increased for:

- early sown crops, as canopy development is complete by late winter (early flag leaf emergence exposes leaf to more disease)
- high rainfall areas or years of above average seasonal rainfall.

Nutritional deficiencies

Research by DAFWA has shown that crops that are deficient in nitrogen and/or potassium are more vulnerable to infection by these diseases.

9.3.5 Managing leaf spot

For the most effective control, an integrated disease management approach is required.

- Use crop rotation to reduce risk from these stubble-borne diseases.
- Avoid very susceptible or susceptible varieties. Favour moderately resistant-moderately susceptible varieties. See the latest wheat variety information for disease ratings.
- Ensure crop has adequate nutrition (particularly nitrogen and potassium).

Fungicides

No seed treatments or in-furrow fungicides are registered for control of yellow spot or septoria nodorum blotch but a few are registered for suppression. Some seed treatments can partially control septoria tritici blotch but are generally not used in this context. For more information see the Registered seed dressing and in-furrow fungicides page.

For wheat grown in rotation, foliar fungicide is more likely to be economic when applied:

- at or around flag leaf emergence (Z39)

- in crops having good yield potential
- where there is evidence of increasing leaf spot intensity down the canopy
- when there are good prospects of finishing rains (approximately 100 mm in the two months after flag leaf emergence).

For wheat after wheat, when there is high disease pressure prior to stem elongation, it may be economic to apply fungicide at or prior to early stem elongation (Z31, first node) particularly in medium to high rainfall areas. A second spray may be required at or after flag leaf emergence based on the above considerations.

Presence of other foliar diseases will enhance returns from fungicide application and direct fungicide choice. Strategies for control of rust diseases with fungicide can vary in important aspects of timing of application.

Use higher rates of fungicide for longer duration of protection, for example, when seasonal conditions favouring infection are likely to persist, for highly susceptible varieties or in long season environments.

Rate and therefore cost should be tuned to crop yield potential; Use a high rate for crops with high yield potential. Refer to product labels.

Late onset of disease (particularly with septoria nodorum blotch - see glume blotch below), may warrant a spray prior to flowering (for example, 50% heads emerged: Z55), particularly in long season environments.

Late spraying is sub-optimal and spraying after crop flowering finishes is generally not economic but further research is being done on this.

Information on which foliar fungicides are registered for leaf spot diseases is available on the Registered foliar fungicides for cereals in WA page. [28]

MORE INFORMATION

Yellow leaf spot – is it worth spraying?

Disease diagnosis

It should be noted that a variety of factors can cause spotting on wheat leaves and the cause is not always a fungal pathogen. For confirmation on disease diagnosis, send 25 infected stems to DDLS - Plant pathology services, Department of Agriculture and Food, Western Australia, Locked Bag 4, Bentley Delivery Centre WA 6983 or call +61 (0)8 9368 3721. This is a chargeable service.

Reporting disease

Please report disease finds to PestFax for the benefit of other growers and the WA wheat industry. You can report disease finds directly online at the PestFax map or otherwise contact the PestFax editor via the PestFax page. PestFax is a free weekly newsletter during the growing season providing information on broadacre disease and pest reports in the WA grainbelt. [29]

9.4 Take-all

Key points:

- Take-all is a fungal disease of the roots of cereals.
- Like cereal rye, Triticale has good resistance to take-all. [30] It is slightly less susceptible to take-all than wheat; early sowing increases the risk. [31]
- In early field experiments conducted over six years with a wide range of Take-all disease severities, triticale was intermediate in resistance to *Gaeumannomyces graminis* (Take-all) between wheat (susceptible) and rye (resistant). [32]

28 Beard C, Jayasena K, Thomas G, Galloway J. (2016). Managing yellow spot and septoria nodorum blotch in wheat. https://www.agric.wa.gov.au/grains-research-development/managing-yellow-spot-and-septoria-nodorum-blotch-wheat?page=0%2C2

29 Beard C, Jayasena K, Thomas G, Galloway J. (2016). Managing yellow spot and septoria nodorum blotch in wheat. https://www.agric.wa.gov.au/grains-research-development/managing-yellow-spot-and-septoria-nodorum-blotch-wheat?page=0%2C2

30 Wallwork, H. (1989). Screening for resistance to take-all in wheat, triticale and wheat-triticale hybrid lines. *Euphytica*, *40*(1–2), 103–109.

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

32 Hollins, T. W., Scott, P. R., & Gregory, R. S. (1986). The relative resistance of wheat, rye and triticale to take-all caused by Gaeumannomyces graminis. *Plant pathology*, *35*(1), 93–100.

- Though triticale is less susceptible to take-all than wheat, it can still carryover the disease into following years. [33]
- The fungi responsible are *Gaeumannomyces graminis var. tritici* (Ggt) and *Gaeumannomyces graminis var. avenae* (Gga).
- Grass free pastures and break crops minimise *G. graminis* survival, e.g. pulses and canola.
- Monitor rainfall patterns 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.

In Western Australia Take-all is caused by two variations of the *Gaeumannomyces graminis* fungus; *G. graminis* var. *tritici* (Ggt) and *G. graminis* var. *avenae* (Gga) and is most severe in the high rainfall areas of the agricultural region (i.e. southern cropping regions and areas closer to the coast). 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. [34]

9.4.1 Symptoms

Initial indications of take-all in a crop are the appearance of indistinct patches of poor growth in the crop; these may be a few metres across up to significant areas of crop. Closer inspection of individual plants will indicate 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 white-heads later in the season is another indicator of a take-all (although frost and micronutrient deficiencies can also cause white-heads), 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. [35]

What to look for

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).
- Affected plants can be individuals scattered among healthy plants or entire populations of plants over a large area.

33 Triticale agronomy. (2004). Online farm trials. http://www.farmtrials.com.au/trial/13801

34 Soilquality.org. (2016). Take-all Disease – WA. http://www.soilquality.org.au/factsheets/take-all-disease

35 Soilquality.org. (2016). Take-all Disease – WA. http://www.soilquality.org.au/factsheets/take-all-disease

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

Source: DAFWA

Plant

- Control First obvious signs of infection are seen after flowering with the development of white heads.
- Roots of affected plants are blackened and brittle and break easily and are black to the core not just on outer surface (Photo 8).
- Severely affected plants can also have blackened crowns and lower stems. [36]

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

Photo 8: *Roots of affected plants are blackened, brittle and break easily, and are black to the core, not just on the outer surface (left). Severely affected plants can have blackened crowns and lower stems (right).*

Source: DAFWA

9.4.2 Conditions favouring development

Gaeumannomyces graminis survives the Australian summer in the residue of the previous season's grass host (Figure 2). The arrival of cooler temperatures and rainfall in the autumn encourages the fungus into action. The fungus infects the roots of the emerging crop during this period.

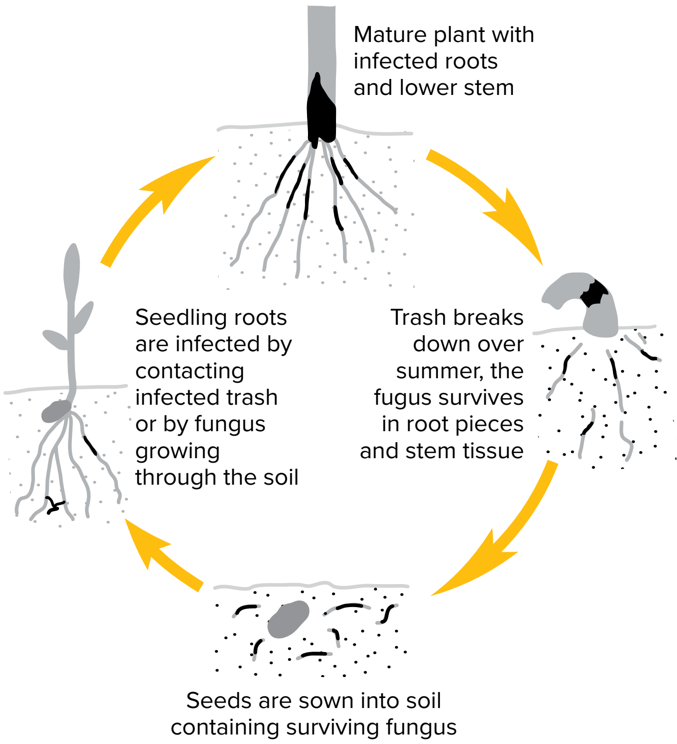


Figure 2: *Common life cycle of the take-all fungus in Western Australian cropping regions (adapted from MacNish, 2005).*

Source: Soilquality.org

Higher rainfall in winter is likely to increase take-all disease pressure. For this reason, the southern regions of Western Australia and those closer to the coast are most likely to suffer yield loss in cereal crops due to take-all (Figure 3). 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.

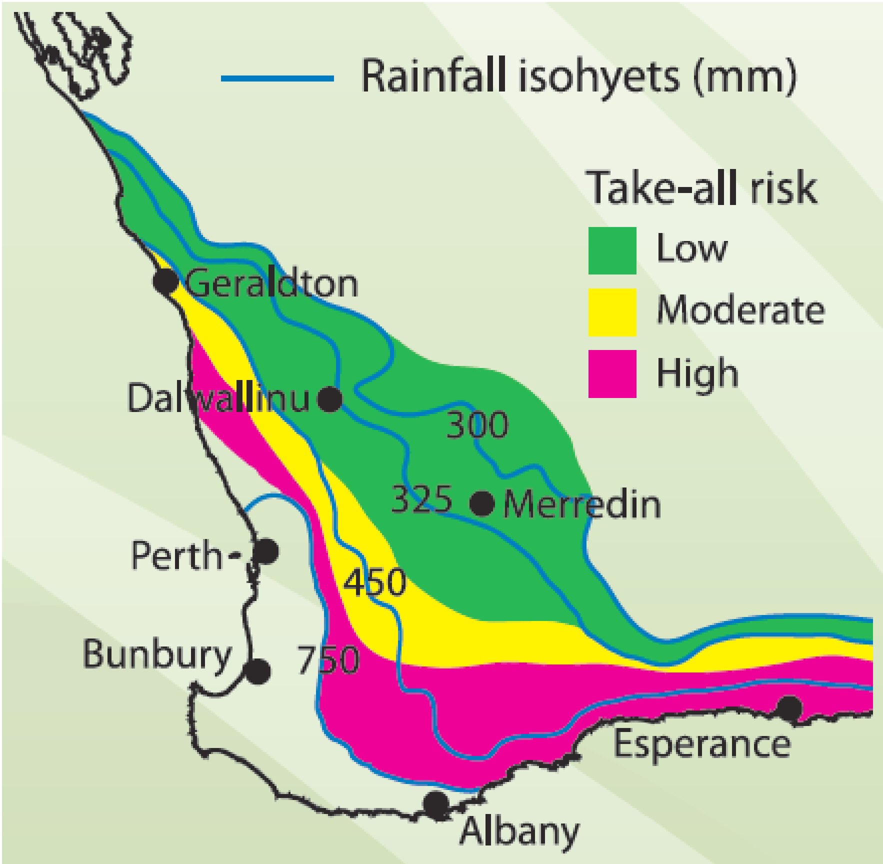


Figure 3: *Western Australian cropping regions most susceptible to take-all infection.*

Source: MacNish, 2005 in Soilquality.org

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 limiting post-anthesis.

Hosts

All annual grasses can be infected by *G. graminis*, although some species are more susceptible than others. While wheat, barley and triticale are the most susceptible crops to take-all, barley grass is also an effective host to the disease. Oats are 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. Brome grass, silver grass and ryegrass are all viable host species for take-all. All non-cereal crops (e.g. lupins, canola and clover) are non-hosts to take-all. [37]

9.4.3 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.

37 Soilquality.org. (2016). Take-all Disease – WA. http://www.soilquality.org.au/factsheets/take-all-disease

- Acidifying fertilisers can slightly reduce disease severity (take-all severity may increase following liming).
- Control volunteer grasses and cereals.
- Delay sowing following the opening rains by implementing a short chemical fallow. [38]

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 (lupin, canola, field peas, faba bean, chickpea, sorghum) 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 allowing 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 but are generally only economically viable where severe outbreaks have occurred. Registered fungicides provide useful protection in low to medium disease risk paddocks. 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;

1. cereal weeds become infected, thus enabling *G. graminis* to survive until crop establishment, and,
2. rapid drying of the topsoil due to weeds decreases the survival of competitive soil organisms, therefore slowing *G. graminis* decline.

Take-all decline

Take-all decline is the apparent waning of take-all incidence following many years of continuous cereal cropping. This has been attributed to the 'build-up' of antagonistic micro-organisms in the soil. Although this process may be possible, the economic losses incurred during the 'build-up' appear to be unacceptable. There have, however, been examples of a reduction in take-all incidence due to gradual acidification of soil; this decline is reversed when lime is applied to increase soil pH. [39]

9.5 Crown rot

Key points:

- Triticale is susceptible to crown rot. [40]
- Fusarium species are responsible for causing two distinctly different diseases in winter cereal crops—crown rot and Fusarium head blight.
- Crown rot survives on infected stubble, from where it is passed onto the following crop.
- Use non host crops (pulse, oilseeds and broad leaf pasture species) in rotation sequences to reduce inoculum levels.
- Control grass weed hosts to reduce opportunities for Fusarium to survive fallow or non-host rotations.
- Sow varieties with partial resistance or improved tolerance where available.

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

39 Soilquality.org. (2016). Take-all Disease – NSW. http://www.soilquality.org.au/factsheets/take-all-disease-nsw

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

Information concerning the resistances of triticale varieties to *Fusarium* diseases is very limited. For crown rot (*Fusarium psuedograminearum)* most work 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 (use of disease break crops such as canola/ mustard) within the cropping system. [41]

There are two types of fusarium disease that affect cereal crops, Fusarium head blight (FHB) and crown rot (CR).

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. [42]

A survey of WA paddocks from 2010–2013 found little incidence of crown rot. However, this study demonstrated that even with low levels of disease present, rotation with break crops can manage inoculum levels of crown rot. Pastures did not offer a break to the cereal, suggesting that unmanaged pastures can contribute to the problem of crown rot. Inoculum levels are likely to build up when continuous cereals are grown; in fertile soils; and in dry summers. [43]

The prevalence of crown rot increased in WA in 2014 with 30–50% of wheat paddocks around Merredin reporting impacts (Figure 4). The increased expression in 2014 was likely the result of intensive cereal production, in combination with 2013 and 2014 seasonal factors. In 2013, wet spring conditions probably contributed to disease build but with few white heads due to the soft finish. In 2014, the drier spring in many areas resulted in a high expression of white head formation. [44]

41 Jessop RS, Fittler M. (2009). Triticale production Manual – an aid to improved triticale production and utilisation. http://www.apri.com.au/1A-102_Final_Research_Report_.pdf

42 GRDC. (2016). Tips and Tactics: Crown rot in winter cereals – Southern region.

43 Lawes R, Harries M, Huberli D, Shea G, Miyan S. (2015). Rhizoctonia and crown rot status of western Australian paddocks can be managed with crop rotation. http://www.giwa.org.au/pdfs/CR_2015/SORT/EOI_67_Lawes_Roger_Rhizoctonia_and_Crown_Rot_status_Paper_CU2015_.pdf

44 DAFWA. (2014). 2014 increase in crown rot in wheatbelt. https://www.agric.wa.gov.au/news/media-releases/2014-increase-crown-rot-wheatbelt

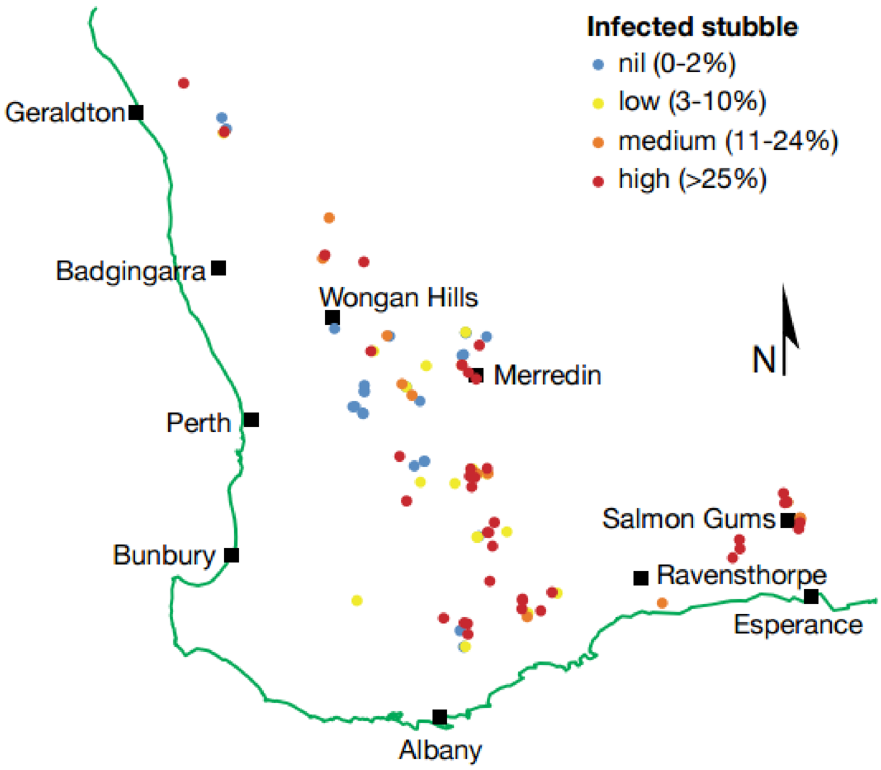


Figure 4: *Crown rot incidence in Western Australia based on two year stubble survey (2013/2014).*

Source: GRDC

Both FHB and CR become apparent after flowering, however head blight requires prolonged wet weather during flowering and grain fill whilst crown rot expresses as whiteheads following periods of moisture and/or heat stress. Crown rot can sometimes be first seen in patches or in wheel tracks, but is often not obvious until after heading. Dead heads containing shrivelled or no grain, called 'whiteheads' appear, although it is important to note that yield loss can occur even without the formation of whiteheads.

9.5.1 Damage caused by crown rot

The presence of crown rot within the plant stem limits water movement, which can result in premature death of the tiller and the presence of white (dead) heads (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 per cent possible at high inoculum levels, and losses in durum up to 90 per cent.

Photo 9: *Scattered whiteheads leading to large yield losses in cereal crops.*

Source: DAFWA

9.5.2 Symptoms

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 pink-purple fungal growth forms inside the lower leaf sheaths and on the lower nodes.

Infection is characterised by a light honey-brown to dark brown discolouration of the base of infected tillers, while major yield loss from the production of whiteheads is related to moisture stress post-flowering.

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). This is the most reliable indicator of crown rot, with browning often becoming more pronounced from mid to late grain filling 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. [45]

45 Soilquality.org. (2016). Crown rot – Qld. http://www.soilquality.org.au/factsheets/crown-rot-queensland

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

Source: DAFWA

Photo 11: *Scattered single tillers and white heads.*

Source: DAFWA

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

Source: DAFWA

MORE INFORMATION

Diagnosing crown rot of cereals

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 wheat varieties, and for assessing the risk after a non-cereal crop. [46]

PreDicta B (B = broadacre) is a DNA-based soil testing service to identify which soilborne pathogens pose a significant risk to broadacre crops prior to seeding.

It has been developed for cropping regions in Australia and includes tests for:

- cereal cyst nematode (CCN)
- take-all (*Gaeumannomyces graminis* var. *tritici* (Ggt) and *G. graminis* var. *avenae* (Gga))
- rhizoctonia barepatch (*Rhizoctonia solani* AG8)
- crown rot (*Fusarium pseudograminearum*) *Note that oats are not very susceptible to crown rot – but does host it.
- root lesion nematode (*Pratylenchus neglectus* and *P. thornei*)
- stem nematode (*Ditylenchus dipsaci*)

46 Soilquality.org. (2016). Crown rot – Qld. http://www.soilquality.org.au/factsheets/crown-rot-queensland

MORE INFORMATION

PIR SA Predicta B website

VIDEOS

WATCH: GRDC Updates: Improving PreDicta B.

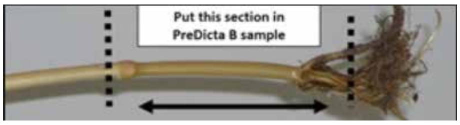


Photo 13: *Sampling for PreDicta B*

Source: GRDC

PreDicta B samples are processed weekly from February to mid-May (prior to crops being sown) to assist with planning the cropping program. PreDicta B is not intended for in-crop diagnosis. That is best achieved by sending samples of affected plants to your local plant pathology laboratory.

9.5.3 Fusarium head blight (FHB) symptoms

FHB is an infection of the head rather than root or crown as with CR. In wheat, FHB appears as premature bleaching of spikelets within a head. Frequently only part of the head (usually the upper half) is affected (Photo 14). Salmon pink to orange spore masses (sporodochia) at the bases of infected spikelets can also be apparent during prolonged warm, humid weather. Infected wheat grains have a chalky white appearance and are usually shrivelled and lightweight; they may sometimes have pink staining too. In barley, infected spikelets have a brown or a water-soaked appearance, rather than bleaching. The grains have an orange or black encrustation on their surfaces rather than being chalky white.

Photo 14: *Heads are partly or fully bleached.*

Source: DAFWA

9.5.4 Conditions favouring development

FHB is a fungal disease that affects cereals. It survives from one season to the next in the stubble remains of infected plants. The disease is more common on heavy clay soils.

Infection is favoured by high soil moisture in the two months after planting. Drought stress during elongation and flowering will lead to the production of 'deadheads' or 'whiteheads' in the crop. These heads contain pinched seed or no seed at all.

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 grain filling 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. [47]

Soil water is by far the biggest factor in the impact of crown rot on profitability. The effect of moisture on crown rot yield losses is huge.

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. [48]

9.5.5 Managing crown rot

Key points:

- Varietal resistance and tolerance to crown rot is limited. Most wheat varieties grown in WA are either susceptible or very susceptible to crown rot
- There are no fungicide options for the control of crown rot.
- Rotate crops. This is the most important management option. A grass-free break from winter cereals is the best way to lower crown rot inoculum levels.
- 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 5).
- 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.
- Choosing more resistant crop varieties can help but still need to be combined with effective management.
- Keeping crown rot inoculum at low levels is the most effective way to reduce yield loss from this disease. [49]

47 Soilquality.org. (2016). Crown rot – Qld. http://www.soilquality.org.au/factsheets/crown-rot-queensland

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

49 GRDC. (2016). Tips and Tactics: Crown rot in winter cereals – Western region. https://grdc.com.au/resources-and-publications/all-publications/factsheets/2016/02/tt-crownrotwintercereals

Figure 5: *The GRDC's "Stop the crown rot" campaign.*

Source: GRDC

The disease may be controlled through planting partially resistant varieties or 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.

Variety selection

Where growers are aware their paddocks are infected with crown rot, resistant varieties can be used to limit yield loses.

Growers need to be aware of the levels of crown rot disease in their paddocks, as even the most resistant crops can suffer yield loss under high levels of the disease. At intermediate levels, the grower can make a calculated risk of returns versus yield loss by growing only resistant varieties. However, where high levels of disease are present even resistant varieties may be affected, and a break crop may be required.

VIDEOS

WATCH: GRDC Updates: Crown rot tolerance in new cereal varieties.

If a cereal must be sown but there is a risk of yield loss from crown rot:

- *Select a cereal type which will have the lowest yield loss. Barley is the first choice, followed by bread wheat and triticale. Avoid durum;*
- *Match nitrogen application to stored soil moisture and potential yield;*
- *Limit nitrogen application prior to and at sowing to avoid excessive early crop growth;*
- *Ensure zinc nutrition is adequate; and*
- *Sow on the inter-row if this option is available.*

Agronomist's view

Rotation Management

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 and sorghum, can be particularly effective, as these help to maintain a moist soil surface, encouraging 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 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 residue decay. However, cultivation also spreads infected residue, which may increase plant infection rates in following crops – thus counteracting any benefits from increased residue breakdown.

Baling, grazing and/or burning crop residues are also not effective solutions for the removal of crown rot. 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 still survive in below ground tissue even if above ground material is removed.

MORE INFORMATION

Rhizoctonia and crown rot status of western Australian paddocks can be managed with crop rotation.

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 can 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.

Managing stubble

- Inoculum will be more concentrated below ground and in the bottom 7 cm of the stem (Figure 6).
- Stubble management practices such as cultivating, spreading and slashing through cultivation can increase the rate of stubble decomposition but can also spread the infected residues across the paddock.
- Where there is no stubble moisture or adequate time to accelerate stubble breakdown, these practices can increase infection rates in the next winter cereal crop.
- Grazing stubble can also spread inoculum.

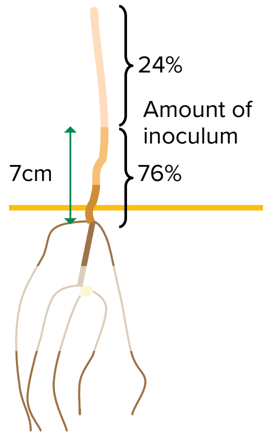


Figure 6: *Crown rot distribution in infected cereal stubble.*

Source: GRDC

IN FOCUS

How to manage crown rot – research update

Key points:

- Impact of crown rot on yield and quality is a balance between inoculum levels and soil water
- The balance is heavily tipped towards soil water yet most management strategies tend to focus solely on combating inoculum, sometimes to the detriment of soil water
- Cultivation (even shallow) distributes infected residue more evenly across paddocks and into the infection zones below ground for crown rot, increasing the likelihood of infection.
- Some of the newer varieties appear promising in that they provide improved tolerance to crown rot
- PreDicta B® is a good technique for identifying the level of risk for crown rot (and other soil-borne pathogens) prior to sowing within paddocks. However, this requires a dedicated sampling strategy and is not a simple add on to a soil nutrition test.

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 – their canopy density and rate of the canopy closure as well as row spacing, the amount of soil water they use and seasonal rainfall.

Cultivation

Growers may cultivate their stubble for a range of reasons e.g. to reduce trash load prior to sowing. However, 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. Cultivating stubble in theory increases the rate of decomposition as it reduces particle size of stubble, buries these particles in the soil where microbial activity is greater and the soil environment maintains more optimal moisture and temperature conditions compared to the soil surface or above ground. However, cultivation also dries out the soil in the cultivation layer, which immediately limits the potential for decomposition of the incorporated stubble. Decomposition of cereal stubbles is a *very slow* process that requires adequate moisture for an extended period of time to occur completely. A summer fallow (even if extremely wet and stubble has been cultivated) is **not** long enough!

*Infection: T*he majority of infection sites with crown rot are below ground and physical contact between an infected piece of residue and these plant parts is required to initiate infection. Cultivation of winter cereal stubble harbouring the crown rot fungus effectively breaks the inoculum into smaller pieces and spreads them more evenly through the cultivation layer across the paddock. Consequently, the crown rot fungus has been given a much greater chance of coming into contact with the major infection sites below ground as the next winter cereal crop germinates and develops. 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 sheathes 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. Cultivation or harrowing negates the option of inter-row sowing as a crown rot management strategy. [50] In the Western region inter-row sowing using accurate ± 2 cm differential GPS autosteer has been shown to decrease the number of infected plants by about 50%, resulting in a 5% to 10% yield advantage in the presence of crown rot. [51]

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 (macropores etc). 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 crown rot expression late in the season. Like crown rot management and all farming practices, cultivation is a balancing act between perceived benefits and costs.

Stubble burning

Burning removes the above ground portion of crown rot inoculum but the fungus will still survive in infected crown tissue below ground so it is **not** a 'quick fix' for high inoculum situations. Removal of stubble through burning will increase evaporation from the soil surface and impact on fallow efficiency. A 'cooler' autumn burn is therefore preferable to an earlier 'hotter' burn as it minimises the negative impacts on soil moisture storage whilst still reducing inoculum levels.

Reduce water loss

Inoculum level is important in limiting the potential for yield loss from crown rot but the overriding factor dictating the extent of yield loss is moisture/temperature stress during grain-fill. Any management strategy that limits 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 grain-fill and exacerbate the impact of crown rot.

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

51 GRDC. (2016). Tips and Tactics: Crown rot in winter cereals – Western region. https://grdc.com.au/resources-and-publications/all-publications/factsheets/2016/02/tt-crownrotwintercereals

Grass weed management

Grass weeds should be controlled in fallow periods and in-crop, 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.

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

Soil type

Soil type does not differentially affect the survival or infection phases of crown rot. However, the inherent water holding capacity of each soil type interacts with expression by potentially buffering against moisture stress late in the season. Hence, yield loss can be worse on red soils compared to black soils due to their generally lower water holding capacities. Any other sub-soil constraint e.g. sodicity, salinity or shallower soil depth effectively reduces the level of plant available water which can increase the expression of crown rot.

Cereal crop and variety choice

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.

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. All current durum varieties are very susceptible to crown rot and should be avoided in medium and high risk situations.

Sowing time

Earlier sowing within the recommended window of a given variety for a region can bring the grain-fill period forward and reduce the probability of moisture and temperature stress during grain-fill. Earlier sowing can increase root length/depth and provide greater access to deeper soil water later in the season, which buffers against crown rot expression. Earlier sowing however 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 is the additional detrimental impact of later sowing on grain size in the presence of crown rot infection.

MORE INFORMATION

[Tips and Tactics: Crown rot in winter cereals – Western region.]

[Understanding crown rot underpins effective management – Southern and Western regions]

Interaction with root lesion nematodes

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

How do I know my level of risk for crown rot and RLN?

PreDicta B® is a DNA based soil test which detects levels of a range of cereal pathogens that is commercially available to growers through the South Australian Research and Development Institute (SARDI). Because the crown rot fungus is stubble-borne, normal soil samples are unreliable and disease detection is highly sensitive to the sampling technique used. Follow the specific protocols for how to collect samples for crown rot testing (further paper in these proceedings).

If you are not willing to follow the recommended PreDicta B® sampling strategy then DO NOT assesses disease risk levels prior to sowing. [52]

9.6 Rhizoctonia

Key points:

- Rhizoctonia bare-patch (*R. solani* AG8) is a major problem across WA's cereal growing regions and is estimated to reduce WA state-wide cereal yields by 1% to 5% annually at a cost of $27M in wheat and barley.
- Rhizoctonia 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, oats are most tolerant followed by triticale, wheat and then barley, which is the most intolerant. [53]
- Adequate nutrition during crop emergence gives the crop 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 is a fungal disease affecting a wide range of crops and has become more prevalent throughout Western Australia in recent years, following the introduction of minimum tillage practices. The previous practice of tillage prior to seeding encouraged the breakdown of the fungus in the soil prior to emergence. Minimum tillage practices decrease the rate of organic matter breakdown, thereby providing a habitat for *Rhizoctonia* over summer.

The disease affects most major crops to varying degrees, with barley being most susceptible and oat crops least susceptible. Bare patch and root rot of cereals, and

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

53 GRDC. (2008). Rhizoctonia – Fact Sheet.

VIDEOS

WATCH: Over the Fence: Improving soil health helps fight against rhizoctonia.

damping off and hypocotyl rot of oilseed and legumes are all caused by differing strains of *R. solani*. [54]

9.6.1 Symptoms

The characteristic symptom of *Rhizoctonia* 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 hyphae into the root. For this reason, once the crop is fully established, plants have either perished due to seedling infection or 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* will typically be shortened with 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. [55]

What to look for

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 15).

Photo 15: *Patches vary in size from less than a metre to several metres in diameter. Stunted plants occur in patches with a distince edge between diseased and healthy plants.*

Source: DAFWA

54 Soilquality.org. (2016). Rhizoctonia – NSW http://www.soilquality.org.au/factsheets/rhizoctonia-nsw

55 Soilquality.org. (2016). Rhizoctonia – NSW http://www.soilquality.org.au/factsheets/rhizoctonia-nsw

Plant

- Affected plants are stunted with stiff, rolled leaves and are sometimes darker green than healthy plants (Photo 16).
- Roots of affected plants are short with characteristic pinched ends: 'spear tips' (Photo 17).

Photo 16: *Affected plants are stunted with stiff, rolled leaves which are sometimes darker than those of healthy plants.*

Source: DAFWA

VIDEOS

WATCH: How to diagnose Rhizoctonia root rot.

MORE INFORMATION

Diagnosing rhizoctonia root rot in cereals

Photo 17: *Roots of affected plants are short with characteristic pinched ends or 'spear tips'.*

Source: DAFWA

9.6.2 Conditions favouring development

Rhizoctonia solani survives best in organic matter just below the surface of an undisturbed soil. The fungus benefits from summer rainfall events by infecting and multiplying on 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, thereby priming itself for infection of germinating seeds. Infection by the pathogen is encouraged by factors that restrict root growth, such as low soil fertility and sulfonylurea herbicides. 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* 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.

Factors Affecting *Rhizoctonia*

There are certain soil conditions that favour *Rhizoctonia* development during and after seeding.

Soil Nutrition

The disease is most common in soils of poor fertility (Department of Agriculture and Food, Western Australia 2006). Crops with access to sufficient nutrients for growth have a better ability to 'get ahead' of *Rhizoctonia* infections.

Soil Disturbance

Rhizoctonia is sensitive to cultivation, with cultivation after rain and before sowing most effective at reducing infection. Disturbing the soil does not allow the fungus to 'prime' itself for infection of the emerging crop.

Soil Moisture

Under moisture stress the crop becomes more susceptible to *R solani* infection and has a decreased ability to get ahead of the disease.

Weeds

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

Herbicides

Sulfonylurea herbicides can sometimes worsen *Rhizoctonia*, and this is attributed to minor herbicidal effects on the crop. [56]

9.6.3 Managing Rhizoctonia

Where reduced tillage is practiced, *Rhizoctonia* bare patch is best controlled through effective management of weeds and maintaining adequate nutrition for the establishing crop. Spraying weeds with a fast acting knock down 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 each event. 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, tillage was the most effective method of reducing the impact of *Rhizoctonia*. The establishment of *R. solani* in the topsoil late in autumn was negated as cultivation broke the network of fungal hyphae. The fungus 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 *Rhizoctonia*. Consult your local advisor for specific information.

In areas where the disease is known or suspected it is best practice to clean knife points once the seeding is complete, thereby eliminating movement of the fungus from one paddock to the next. In general, maintaining adequate nutrition (especially nitrogen) during crop establishment is the best way to reduce the chance of *R. solani* infection. [57]

IN FOCUS

Integrated disease management options to control rhizoctonia bare-patch in cereals

Key points:

- When sowing to wheat or another cereal in a paddock with a previous history of Rhizoctonia bare-patch, using cultivation below the seed (~10 cm) and a registered fungicide can reduce disease impact.

56 Soilquality.org. (2016). Rhizoctonia – NSW http://www.soilquality.org.au/factsheets/rhizoctonia-nsw

57 Soilquality.org. (2016). Rhizoctonia – NSW http://www.soilquality.org.au/factsheets/rhizoctonia-nsw

- A break crop of canola or a chemical fallow may be useful for reducing Rhizoctonia inoculum in the soil prior to sowing a cereal crop.
- In the near future, new in-furrow fungicide options, that improve the control of Rhizoctonia disease in barley and wheat, may become available to WA farmers.

Research in WA in 2012 aimed to determine the efficacy of the new fungicides to control Rhizoctonia in cereals. Also, the effect of rotation and current management options to control *R. solani* were examined. All test sites had visible patches in cereals the previous year and the pathogen was confirmed to be R. solani (AG8) by PreDicta-B® soil test. Trials were sown by cone-seeder and spayed regularly with foliar fungicide to remove confounding effects of differences in leaf disease.

The results of this research support the current recommendation for management of Rhizoctonia bare-patch. When sowing to wheat or another cereal in a paddock with a high rhizoctonia risk, cultivate below the seed (at least 10 cm) at the time of sowing and use a registered fungicide.

A break crop of canola or chemical fallow, in paddocks with severe Rhizoctonia bare-patch, may reduce Rhizoctonia inoculum levels and reduce disease in the following cereal crop.

In paddocks with Rhizoctonia, barley will exacerbate the disease substantially compared to other crops.

MORE INFORMATION

Integrated disease management options to control rhizoctonia bare-patch in cereals

Rhizoctonia Fact sheet – Western region

9.7 Smut and bunt

Cereal smut and bunt diseases are caused by fungi which parasitise the host plant and produce masses of soot-like spores in the leaves, grains or ears. These fungi are damaging pathogens of cereal crops, reducing yield and quality of harvested grain. In many cases grain receival points have low or zero tolerance of smut contaminated grain. The major Western Australian cereal crops, wheat, barley and oats, are susceptible to a range of smut and bunt diseases. [58]

Triticale is not usually prone to infection from smuts and bunt. However, it is good insurance to apply a seed dressing to the grain when it is being graded. [59]

9.7.1 Bunt or stinking smut

This disease affects mature triticale, durum and wheat ears in which a mass of black-fungal spores replaces the interior of the grain and forms a bunt ball. Infected plants are shorter and have darker green ears and gaping glumes than healthy plants (Photo 18). Bunt is usually only noticed at harvest when bunt balls and fragments are seen in the grain.

58 DAFWA. (2016). Smut and bunt diseases of cereal – biology identification and management. https://www.agric.wa.gov.au/autumn/smut-and-bunt-diseases-cereal-biology-identification-and-management

59 Agriculture Victoria. (2012). Growing Triticale. http://agriculture.vic.gov.au/agriculture/grains-and-other-crops/crop-production/growing-triticale

Photo 18: *Common bunt in cereal head showing glumes containing bunt balls.*

Source: DAFWA

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

Managing bunt

- Seed that is sown to provide the following season's wheat 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 wheat seed should be treated with fungicidal seed dressing for at least six years.

These recommendations could be adopted in one of two ways:

1. Treat all wheat seed with a fungicidal seed dressing every second year.
2. Treat a small quantity of seed of each variety with a fungicidal seed dressing every year and use the grain from this as planting seed in the following year. [60]

9.7.2 Loose smut

Triticale is susceptible to loose smut,[61] though it does not usually occur to a degree where control is warranted.

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 spores are readily blown away leaving a bare, ragged stalk (Photo 19).

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

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

Photo 19: *Close up view of barley heads affected with loose smut.*

Source: DAFWA

If the spores settle on healthy flowers, they may germinate and infect the embryo of the developing seed. When this 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. [62]

Managing smut

The disease is controlled by pickling seed with a systemic fungicide which penetrates the developing seedling to kill the internal infection. Cereal seed dressing fungicides 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. [63]

9.8 Common root rot

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

Common root rot is not common in WA but can build up to damaging levels in continuous wheat crops. [64]

Common root rot symptoms:

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

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

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

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

9.8.1 Damage caused by disease

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

9.8.2 Symptoms

Paddock

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

Plant

- Browning of roots and sub-crown internode (the piece of stem emerging from the seed to the crown) (Photo 20).
- Blackening of sub-crown internode in extreme cases.

Photo 20: *Blackening of sub-crown internode in extreme cases.*

Source: SARDI in DAFWA

9.8.3 Conditions favouring development

- Can occur from tillering onwards but most obvious after flowering
- No distinct paddock symptoms, although the crop may lack vigour
- Severe infections can lead to stunting of plants.
- Appears 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
- Widespread through the grain belt; often found in association with Crown Rot.

- 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 wheat rotations. [65]

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

9.8.4 Management

The disease may be controlled by planting partially resistant varieties or 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. [66]

- Reduce levels of the fungus in your paddocks by rotating with crops such as field pea, faba bean, canola, mustard, mungbean, sorghum or sunflower.
- Weak crops or pasture must be grass-free.
- Sow partly resistant wheat or barley varieties.
- If moisture permits, reduce sowing depth to limit the length of the SCI (sub-crown internode).
- Ensure adequate nutrition especially of phosphorus which reduces severity.
- Burning does not decrease spore levels in the soil. [67]

9.9 Ergot

Triticale, like rye, is susceptible to ergot, a fungal disease that can ruin a year's crop. Careful crop rotation, the use of a clean seedbed, and diligent maintenance of field edges will minimize this chance. Triticale intended for human or animal consumption should be tested for toxins. Ergot can make grain less palatable for livestock as well as causing serious health problems. [68]

9.9.1 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 animals. As these toxins accumulate in the body, symptoms can begin to occur after long periods of low level ingestion. Crops affected by Ergot generally do not experience significant yield losses, but economic losses can be quite severe when grain tendered by growers is rejected at receival. [69]

Gangrenous ergotism of man and cattle;

Blockage of circulation to the extremities, tingling in the fingers, vomiting, diarrhoea, gangrene of the toes and fingers, ulceration of the mouth. It is a dry form of gangrene and limbs may fall off. 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 similar to those of gangrenous ergotism and are followed by painful spasms of the limbs, epileptic convulsions and delirium in man. Cattle become excitable and run with a swaying uncoordinated gait. [70]

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

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

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

68 UVM. (2011). Triticale. http://northerngraingrowers.org/wp-content/uploads/TRITICALE.pdf

69 AWB. Wheat Quality Factsheet – ERGOT.

70 Collated by HerbiGuide. Phone 08 98444064 or www.herbiguide.com.au for more information. http://www.herbiguide.com.au/Descriptions/hg_Rye.htm

9.9.2 Symptoms

Characteristically Ergot pieces have a purple – black surface with a white to grey interior (Photo 21). 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.

What to look for

In crop

- 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. [71]

Photo 21: *Ergot bodies in cereal grain head.*

Source: Natgeocreative

In stock

In WA the most common symptom of ergot poisoning in livestock is hyperthermia. [72] Producers are encouraged to keep an eye on animals eating ergot-infected grain in hot or sunny weather (Photo 22). 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. [73]

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

72 DAFWA. (2014). WA Livestock disease outlook. http://www.wafarmers.org.au/wp-content/uploads/2014/04/Producer-edition-WA-Livestock-Disease-Outlook-April-2014.pdf

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

Photo 22: *Producers need to be aware that even a small amount of ergot in grain can cause serious illness to their stock.*

Photo: Michael Raine

9.9.3 Conditions favouring development

Key points:

- Ergots survive in the soil for up to one year, producing spores that infect plants during flowering.
- Infection prefers cool wet weather at flowering.
- 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. [74]

The development of Ergot is favoured by moist soil surfaces during spring and early summer. In addition, wet conditions during flowering of cereals and grasses increases the period of infection. The disease cycle of Ergot consists of two stages. The cycle begins in spring when the Ergot bodies germinate in wet soils after a period of cold temperatures (winter) and develop fruiting bodies that contain spores (ascospores). These spores can be spread to neighbouring susceptible plants by wind and rain. To infect these plants, the spores must land on the florets and within five days the second stage commences, referred to as the "honeydew stage". During this stage the infected florets exude a sugary slime that contains spores (conidia). These spores can in turn 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 that 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. [75]

Ongoing periods of spring and summer rain can increase occurrence of ergots in ryegrass, therefore Ergots in crop are more likely to develop in years of above-average rain when ryegrass is flowering. [76]

9.9.4 Management of disease

Key points:

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

75 AWB. Wheat Quality Factsheet – ERGOT.

76 DAFWA. (2015). Look out for ergots when selecting stock feed. 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.
- Seed cleaning. [77]

For grain that is contaminated with pieces of Ergot, grain-cleaning equipment can be used to remove the majority of Ergot bodies (Photo 23). However, the grower will need to determine whether this is an economically viable option.

Photo 23: *Ergot contaminated seed.*

Source: DPI Vic, in 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 amount of viable Ergot pieces in the soil to negligible levels.

During planting clean seed must be used, as there is currently no effective treatments against Ergot. For growers using conventional tillage, Ergot pieces need to be buried to a minimum depth of 4 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. [78]

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

78 AWB. Wheat Quality Factsheet – ERGOT.

Control of grasses within cereal crops will help prevent cross infection. This is best achieved by preventing seed set in the season before cropping, by clear fallowing, hard grazing or hay cutting, together with the use of selective herbicides. [79]

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 seed set will reduce or eliminate this major source of ergot re-infestation. [80]

Strategies to reduce the risk of ergot infection:

- Use ergot-free seed if possible.
- Rotate with crops resistant to ergot, such as flax, canola and legumes.
- As the source of ergot infection is often the grass in headlands or ditches, mowing this grass before flowering or seed set will greatly reduce or eliminate the chances of ergot infection.
- Ergots germinate at or near the soil surface to produce infectious spores that attack cereal flowers. To prevent them from germinating, work the field to a depth greater than two inches 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 combine rounds to prevent contamination of the entire lot as most of the ergot infested grain will likely be concentrated in this region. [81]

Marketing options

Stockfeed intended for feedlot cattle has been further limited to 0.1% sclerotes by weight since 2004.

Deliveries of sorghum with sclerote levels higher than 0.3% will be rejected by grain merchants, and higher than 0.1% will be rejected by cattle feedlotters. Most commonly, a sorghum sample containing 0.3% sclerote will contain about 1 mg alkaloid/kg (1 ppm), but because the alkaloid concentration can vary, it will be advisable to minimise ergot wherever possible.

Although there is a 0.3% sclerote contamination limit for sorghum intended for livestock, some end-users will not accept ergot-contaminated grain at all. Grower pigs, chickens and laying hens are most tolerant of the alkaloids in sclerotes, and so are a potential market for sorghum that contains 0.3% sclerotes. Sorghum with levels higher than the animal feed limit can be mixed with clean grain to reduce the sclerote levels. Fortunately, the incidence of ergot contamination of bulk grain has been extremely low over the past few years. [82]

9.10 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.

Key points:

- 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 agronomically suitable varieties are available, opt for moderately resistant (MR) to resistant (R) varieties in disease-prone environments.

79 Agriculture Victoria. (1999). Ergot of pasture grasses. http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/plant-diseases/grains-pulses-and-cereals/ergot-of-pasture-grasses

80 Alberta Gov. (2016). Fall Rye Production. http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex1269/$file/117_20-1.pdf

81 Alberta Gov. (2016). Fall Rye Production. http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex1269/$file/117_20-1.pdf

82 DAFF QLD. (2010).Ergot-affected and mouldy sorghum. https://www.daf.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/sorghum/disease-management/ergot-affected-and-mouldy-sorghum

- Disease control using fungicides is an economic decision.
- Understand the role of the season and have a plan in place, and if growing susceptible varieties have the right chemicals on hand.
- For cereal rusts and mildew, remove the green bridge between crops 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.
- Fungicide resistance is a major emerging issue. Do not use tebuconazole-based products on barley if there is any chance of powdery mildew occurring, and select varieties that are resistant to powdery mildew (Table 5).

Table 5: *Modes of action registered for control of foliar diseases in Australian cereals.*

Group	Active ingredient	Example product name	Foliar (F), seed (S) or in-furrow (IF)
	Triadimefon	Triad®	F and IF
	Propiconazole	Tilt®	F
	Propiconazole + cyproconazole	Tilt® Xtra	F
	Tebuconazole	Hornet®	F and S
3 - DMI	Flutriafol	Impact®	F and IF
	Tebuconazole + flutriafol	Impact® Topguard	F
	Tebuconazole + prothioconazole	Prosaro®	F
	Epoxiconazole	Opus® 125	F
	Triadimenol	Baytan®	S
	Fluquinconazole	Jockey®	S
3 + 11 (Stobilurins)	Azoxystrobin + cyproconazole	Amistar® Xtra	F
	Pyraclostrobin + epoxiconazole	Opera®	F

Source: Oliver R, Curtin University in GRDC

VIDEOS

WATCH: GCTV9: Banding Fungicide in Cereals.

9.10.1 Fungicide stewardship

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

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.
- Do not sow wheat on wheat or barley on barley to avoid rapid disease build-up.

2. Variety choice.

- 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. Fungicide choice and use.

- Do not use the same triazole active ingredient more than once in a season. Do not use a strobilurin or Succinate DeHydrogenase Inhibitors (SDHI) more than once in a season.
- Aim for early control of necrotrophic diseases 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.

Timing of application in the disease epidemic is critical to getting the most out of these products. [83]

Which foliar fungicide active ingredients are registered for which cereal diseases in WA? The DAFWA provide details on how to apply fungicides effectively and minimise the risk of fungicide resistance developing. For details on foliar fungicide application rates, adjuvants, withholding periods and other instructions please refer to product labels.

MORE INFORMATION

Registered foliar fungicides for cereals in Western Australia

Seed dressing and in-furrow fungicides for cereals in Western Australia

GRDC Cereal Fungicides Factsheet.

9.11 Barley yellow dwarf virus (BYDV)

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 grass species. These viruses are not seed-borne and persist from one growing season to the next in oversummering grasses. BYDV and CYDV infection decreases grain yield and also causes shrivelled grain. These viruses can cause serious problems in cereal crops in the southern and south-west agricultural areas of WA (more than 500 mm of rain). BYDV is often more prevalent than CYDV. [84]

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 (YDV) can occur in all cropping regions. The virus is best controlled by monitoring and spraying for aphids early in the season.

Economic importance

The effect of the disease on yield depends on the viral species or strain, time of infection and rate of spread. Ten per cent yield losses may occur without visible symptoms of infection, with severe losses approaching 80% when infection is early. Trials with wheat in WA have shown that yield losses caused by BYDV infection vary greatly between varieties depending on their tolerance or susceptibility to the virus. Yields of sensitive varieties were reduced by up to 67 %. Similar losses develop in barley and oats. [85] Trial data has shown that yield losses of between 9–79% can occur when plants are infected early in the growing season (before the end of tillering) and losses of 6–9% may occur when plants are infected late (post tillering). [86]

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

84 Coutts B. (2015). Managing barley yellow dwarf 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

85 Coutts B. (2015). Managing barley yellow dwarf 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

86 Agriculture Victoria. (2011). Barley Yellow Dwarf Virus. http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/plant-diseases/grains-pulses-and-cereals/barley-yellow-dwarf-virus

9.11.1 Symptoms

Symptoms take at least three weeks to appear after infection. 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 24). If crawling aphids move into the crop from adjoining pastures or crops then symptoms will appear along the fence line first.

Photo 24: *Patches where aphids have landed and transmitted the virus emerge in paddocks.*

Source: DAFWA

YDV symptoms 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. [87]

Infected wheat plants develop a slight to severe yellowing or pale striping between veins (interveinal chlorosis) in young leaves (Photo 25). 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 wheat. 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. [88]

87 Agriculture Victoria. (2011). Barley Yellow Dwarf Virus. http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/plant-diseases/grains-pulses-and-cereals/barley-yellow-dwarf-virus

88 Coutts B. (2015). Managing barley yellow dwarf 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

Photo 25: *Barley yellow dwarf virus infection of a cereal plant.*

Source: DAFWA

9.11.2 Conditions favouring development

The YDVs have a very wide host range in the grass family (Poaceae). They survive between cropping seasons in volunteer cereals, annual and perennial pasture grasses and wild grasses. The virus and vectors can survive in small pockets of surviving grass even in the low rainfall areas. The aphid vectors of the viruses tend to build up in autumn and spring on the grasses, and then move into cereal crops where they often develop colonies. High rainfall areas have a greater build up of the grasses, virus and vectors.

There are at least six serotypes of the YDVs which are spread predominantly by different aphid vectors. The distribution and relative importance of the different types are largely dictated by the abundance of the aphid vector species. If samples are being tested, tests should include serotype PAV, MAV, RMV for (BYDV) and RPV for (CYDV).

In Western Australia (WA), the virus is spread mainly by the oat (*Rhopalosiphum padi*) and the corn leaf (*Rhopalosiphum maidis)* aphids. The oat aphid is the most important; it feeds on wheat, barley, oats and grasses. The corn leaf aphid usually only feeds on barley and some grasses. Other minor aphid vectors include the grain aphid (*Sitobion sp*.) and two cereal root aphids (*Rhopalosiphum insertum* and *Rhopalosiphum rufiabdominalis*). [89] 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 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.

YDV outbreaks 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. [90]

89 Coutts B. (2015). Managing barley yellow dwarf 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

90 Agriculture Victoria. (2011). Barley Yellow Dwarf Virus. http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/plant-diseases/grains-pulses-and-cereals/barley-yellow-dwarf-virus

9.11.3 Management

Where resistant varieties are not an option the management of aphid activity in crops especially early in the season to prevent its spread and or delayed sowing to avoid the main aphid flights in the autumn can reduce YDV infection.

Later sowing to avoid the main aphid flights will reduce the incidence of YDV but this needs to be weighed up against possible yield reduction from delayed sowing.

Resistant varieties when available are the preferred option for management. There are a number of oat and a couple of wheat and barley varieties with varying levels of resistance.

Chemical treatments

It is vital to prevent spread of the virus by aphids during the first 8–10 weeks after crop emergence 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.

Foliar sprays can be used early 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. You will need to discuss with your agronomist the insecticide best suited to your situation. [91]

Insecticides

Strategic applications of insecticides can be used against the aphids that carry BYDV or CYDV to reduce its spread. It is important to protect the crop during the first 10 weeks after emergence. First pyrethroid spray: 3 weeks after emergence (or 2-leaf stage if aphids easily found). Second pyrethroid spray: 7 weeks after emergence. In high risk situations, seed dressings containing imidacloprid applied to seed before sowing are recommended for good early season control but requires a follow-up pyrethroid spray. [92]

Delayed Sowing

Later sowing to avoid the main aphid flights will reduce the incidence of YDV but this needs to be weighed up against possible yield reduction from delayed sowing. [93]

MORE INFORMATION

Managing barley yellow dwarf virus and cereal yellow dwarf virus in cereals

Diagnosing yellow dwarf virus

9.12 Disease following extreme weather events

9.12.1 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.

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

91 Agriculture Victoria. (2011). Barley Yellow Dwarf Virus. http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/plant-diseases/grains-pulses-and-cereals/barley-yellow-dwarf-virus

92 Coutts B. (2015). Managing barley yellow dwarf 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

93 Agriculture Victoria. (2011). Barley Yellow Dwarf Virus. http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/plant-diseases/grains-pulses-and-cereals/barley-yellow-dwarf-virus

Large amounts of seed produced in abandoned crops, or pinched seed from 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 these 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. [94]

9.12.2 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 rain included transport of inoculum (crown rot, nematodes, leaf spots through movement of infected stubble and soil) (Photo 26), development of sexual stages (leaf spots, head blights), survival of volunteers (unharvested material and self-sown plants in double-crop situations), and weather damaged seed. [95]

Photo 26: *Tan spot infected stubble following flood.*

Photo: Rachel Bowman, Seedbed Media

94 Murray G, Hind-Lanoiselet T, Moore K, Simpfendorfer S, Edwards J. (2006). Crop diseases after drought. Primefacts 408 NSW DPI.

95 DAFF (2013) Winter cereals pathology. Department of Agriculture, Fisheries and Forestry Queensland, https://www.daf.qld.gov.au/business-priorities/plants/field-crops-and-pastures/broadacre-field-crops/prepare-for-winter-crops-following-floods/winter-cereals-pathology