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GRDC GROWNOTES™

GRDC
GRAINS RESEARCH & DEVELOPMENT CORPORATION

WHEAT

SECTION 9

DISEASES

SECTION 9

Diseases

Diseases can severely affect yield and quality in wheat. In some cases, diseases are controlled through simple cultural practices and good farm hygiene. One of the major practices used in the control of diseases is crop rotation.

To minimise the effect of diseases:

- 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 self-sown cereals over summer that may act as a green bridge.
- Rotate crops. [1]

More information

GRDC: The current and potential costs from diseases of wheat in Australia

GRDC Fact Sheets: Green bridge control is integral to pest and disease management

Brennan and Murray (1988) published a detailed analysis of the cost of wheat diseases, based on the estimated yield losses as well as the cost of control measures. They estimated that in the 1980s, the annual cost of wheat diseases nationwide was AU$400 million. Most alarming was that this translated to an average of $34/ha. [2] With current yields, this figure is likely to be substantially higher.

Broadly, diseases can be caused by environmental factors such as temperature or water stress and nutrient deficiencies, as well as living agents (pathogens). Here we will consider only diseases with a biotic (living) cause. However, many diseases in grain crops, especially soil-borne diseases, have important interactions with environmental stresses. [3]

9.1 Causes of cereal diseases

Cereal diseases are caused by fungi, viruses, bacteria and nematodes.

9.1.1 Fungi

Fungi and other pathogens (disease-causing organisms) often reduce grain yields by damaging green leaves, preventing them from producing the sugars and proteins

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

[2] J Brennan, G Murray (1988) Australian wheat diseases—assessing their economic importance. *Agricultural Science* (New Series), Vol. 1, pp. 26–35.

[3] UNE Agronomy of Grains Production course notes.

needed for growth. In other cases, they block or damage the plant's internal transport mechanisms, reducing the movement of water and sugars through the plant. Yields are also reduced when the pathogen diverts the plant's energy into reproducing more of the pathogen at the expense of plant growth or grain formation.

Fungi come in a diverse variety of forms. They spread by producing one or more types of spores, which may be carried by wind, through raindrop splashes or, in the case of smuts, by mechanical movement and mixing during harvest. Some fungi survive as spores in the soil, on seed or on plant debris. Others survive as fine threads of growth inside plant debris or seed, and produce fresh spores in the following season. Spores are sometimes produced inside small fruiting bodies on infected plant tissue or stubble. Some diseases such as rust require continuous green host plants to survive from one season to the next.

9.1.2 Viruses

Viruses are invisible to the eye and even through a conventional microscope. Unlike other pathogens, viruses are totally dependent on the host for growth and multiplication. They cannot survive outside the plant, except in an insect or other animal that transmits the disease. They often damage plants by blocking its transport mechanisms. *Barley yellow dwarf virus* (BYDV) is a virus that affects all of the cereals.

9.1.3 Bacteria

Bacteria differ from fungi in that they do not form fine threads of growth, but instead multiply rapidly by continually dividing. They grow best under damp conditions and do not survive as well as fungi under dry conditions.

9.1.4 Nematodes

Nematodes are worm-like animals that cause various diseases in cereals. Most nematodes attack the plant roots or lower stems. An exception is the seed gall nematode, which causes cockles in wheat. Nematodes feeding on plants cause direct damage by reducing root area, damaging the transport mechanism, or, in the case of the seed gall nematode, by replacing the grain with galls full of nematodes. [4]

For more information, see GrowNotes Wheat South Section 8. Nematodes.

9.2 The disease triangle

Plant pathologists talk about the occurrence of disease in terms of the '*disease triangle'* (Figure 1)—an interaction of host, pathogen and environment. Alteration to any of these components of the disease triangle will influence the level of disease.

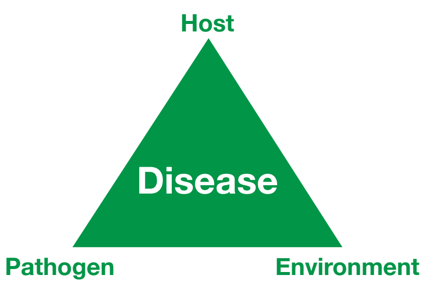

Figure 1: The disease triangle.

For disease to occur, there must be a susceptible host and a virulent pathogen, and the environment must be favourable. Some important examples of interactions of environmental conditions with diseases of grain crops are as follows:

4 H Wallwork (2000) Cereal leaf and stem diseases. GRDC.

- Low temperatures reduce plant vigour. Seedlings, especially of summer crops, become more susceptible to *Pythium*, *Rhizoctonia* and other root and damping-off pathogens if they are emerging in soils below their optimum temperature.
- Pathogens have different optimum temperature ranges. For example, hatching in nematodes tends to occur over narrow soil temperature ranges, within a 10–25°C range and optimal at 20°C, whereas take-all fungus *Gaeumannomyces graminis* var. *tritici* is more competitive with the soil microflora in cooler soils. This can lead to diseases being more prevalent in certain seasons or in different areas, such as wheat stem rust in warmer areas and stripe rust in cooler areas.
- Fungi such as *Pythium* and *Phytophthora* that have swimming spores require high levels of soil moisture in order to infect plants; hence, they are most severe in wet soils.
- Foliar fungal pathogens such as rusts require free water on leaves for infection (see below). The rate at which most leaf diseases progress in the crop depends on the frequency and duration of rain or dew periods.
- Diseases that attack the roots or stem bases, such as crown rot, reduce the ability of plants to move water and nutrients into the developing grain. These diseases generally have more severe symptoms and larger effects on yield if plants are subject to water stress. [5]

Information on the main diseases affecting wheat, including their control, is presented in Table 1.

Table 1: Guide to wheat diseases

Disease	Organism	Symptoms	Occurrence	Inoculum source	Control
Foliar					
Leaf rust	*Puccinia triticinia*	Small orange-brown powdery pustules on leaf.	Develops in spring. Favoured by mild (15°C–22°C) moist weather.	Airborne spores from living wheat plants.	Resistant varieties, control volunteer summer-autumn wheat. Seed dressings and foliar fungicides.
Stem rust	*Puccinia graminis* f. sp. *tritici*	Red-brown, powdery, oblong pustules with tattered torn edges on leaf and stem.	Can develop from mid spring into summer. Favoured by warm (15–30°C) humid conditions.	Airborne spores from living plants (wheat, barley, durum volunteer summer-autumn and triticale).	Resistant varieties, control wheat and barley. Foliar fungicides.
Stripe rust	*Puccinia striiformis* f. sp. *tritici*	Yellow powdery pustules often in stripes on leaves.	Can develop throughout the growing season. Favoured by cool (8–15°C), moist weather.	Airborne spores from living wheat and barley grass plants.	Resistant varieties, fungicides (seed, fertiliser and foliar), control volunteer summer- autumn wheat.
Septoria nodorum blotch (Glume blotch)	*Stagonospora nodorum*	Leaf lesions with minute black spots, leaf death. Can infect the head.	More common in early sown crops and in wet springs	Initially airborne spores released from stubble, and then spread by rain splashed spores within crop.	Resistant varieties, foliar fungicides, seed treatments, stubble removal.
Septoria tritici blotch	*Zymoseptoria tritici*	Leaf lesions with minute black spots, leaf death.	More common in early sown crops and in wet springs.	Initially airborne spores released from stubble, and then spread by rain splashed spores within crop.	Resistant varieties, foliar fungicides, seed treatments, stubble removal.
Yellow spot	*Pyrenophora tritici-repentis*	Leaf lesions often with yellow border, leaf death.	More severe in close rotations, when wheat is sown into wheat stubble.	Ascospores from stubble infect plants. Then secondary spread is by airborne spores in spring.	Stubble removal, crop rotation, foliar fungicides, resistant varieties.
BYDV	Barley yellow dwarf virus	Yellowing, dwarfing of infected plants, interveinal chlorosis, reduced seed set.	Most common in perennial grass pastures and in early sown crops.	A virus transmitted by aphids from infected grasses and cereals.	Resistant varieties, seed treatments and/or insecticide treatments to control aphids
Grain					
Bunt	*Tilletia laevis T. tritici*	Seed contains a black, foul smelling mass of spores. Affected grain is not accepted at silos.	Potentially region wide.	Spores on seed coat infect seedling before it emerges.	Seed applied fungicide.
Flag smut	*Urocystis agropyri*	Stunted plants with black, powdery streaks in leaves.	Most likely in crops sown early in warm soils.	Soil and seedborne spores.	Resistant varieties, seed-applied fungicide.
Loose smut	Ustilago tritici	Black powdery heads on diseased plants.	Region wide.	Infected seed is the predominant source.	Seed-applied fungicide.

5 UNE Agronomy of Grains Production course notes.

Disease	Organism	Symptoms	Occurrence	Inoculum source	Control
Root/crown					
Common root rot	*Bipolaris sorokiniana*	Browning of the roots, sub-crown internode and the stem base. Brown spots on leaves. White heads and pinched grain.	Scattered through crop.	Soil borne on grass and cereal residues. Also as spores in the soil.	Crop rotation, one year free from hosts.
Crown rot	*Fusarium pseudogram inearum, F. culmorum*	Browning of stem bases, crown and sometimes roots. White heads and pinched grain.	More severe following a wet winter and dry spring, especially on heavy soils which are poorly drained	Soil borne on grass and cereal residues.	Crop rotation. Avoid highly susceptible varieties, especially durum wheat.
Cereal cyst nematode (CCN)	*Heterodera avenae*	Yellow, stunted plants with knotted roots, often in patches.	Light soils and well structured clays where cereals are common.	Present in most soils in the southern region of Australia.	Resistant varieties, two year break from susceptible cereals and grasses, in particular wild oats.
Rhizoctonia bare patch	*Rhizoctonia solani* (AG 8)	Patches of stunted plants with yellow-red erect leaves. Spear tipped roots.	Associated with reduced tillage and poor weed control in autumn. Discouraged by soils with high organic matter.	Fungus carries over in organic matter in the soil. Wide host range.	Pre-cropping weed control, chemical fallow, cultivation, modified sowing equipment. Group B herbicides may increase severity on some soil types. Read the label.
Root lesion nematode	*Pratylenchus thornei* and *Pratylenchus neglectus*	Reduced tillering, ill thrift; a lack of root branching and lesions on roots.	Favoured by wheat in rotation with chickpea, medic and vetch.	Survive as dormant nematodes in the soil.	Crop rotation using resistant crops and resistant varieties.
Take-all	*Gaeumannomyces graminis* var. *tritici*	Blackening of roots, stem bases and crown. Plant stunting with white heads and pinched grain.	Favoured by a wet spring with a dry finish.	Soil borne on grass hosts and cereal residues.	Crop rotation, at least one year free of hosts (cereals and grasses, especially barley grass). Fungicide applied to seed or fertiliser.

This table has been developed from information in the publications Wallwork H (2000) (Ed) Cereal Root and Crown Diseases (Grains Research and Development Corporation, SARDI) and Wallwork H (2000) (Ed) Cereal Leaf and Stem Diseases (Grains Research and Development Corporation, SARDI).

9.3 Variety response

Wheat varieties carry varying tolerance and resistance to diseases (Table 2).

Table 2: Wheat variety disease ratings

	Rust						Pratylenchus					
	Stem	Stripe	Leaf	Yellow Leaf spot	Septoria tritici	CCN Res	*P. neglectus* resistance	*P. thornei* resistance	Crown rot	Common Root rot	Black tip (black point)	Flag smut
Bread wheat												
Axe	MS	RMR	Sp	S	SVS	S	MSS	MSS	S	MSS	S	S
Bolac	MRMS	RMR	S	S	MSS	S	MSS	MRMS	S	MSS	MSS	RMR
Chara	MRMS	MSS	Sp	MSS	MSS	R	SVS	MRMS	S	S	MS	MS
Condo	RMR	MSS	MRMSp	MSS	SVS	MR	S	MRMS	S	MSS	MRp	S
Corack	MR	MS	SVSp	MR	SVS	RMR	MSS	MRMS	S	MS	MSS	S
Correll	MRMS	MRMS	Sp	SVS	MSS	MR	MSS	MSS	S	MS	MS	R
Cosmick	MS	MSS	Sp	MRMS	S	MS	MS	MS	S	MSS	-	SVSp
Derrimut	MR	MSS	MSp	S	S	R	MSS	MSS	MSS	S	MSS	RMR
EGA Gregory	MR	MR	MR	S	MSS	S	MSS	MS	S	MSS	MSS	MSS
EGA Wedgetail	MRMS	MS	MS	MSS	MSS	S	S	S	S	-	MS	MRMS
Elmore CL Plus	MR	MRMS	RMR	S	MSS	S	SVS	MSS	S	MSS	MS	S
Emu Rock	MRMS	MRMS	S	MRMS	SVS	S	S	S	MS	MSS	MS	MS
Estoc	MR	MS	MRMS	MSS	S	MR	VS	MSS	MSS	MRMS	MS	MRMS
Forrest	RMR	RMR	MSSp	MRMS	MS	S	S	SVS	SVS	MS	MR	MR
Gladius	MR	MRMS	MS	MS	S	MS	MSS	S	S	MS	MS	RMR
Grenade CL Plus	MR	MRMS	Sp	S	S	MR	MSS	S	S	MRMS	MS	RMR
Justica CL Plus	MR	MRMS	Sp	S	S	MS	S	MSS	S	MS	S	R
Kellalac	MSS	MRMS	S	S	MS	MR	S	S	-	-	-	R
Kiora	RMR	RMR	MRMSp	MSS	S	MS	MSS	MRMS	S	MS	MSp	MRMS

	Rust						Pratylenchus					
	Stem	Stripe	Leaf	Yellow Leaf spot	Septoria tritici	CCN Res	*P. neglectus* resistance	*P. thornei* resistance	Crown rot	Common Root rot	Black tip (black point)	Flag smut
Kord CL Plus	MR	MRMS	MS	MSS	S	MR	S	MS	S	MRMS	MRMS	MR
Livingston	MRMS	MRMS	MSp	MS	S	MS	S	MS	S	S	MRMS	R
LRPB Cobra	RMR	MSS	MR	MRMS	MSS	MRMS	MSS	MSS	S	MSS	MSS	S
LRPB Dart	MR	MR	SVSp	MS	SVS	S	MSS	MS	MSS	MS	MRMSp	MSS
LRPB Gauntlet	RMR	MRMS	MS	MS	MS	MRMS	MSS	MR	MSS	MSS	MS	MS
LRPB Lancer	R	MR	RMR	MS	MSS	S	MSS	MS	MSS	S	MRMSp	MSp
LRPB Lincoln	MR	RMR	MSSp	MSS	S	S	MSS	SVS	SVS	MS	MR	RMR
LRPB Merlin	MR	MR	MS	S	S	MS	MSS	MSS	MSS	MSS	S	MRMS
LRPB Phantom	MS	MR	MSSp	SVS	SVS	MRMS	S	S	MSS	MSS	MRMS	MRMS
LRPB Scout	MR	MS	MRMS	SVS	SVS	R	S	MSS	S	S	S	MR
LRPB Spitfire	MR	MR	Sp	MSS	S	S	S	MS	MS	MS	S	MSS
LRPB Trojan	MRMS	MR	MRMSp	MSS	MSS	MS	MSS	MS	MS	MS	MRMS	SVS
LRPB Viking	MR	RMR	SVSp	MSS	S	Rp	S	MRMS			MRp	-
Mace	MR	SVS	MSSp	MRMS	S	MRMS	MS	MRMS	S	MS	MS	S
Magenta	RMR	MS	MS	MR	S	S	MSS	SVS	MSS	S	S	S
Merinda	RMR	MRMS	R	MSS	MSS	S	S	MSS	-	-	-	MSS
Sentinel 3R	RMR	RMR	R	MS	MRMS	S	S	MSS	MSS	S	MSS	MSS
Shield	RMR	MR	R	MSS	MSS	MR	MSS	MSS	S	MRMS	MS	S
Suntop	MR	MRMS	MRMSp	MSS	MSS	S	MSS	MR	MSS	MS	MRMS	R
Wallup	MRMS	MRMS	SVSp	MSS	S	MR	MS	MRMS	S	MS	MRMS	SVS
Yitpi	S	MRMS	Sp	SVS	MSS	MR	MSS	MSS	S	MS	MS	MR
Young	RMR	MS	MRMS	MS	MS	R	SVS	MSS	S	MSS	MR	MS
Biscuit wheat												
Barham	MRMS	S	MRMS	MSS	MSS	MS	MR	MSS	S	MSS	MRMS	MRMS
LRPB Gazelle	MR	MR	MR	MSS	MSS	S	S	S	-	MSS	MSS	S
LRPB Impala	MR	MR	SVSp	MSS	SVS	S	S	S	S	S	MRMS	SVS
Yenda	R	S	-	MRMS	-	S	MR	S	S	MSS	S	MR
Durum wheat												
Caparoi	MR	MR	MRMS	MRMS	R	-	MSS	MR	VS	MS	MSS	R
DBA Aurora	RMR	RMR	RMR	MRMS	MSp	Sp	MRMS	RMR	VS	MRMS	MS	R
EGA Bellaroi	MR	MR	MRMS	MRMS	MRMSp	-	MS	MR	VS	-	-	-
Hyperno	R	MR	RMR	MS	MRMS	MS	MS	RMR	SVS	MS	MS	R
Jandaroi	RMR	MR	MR	MS	MRMS	MS	MS	MRMS	VS	-	MSSp	R
Saintly	MR	MR	MRMS	MRMS	S	MS	MS	RMR	VS	MS	MS	R
Tjilkuri	MR	MR	RMR	MS	MS	MS	MRMS	MR	VS	MS	MSS	R
WID802	RMR	MR	RMR	MS	MS	MS	MSS	MS	VS	MS	MSS	R
Yawa	RMR	MR	MR	MRMS	MR	MS	MS	RMR	VS	MRMS	MRMS	R
Feed wheat												
Beaufort	SVS	RMR	MSp	MRMS	S	S	MS	MS	S	MSS	MRMS	RMR
Manning	MR	RMR	RMR	MRMS	MR	S	MSS	S	VS	SVS	-	Rp
Naparoo	RMR	MR	S	MS	MS	-	SVS	SVS	S	S	-	VS
Preston	SVS	RMR	SVSp	MSS	S	S	MSS	MSS	S	MS	MRMS	S
SF Adagio	SVS	RMR	MSp	MRMS	MR	-	MS	MS	SVS	MSp	-	MS
SF Ovalo	S	R	MSp	MR	MRMS	-	MS	MS	SVS	MS	-	-
SF Scenario	MSS	MR	Sp	MS	MR	-	MSS	MS	SVS	MSp	-	-
SQP Revenue	RMR	R	Sp	MS	MS	S	MSS	MSS	S	SVS	MSS	S

Varieties marked may be more susceptible if alternative strains are present. p = ratings are provisional - treat with caution.

R = Resistant RMR = Resistant to moderately resistant MR = Moderately resistant MRMS = Moderately resistant to moderately susceptible MS = Moderately susceptible MSS = Moderately susceptible to susceptible S = Susceptible SVS = Susceptible to very susceptible VS = Very susceptible.

9.4 Environmental factors

9.4.1 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. Conversely, bacterial numbers decline in dry soil. Some bacteria are important antagonists of soilborne fungal diseases such as common root rot, and these diseases can be more severe after drought.

For information on effects on crown rot, Rhizoctonia root rot, inoculum, tan (yellow) spot, rusts, *Wheat streak mosaic virus* (WSMV), other cereal diseases, and burning stubble to control disease, see the NSW Department of Primary Industries (DPI) information sheet: Cereal diseases after drought. [6]

9.4.2 Cereal disease after flood events

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 floods and rain includes transport of inoculum (crown rot, nematodes, leaf spots through movement of infected stubble and soil) (Figure 2), 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.

Cereal diseases that need living plants over-season on volunteer (self-sown) crops. This is particularly so for rusts and mildews. Diseases such as yellow spot, net blotches and head blights survive on stubble. Crown rot and nematodes over-season in soil.

Problems are recognised by inspecting plants. Leaf and stem rusts produce visible pustules on leaves, whereas stripe rust survives as dormant mycelium, with spores not being produced until temperatures favour disease development.

The presence of leaf spots is recognised by the occurrence of fruiting bodies (pseudothecia) on straw and lesions on volunteers. Head blights produce fruiting bodies (perithecia) on straw, and crown rot survives mainly as mycelia in straw. Soilborne nematodes are detected through soil tests. [7]

Figure 2: Yellow spot (tan spot) infected stubble following flood. (Photos: Rachel Bowman)

[6] G Murray, T Hind-Lanoiselet, K Moore, S Simpfendorfer, J Edwards (2006) Cereal diseases after drought. Primefacts. NSW Department of Primary Industries, http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0004/123718/crop-diseases-after-drought.pdf

[7] DAF Qld (2013) Winter cereals pathology. Department of Agriculture and Fisheries Queensland, https://www.daf.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/prepare-for-winter-crops-following-floods/winter-cereals-pathology

9.5 Management options

Management options for disease control include elimination of volunteers, if possible having a 4-week period that is totally host-free, crop rotation with non-hosts, growing resistant varieties, reduction of stubble, and use of fungicides.

Fungicides are far more effective as protectants than eradicants, so are best applied prior to, or very soon after, infection. Systemic fungicides work within the sprayed leaf, providing 3–5 weeks of protection. Leaves produced after this spraying are not protected. Spray to protect the upper three or four leaves, which are the most important because they contribute to grainfill. In general, rusts are easier to control than leaf spots. Fungicides do not improve yield potential; they can only protect the existing yield potential.

The application of fungicides is an economic decision, and in many cases, a higher application rate can give a better economic return through greater yield and higher grain quality. Timing and rate of application are more important than product selection. Stripe-rust ratings in variety guides are for adult plant response to the pathogen and may not accurately reflect seedling response. [8]

9.5.1 Strategies

The incidence and severity of disease will depend on the environment, but with plentiful inoculum present, even in a season with average weather, disease risks will be significant.

Strategies include:

- using the best available seed
- identifying your risks
- formulating management strategies based on perceived risk
- monitoring crops regularly
- timely intervention with fungicides [9]

9.6 Foliar diseases

Wheat can incur several foliar diseases, including:

- stem rust
- leaf rust
- stripe rust
- *Septoria tritici* blotch
- yellow (tan) spot
- BYDV
- eyespot
- powdery mildew

8 DAF Qld (2013) Winter cereals pathology. Department of Agriculture and Fisheries Queensland, http://www.daff.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/prepare-for-winter-crops-following-floods/winter-cereals-pathology

9 DAF Qld (2013) Winter cereals pathology. Department of Agriculture and Fisheries Queensland, http://www.daff.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/prepare-for-winter-crops-following-floods/winter-cereals-pathology

9.6.1 Diagnosing leaf diseases in wheat

Refer to Table 3 for the symptoms of leaf diseases in wheat.

Table 3: Diagnosing leaf diseases in wheat [10]

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

FAQ

9.6.2 Rusts—general information

In the Southern Region, there are three rust diseases of wheat: stem rust, leaf rust and stripe 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 that erupts through the plant's epidermis has the appearance of rusty metal. These spores can be spread over considerable distances by wind but may also be spread on clothing and equipment.

Wheat rusts have a number of features in common. They can infect only a limited number of specific host plants (mostly volunteer wheat, triticale and barley) and can survive only on green, growing plant tissue. Plants facilitating the survival of rust fungi through the summer are known as the 'green bridge'. These are alternative hosts as shown in Table 4, or volunteer cereals.

Table 4: Alternative hosts for cereal rusts [11]

Disease	Pathogen	Primary hosts	Alternative hosts	Symptoms
Leaf rust	*Puccinia triticina*	Bread and durum wheats, triticale	*Thalictrum, Anchusa, Isopyrum, Clematis*	Isolated uredinia on upper leaf surface and rarely on leaf sheaths
Leaf rust duri type	*Puccinia tritici-duri*	Durum and bread wheats in traditional agriculture	*Anchusa italica*	Isolated uredinia on lower leaf surface; fast teliospore development
Stem rust	*Puccinia graminis* f. sp. *tritici*	Bread and durum wheats, barley, triticale	*Berberis vulgaris*	Isolated uredinia on upper and lower leaf surfaces, stem and spikes
Stripe rust	*Puccinia striiformis* f. sp. *tritici*	Bread and durum wheats, triticale, a few barley cultivars	Unknown	Systemic uredinia on leaves and spikes and rarely on leaf sheaths

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

Wherever possible, wheat varieties that are resistant should be sown (i.e. MR, moderately resistant = 6, and above).

[10] DAF Qld (2012) Integrated disease management of wheat rusts and yellow spot. Key points to reduce the risk of rusts in wheat. Department of Agriculture, Fisheries and Forestry Queensland, http://www.daff.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/wheat/wheat-rusts

[11] RP Singh, J Huerta-Espino, AP Roelfs. The wheat rusts. FAO, http://www.fao.org/docrep/006/y4011e/y4011e0g.htm

Rust fungi continually 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 regularly monitored for foliar diseases. See the University of Sydney's Plant Breeding Institute (PBI) site and publications for more information.

Monitoring should start no later than Zadoks growth stage (GS) 32, the second node stage on the main stem, and continue to at least GS39, the flag leaf stage. This is because the flag leaf and the two leaves below it are the main factories contributing to yield and quality. It is most important to protect these leaves from diseases. [12]

To keep up to date with rust incursions throughout the winter crop season, subscribe to the PBI Cereal Rust Report.

The PBI also offers a rust testing service for growers and agronomists. For more details, see the Dispatch forms at: http://sydney.edu.au/agriculture/plant_breeding_institute/cereal_rust/reports_forms.shtml#df.

Key points to reduce the risk of rusts in wheat

- Destroy volunteer wheat plants by March, because they can provide a green bridge for rust carryover.
- Community effort is required to eradicate volunteers from roadsides, railway lines, bridges, paddocks and around silos.
- Growing resistant varieties is an economical and environmentally friendly means of disease reduction.
- Seed or fertiliser treatment can control stripe rust up to 4 weeks after sowing and suppress it thereafter.
- During the growing season, active crop monitoring is important for early detection of diseases.
- Correct disease identification is crucial; you can consult state agricultural department fact sheets, charts, websites and experts.
- When deciding whether 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 important.
- Read the label and wear protective gear; protect yourself and the environment.
- Avoid repeated use of fungicides with the same active ingredient in the same season.
- Check for withholding periods before grazing and harvesting a crop that has received any fungicide application.
- If you suspect a severe disease outbreak, especially on resistant varieties, contact your state agricultural department.

Adult plant resistance (APR) is a useful trait to consider in variety selection, especially for rust resistance. Understanding how it works can make fungicide application decisions easier. APR to cereal fungal diseases provides protection in a crop's post-seedling stages (typically between tillering and booting, GS20–GS49).

Seedling resistance, by comparison, is effective at all growth stages. APR can complement a fungicide strategy by protecting from rust those parts of the plant most responsible for yield. When selecting a variety, choose one rated at least MR–MS (moderately resistant–moderately susceptible, the minimum disease resistance standard). In high-risk regions, varieties rated at least MR are recommended.

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

More information

[GRDC Fact Sheets: Adult plant resistance](http://www.grdc.com.au/GRDC-FS-AdultPlantResistance)

Where the more susceptible varieties are used, ensure that a suitable fungicide strategy is in place, with the right chemicals available at short notice. Fungicides are better at protecting than curing. Fungicide applications on badly infected crops provide poorer control and do not restore lost green leaf area. [13]

Recommended fungicides for rusts

To keep up to date with the latest recommended fungicides for rusts, visit: Australian Pesticides and Veterinary Medicines Authority.

The three top leaves in wheat make the greatest contribution to yield, so the aim of any stripe-rust management strategy in susceptible varieties is to keep these leaves largely clean of infection. However, when applying a fungicide at GS25, these important leaves have not emerged, so they are unprotected by fungicide once they do come out.

Recent research shows that delaying the first fungicide application to GS32, when the flag-2 leaf has emerged, protects this leaf from infection and reduces the time, and subsequent disease build-up, until the second spray is applied at full flag-leaf emergence (GS39). Delaying the first spray from GS25 until GS32 returned an additional AU$55/ha under high disease pressure and $42/ha under moderate disease pressure in the MS (moderately susceptible) variety Ellison⟮D⟯.

A common strategy used in medium—high-rainfall areas is to use flutriafol on the fertiliser, followed by a foliar fungicide at GS39 for varieties with some susceptibility (very susceptible varieties may also require a fungicide at GS32).

9.6.3 Stem rust

Figure 3: Stem rust in wheat. (Photo: DAF Qld)

Stem rust is caused by the fungus *Puccinia graminis* f. sp. *Tritici* (Figure 3). It can attack wheat, barley, rye and triticale.

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

[13] GRDC (2012) Adult plant resistance. Northern, Western and Southern Regions. GRDC Fact Sheet, 2 Nov. 2012, http://www.grdc.com.au/GRDC-FS-AdultPlantResistance

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 6 hours to infect the plant, and pustules can be seen after 10–20 days of infection.

In Victoria, conditions that favour stem rust epidemics are rare and occur, on average, once every 16 years. However, when conditions are conducive, the disease can cause complete crop loss in susceptible varieties. With increased cultivation of stem-rust resistant varieties and greater availability of effective foliar fungicides, severe losses to stem rust are now less likely. In recent years, there have been few localised occurrences of stem rust in Victoria. Following the exceptionally wet January of 2011, a large amount of inoculum was carried over, resulting in extensive stem rust during 2011. Despite this, the widespread use of chemicals helped to minimise losses from the disease. [14]

More information

[NSW DPI: Strip rust: understanding the disease in wheat]

[ACRCP: The Rust Bust]

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.

9.6.4 Leaf rust

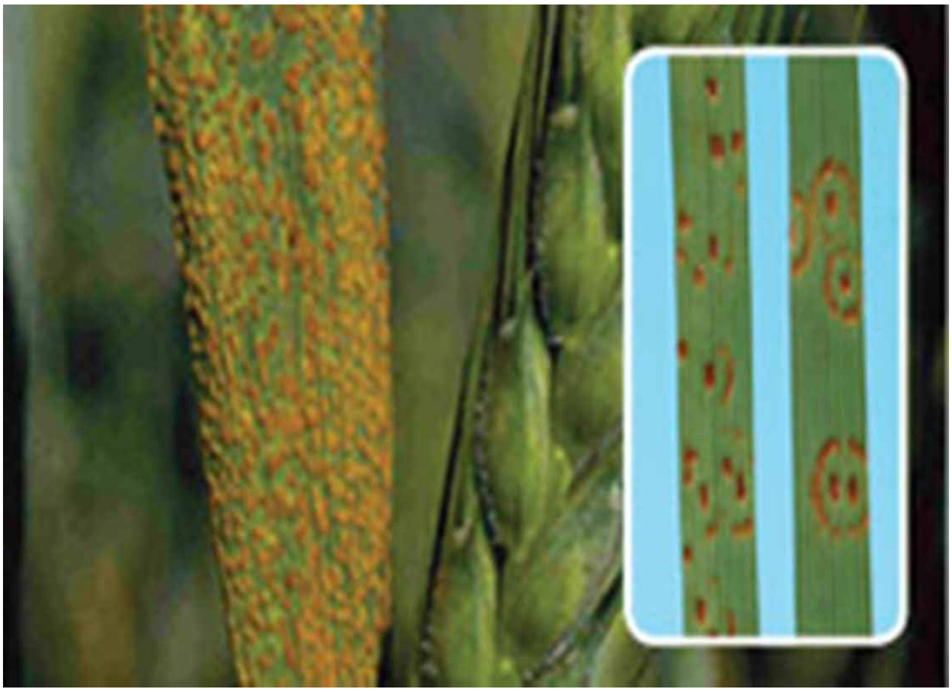

Figure 4: Leaf rust in wheat. (Photo: DAF Qld)

Leaf rust (Figure 4) is caused by the fungus *Puccinia triticina* (previously called *Puccinia recondite* f. sp. *tritici*). The disease can also infect rye and triticale.

Leaf rust produces reddish orange spores that occur in small, 1.5-mm, circular to oval 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.

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

A new strain of wheat leaf rust was detected at multiple locations in Victoria during 2014. Many cultivars are now one rating more susceptible than previously. Several cultivars (including Axe⒫, Beaufort⒫, Corack⒫, Derrimut⒫, Mace⒫, SQP Revenue⒫, and

14 G Hollaway (2014) Stem rust of wheat. AG1251. Revised May 2014. DEDJTR Victoria, http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/plant-diseases/grains-pulses-and-cereals/stem-rust-of-wheat

Wallup(b) are now two or more rating levels more susceptible. The new ratings were marked as provisional in 2015, with only have one season of data. It is likely that this new leaf rust will be dominant in Victoria during the coming years so growers need to be more vigilant with leaf rust control. [15]

9.6.5 Stripe rust

Figure 5: Stripe rust in wheat. (Photo: DAF Qld)

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 (Figure 5). The spores occur on the upper surface of the leaves, the leaf sheaths, awns and inside of the glumes.

More information

GRDC Update Papers: Stripe rust—prevention is generally best

GRDC Update Papers: Fungicide management of stript rust in wheat: up-front vs in-crop options

Stripe rust requires cool and wet conditions to infect the crop. Free moisture on the leaves and an optimal temperature of 10–15°C are required for infection. Pustules erupt 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 MR–MS (= 5) or lower provided there is inoculum from a neglected green bridge or from an infected crop.

Several fungicides are recommended for the control of stripe rust. Fungicides can be incorporated with the fertiliser or applied as seed dressings to delay the onset of disease. Later, if 'money' leaves (the flag leaf and the two leaves below it) require protection, recommended foliar fungicides can be applied. [16]

9.6.6 *Septoria tritici* blotch

Septoria tritici blotch (STB) is caused by a fungus, *Zymoseptoria tritici* (synonyms *Mycosphaerella graminicola*, *Septoria tritici*), which survives in wheat stubble. Initial infection arises from ascospores produced within fruiting bodies (pseudothecia) on the

[15] G Hollaway, M McLean, J Fanning (2015) Cereal disease guide. AG1160. Revised February 2015. DEDJTR Victoria, http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/plant-diseases/grains-pulses-and-cereals/cereal-disease-guide

[16] DAF Qld (2012) Integrated disease management of wheat rusts and yellow spot. Key points to reduce the risk of rusts in wheat. Department of Agriculture and Fisheries Queensland, http://www.daff.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/wheat/wheat-rusts

More information

[GRDC Fact Sheets: Managing Septoria tritici blotch in wheat]

stubble. These windborne spores can travel over long distances. Secondary, short-distance dispersal is caused by different spores, called conidia, which are produced on the infected leaves. These are predominantly dispersed by splash from raindrops. [17]

Host range

The fungus can infect all bread wheat, durum and triticale varieties to some degree. Although most Australian durum wheats and triticales have good resistance, growers need to consult a current cereal variety disease guide (e.g. PIRSA Cereal disease guide, Agriculture Victoria Cereal disease guide) for individual variety resistance ratings. The fungal population differs in virulence across Australia so ratings in different regions may vary.

Wheat STB can occasionally infect oats and barley plants but those crops rarely develop significant levels of disease. However, both oats and barley can be infected by specialised forms of Septoria that have leaf symptoms similar to wheat STB (e.g. *Septoria tritici* f. sp. *avenae* on oats).

Risk factors

Farm practices such as early sowing, minimum tillage, stubble retention, wheat–wheat crop sequences and growing susceptible wheat varieties are the main risk factors that increase the chance of infection. Weather conditions are also an important risk factor. Infection by the fungus is much greater with frequent rain events and where moist conditions extend over long periods. [18]

Symptoms

Septoria tritici blotch in wheat causes brown lesions (Figure 6). In the more susceptible varieties, the lesions can appear silver-grey. The lesions tend to run parallel to the leaf veins. Black fruiting bodies (pycnidia) are usually visible on the dead leaf tissue. In the southern grain-growing region, favourable conditions for infection rarely persist into spring, so infection of the upper canopy is less common. In high-rainfall zones when conditions are favourable, lesions can spread across the leaf, forming large blotches. In wet springs, if infection appears after flowering, the glumes may become diseased.

As the plant matures, the fungus grows and feeds on decaying organic matter, which leads to infection of the stubble and survival of the fungus into the following season. The survival of STB on the stubble means that a break crop is necessary to reduce disease carryover. [19]

17 GRDC (2014) Managing *Septoria tritici* blotch disease in wheat. Southern Region. *Septoria tritici* Blotch Fact Sheet, http://www.grdc.com.au/GRDC-FS-Septoria-Tritici-Blotch-Wheat

18 GRDC (2014) Managing *Septoria tritici* blotch disease in wheat. Southern Region. *Septoria tritici* Blotch Fact Sheet, http://www.grdc.com.au/GRDC-FS-Septoria-Tritici-Blotch-Wheat

19 GRDC (2014) Managing *Septoria tritici* blotch disease in wheat. Southern Region. *Septoria tritici* Blotch Fact Sheet, http://www.grdc.com.au/GRDC-FS-Septoria-Tritici-Blotch-Wheat

Figure 6: A wheat plant with typical symptoms of Septoria tritici blotch. (Photo: Andrew Milgate)

Disease cycle

The fungus *Zymoseptoria tritici* can survive in crop stubble and plant debris for more than one season. The length of survival depends on the rate of stubble breakdown. In autumn–winter, the fungus develops sexual fruiting bodies that appear as black, pinhead-sized structures that sit at, or just below, the surface of the stubble and leaf blades.

Primary infection is mostly initiated by sexual spores (ascospores) produced in the fruiting bodies. Ascospores become airborne and can infect young plants in early-sown crops. The airborne nature of the spores means they can infect surrounding crops and regions. Secondary spread within the crop occurs from rain-splash by asexual fungal spores (conidia) produced on infected leaves. Temperatures of 15–20°C with rain followed by at least 6 hours of leaf wetness or dew are optimal for infection. [20]

Strain types

Different strains (pathotypes) of *Z. tritici* have been found throughout the cropping zone, resulting in different variety ratings. Resistant varieties may become more susceptible over time as the pathogen adapts to the resistance genes carried by the plants. Growers should check the resistance rating of varieties in their region by using a current disease guide, but also be aware that if a variety is susceptible in neighbouring regions, there is a risk of that strain migrating into a new area. [21]

20 GRDC (2014) Managing *Septoria tritici* blotch disease in wheat. Southern Region. *Septoria tritici* Blotch Fact Sheet, http://www.grdc.com.au/GRDC-FS-Septoria-Tritici-Blotch-Wheat

21 GRDC (2014) Managing *Septoria tritici* blotch disease in wheat. Southern Region. *Septoria tritici* Blotch Fact Sheet, http://www.grdc.com.au/GRDC-FS-Septoria-Tritici-Blotch-Wheat

Management

An integrated approach that incorporates crop rotation, variety selection, stubble management and fungicides (if required) can provide effective suppression of STB.

Crop rotation

Septoria tritici blotch survives on cereal stubble between crops, specifically where wheat on wheat is sown. After a very dry season, the fungus may survive over 18 months and infect second-year crops. In most instances, a 1-year rotation out of wheat is highly effective in reducing early disease occurrence.

Variety selection

Variety choice has a major influence on STB development in crops. Resistance ranges from MR to very susceptible (VS); however, growers should check their local current variety disease guide and ensure that they make appropriate selections. Where wheat is to be sown into wheat stubble, it is best to avoid varieties that are rated susceptible (S), S–VS or VS.

Stubble management

Any tillage practice that reduces stubble density on the surface will reduce the level of inoculum. Surface stubbles may be reduced by burial, burning or grazing. Stubble reduction must be balanced against the increased risk of soil erosion by wind or water, especially in light soils. Stubble management will not reduce disease caused by spores blown in from other fields early in the season.

Fungicide management

Most STB in south-eastern Australia occurs only at early seedling growth stages. If wet conditions persist, such as in high-rainfall zones, and susceptible varieties have been sown, then fungicides may provide some useful control. In high-risk areas, the timing of fungicides will be important to achieve adequate disease control. In early-sown susceptible varieties, an early fungicide application at GS31–32 may be required to suppress the disease and protect emerging leaves. Once the flag leaf has fully emerged at GS39, another fungicide application may be required to protect the upper canopy. Azole fungicides are used in combination with variety resistance to control STB in south-eastern Australia. Growers need to use fungicides in a way that prolongs their effectiveness.

Changes in STB resistance to fungicides have been detected in the southern grain-growing region, especially where wheat is sown into wheat stubble. Variety selection and crop rotations are essential for effective disease control. [22]

9.6.7 Tan (yellow) spot

Tan spot or yellow spot causes tan–brown flecks turning into yellow brown, oval spots or lesions surrounded by yellow margins (Figure 7); lesions may expand to 10–12 mm in diameter. Large lesions coalesce with dark brown centres. Spot develops on both sides of leaves. Temperatures of 20–30°C and free moisture favour disease development. In susceptible cultivars, yellow spot can cause up to 30% yield losses. A break from wheat-on-wheat (crop rotation with non-host crops) can reduce the risk of yellow spot. Sow resistant varieties; see the wheat variety guides. [23]

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

[22] GRDC (2014) Managing *Septoria tritici* blotch disease in wheat. Southern Region. *Septoria tritici* Blotch Fact Sheet, http://www.grdc.com.au/GRDC-FS-Septoria-Tritici-Blotch-Wheat

[23] DAF Qld (2012) Integrated disease management of wheat rusts and yellow spot. Key points to reduce the risk of rusts in wheat. Department of Agriculture and Fisheries Queensland, http://www.daff.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/wheat/wheat-rusts

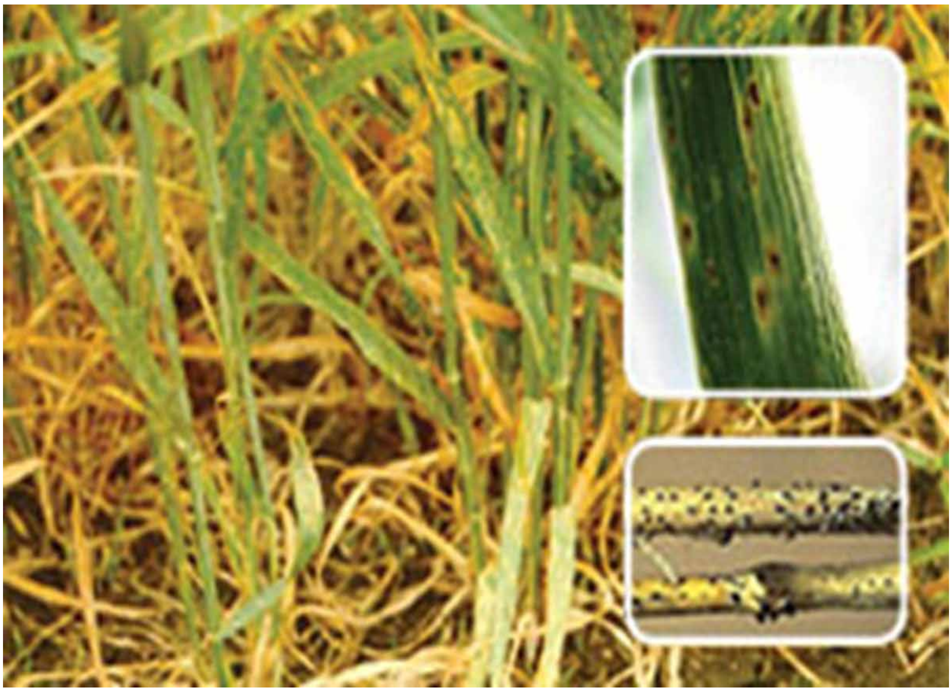

Figure 7: Tan spot in wheat. (Photo: DAF Qld)

Disease development and yield loss

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

Severe yellow spot may result in short, spindly plants with reduced tillering and root development. Where conditions are favourable, plants may be fully defoliated soon after flowering.

Grain yield can be substantially reduced and losses of >50% may occur in extreme situations. Pink grain with reduced value is also a frequent result of severe epidemics of yellow spot. 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.

Management

Yellow spot is likely to develop in wet years in fields where wheat residues remain on the soil surface. The impact of the disease can be reduced by:

- planting partially resistant varieties
- rotation with resistant crops such as barley, oats or chickpeas
- incorporation of stubble into the soil
- grazing or burning the stubble late in the fallow period

Varieties partially resistant to yellow spot offer the only long-term solution and they should be considered for planting where yellow spot could be a problem.

Fungicide management

Fungicides and fungicide combinations used against yellow spot in Australia include:

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

Timing for applying the chosen fungicide is crucial, and growers can use short-term weather forecasts to assist in the timing of fungicide applications. The most effective time of application is at 90% flag leaf emergence with disease levels of <10% on the flag leaf.

The time between infection and appearance of symptoms is termed the latent period, and this is a short time in tan spot.

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

Information on fungicide efficacy has been gathered from irrigated field trials and it does not confirm the economic viability of such applications during the extreme pressure of large-scale epidemics. [24]

Make management decisions at or before sowing

- Avoid sowing wheat-on-wheat.
- However, if you do plan to sow wheat-on-wheat, consider a late (autumn) stubble burn. Burning, depending on completeness, eliminates the wheat stubble harbouring the yellow spot fungus. A late pre-sow burn, even though cooler, is still preferable to an earlier, hotter burn due to considerations of soil moisture storage and erosion risk. Cultivation is less advisable, because stubble can remain on the soil surface, carrying yellow spot inoculum. Cultivation dries out the soil where you are planning to establish your next crop; it reduces water infiltration into the soil (in fallow and throughout season); and it evenly spreads another stubble-borne wheat pathogen, crown rot, across the paddock, distributing it through the soil cultivation layer where it can access the main infection sites in the following cereal crops.
- Select a wheat variety with some level of resistance to yellow spot (note tolerance–resistance to other diseases though, especially *Pratylenchus thornei*).

Primary management decisions for yellow spot need to be made prior to and/or at sowing. Fungicides are a poor last resort for managing yellow spot, because they have reduced efficacy against this leaf disease. [25]

9.6.8 Barley yellow dwarf virus

Growers in high rainfall zones should be proactive and develop a BYDV management plan that includes crop monitoring, green-bridge management, foliar pesticide sprays and pre-sowing seed treatment. These actions will control the aphid populations that spread BYDV. [26]

BYDV transmission

The virus is transmitted from plant to plant by aphids. When aphids feed on plants, their mouthpart, called the stylet, penetrates the leaf epidermis and enters the plant's vascular system (the phloem). Within 15 minutes of feeding, the aphid either contracts the virus (if the plant is already infected) or transmits the disease to the uninfected plant. The infection is restricted to the phloem, where it replicates and blocks phloem tissues, reducing transport of sugars through the leaves. BYDV is a persistent virus, which means an infected aphid will transmit the virus for the rest of its life.

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

[25] S Simpfendorfer (2013) Management of yellow spot in wheat: decide before you sow. GRDC Update Papers, 5 March 2013, http://www.grdc.com.au/Research-and-Development/GRDC-Update-Papers/2013/03/Management-of-yellow-spot-in-wheat-decide-before-you-sow

[26] GRDC (2013) Management tips to avoid yield penalties. Southern Region. Barley Yellow Dwarf Virus Fact Sheet, GRDC, http://www.grdc.com.au/GRDC-FS-BYDV

The virus survives from one season to the next in infected summer crops, weeds and host volunteer plants. It can only survive in living tissues and does not survive in stubbles or soils. It is not airborne.

Five different species of aphids transfer different types of BYDV. However, in the southern grain-growing region, the most common species include the oat aphid (*Rhopalosiphum padi*), the corn aphid (*R. maidis*) and rose grain aphid (*Metopolophium dirhodum*). Trials have found that the oat and rose grain aphids occur on wheat and barley and the corn aphid favours barley and is rarely found on wheat. [27]

Symptoms

Symptoms of BYDV infection may take at least 3 weeks to appear. When assessing a paddock for an outbreak, growers should look for:

- Sporadic patches of plants that have turned yellow, red or purple, most defined at the tip of the leaf, extending to the base. Plants may also appear stunted.
- Damage to crops along the fenceline. If aphids are moving into the crop from a 'bridge' of adjoining pastures, crops, weeds or grasses, then they are likely to attack plants near fencelines first.
- Aphids located on the crown and lower stem, then leaves.

BYDV symptoms vary with the crop and include:

- Wheat: leaves may show a range of symptoms including a slight mottling to bright yellow colour. Leaves first turn yellow at the tip, with the colour extending down the base in a dappled pattern (Figure 8). There may be streaks of red to purple at the tip. An infection before tillering can lead to stunted growth, sterility and reduced grainfill.

If left untreated, damage will radiate outwards as wingless juvenile aphids crawl to the next plant to feed, spreading the virus. [28]

Figure 8: A wheat leaf damaged by BYDV. The leaf shows yellowing at the tip with the colour extending down the base plus streaks of purple. (Photo. Hugh Wallwork, SARDI)

[27] GRDC (2013) Management tips to avoid yield penalties. Southern Region. Barley Yellow Dwarf Virus Fact Sheet, GRDC, http://www.grdc.com.au/GRDC-FS-BYDV

[28] GRDC (2013) Management tips to avoid yield penalties. Southern Region. Barley Yellow Dwarf Virus Fact Sheet, GRDC, http://www.grdc.com.au/GRDC-FS-BYDV

Yield loss

All early BYDV infections of cereal plants will mean they have less aboveground biomass and a less extensive root system. Grain size can be smaller or grain can become shrivelled, which causes lower yields, higher screenings and reduced marketing options.

Research by the Victorian Department of Primary Industries Field Crops Pathology Group at Horsham in 1984 found that yield losses of 9–79% occurred when plants were infected early in the growing season (before the end of tillering) and losses of 69% may occur when plants are infected after tillering.

A trial conducted by Trent Potter in the South East of South Australia also investigated yield losses in wheat caused by BYDV. Losses varied from 'nil' in 1990 and 2002 up to 40% in 2008. In other years, the yield losses were 10–20%. Even where large yield losses due to BYDV have occurred, trial results have shown no difference in protein content between sprayed and untreated plots. [29]

Additional yield loss by aphid feeding

Growers in high-rainfall areas are encouraged to check for aphids on a regular basis, especially early in the season (autumn) when winged aphids migrate into cereal crops. The autumn flight is most significant because plants are most vulnerable to damage in their early growth phase.

If aphids are observed and there is a concern about aphid feeding damage, then it is suggested that you walk throughout the crop and pull up 10–20 plants from a range of locations. Inspect the crown, lower stem and leaves for aphids. In barley, check inside the unfurled leaf at the top of the tiller.

If plants average ≥10 aphids per tiller, a foliar insecticide spray should be considered. It is likely to be too late for control of BYDV, but yield loss can be reduced. [30]

Predicting infection

The prevalence of BYDV depends on environmental conditions, host–pathogen dynamics and aphid populations. The virus is generally worse in seasons with a wet summer (which allows for significant volunteer or green-bridge growth) followed by a mild autumn and winter.

However, the aphids are able to survive hot summers in perennial grasses such as perennial ryegrass, kikuyu, paspalum, couch grass and African love grass in permanent or irrigated pasture areas and along waterways.

Winged aphids are able to migrate around the southern grain-growing region regardless of summer conditions. Growers should not be complacent in dry summers.

BYDV can be caused by relatively few infected aphids if they arrive early in the growing season and are very mobile through the crop. [31]

Management

For grain growers who decide to manage aphids, it is critical to have a control strategy and put it in place before sowing starts. Do not wait until aphids are found, because infection or damage will have already occurred.

[29] GRDC (2013) Management tips to avoid yield penalties. Southern Region. Barley Yellow Dwarf Virus Fact Sheet, GRDC, http://www.grdc.com.au/GRDC-FS-BYDV

[30] GRDC (2013) Management tips to avoid yield penalties. Southern Region. Barley Yellow Dwarf Virus Fact Sheet, GRDC, http://www.grdc.com.au/GRDC-FS-BYDV

[31] GRDC (2013) Management tips to avoid yield penalties. Southern Region. Barley Yellow Dwarf Virus Fact Sheet, GRDC, http://www.grdc.com.au/GRDC-FS-BYDV

Growers in high-risk areas should treat each year as a 'BYDV year' unless there has been low rainfall over summer and autumn. [32]

More information

[Australian Pesticides and Veterinary Medicines Authority]

Seed dressings

Seed dressings with imidacloprid have been shown to reduce aphid numbers in cereal crops at the early stage of growth when cereals are most susceptible to BYDV. Do not graze treated cereal crops within 9 weeks of sowing. In high-risk areas, a top-up spray (see below: *Insecticides*) is recommended at 6–8 weeks after sowing. [33]

Insecticides

Growers must work to prevent the spread of BYDV early after crop emergence, when plants are most vulnerable.

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

Trial results have led to the recommendation that sprays are applied at 3 and 7 weeks after crop emergence. This is because BYDV symptoms are usually not obvious until 3 weeks after the aphids have fed on plants. These applications will enable aphid populations to be managed before the problem has been noticed and the aphids have spread even further.

Considerable BYDV spread can occur even when aphid numbers are low. Symptoms can be hard to see in winter. Consultation with an agronomist or crop pathologist is recommended.

In years conducive to aphid build-up, a follow-up insecticide application in spring, in addition to the early foliar or seed treatment strategies, may be required to limit feeding damage. The effect of late BYDV infection by itself is generally not sufficient to warrant spraying in spring, so the decision should be purely based on aphid pressure. [34]

BYDV resistance

There is some level of resistance to BYDV in cereals. Some wheats are highly susceptible (e.g. Brennan⁽ᶦ⁾), whereas others have some resistance. CSIRO researchers have found a source of BYDV resistance and used it in Mackellar⁽ᶦ⁾ winter wheat. No yield losses were observed in BYDV infection trials with Mackellar⁽ᶦ⁾ wheat. [35]

Delayed sowing

Delayed sowing avoids the main autumn peak of aphid flights and can reduce the incidence of BYDV. However, other yield penalties associated with late sowing mean that this option is generally considered a poor choice over use of insecticides. Growers in the late-sown high-rainfall areas should note that late sowing may coincide with peak spring flights of aphids, resulting in more severe damage. [36]

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[32] GRDC (2013) Management tips to avoid yield penalties. Southern Region. Barley Yellow Dwarf Virus Fact Sheet, GRDC, http://www.grdc.com.au/GRDC-FS-BYDV

[33] GRDC (2013) Management tips to avoid yield penalties. Southern Region. Barley Yellow Dwarf Virus Fact Sheet, GRDC, http://www.grdc.com.au/GRDC-FS-BYDV

[34] GRDC (2013) Management tips to avoid yield penalties. Southern Region. Barley Yellow Dwarf Virus Fact Sheet, GRDC, http://www.grdc.com.au/GRDC-FS-BYDV

[35] GRDC (2013) Management tips to avoid yield penalties. Southern Region. Barley Yellow Dwarf Virus Fact Sheet, GRDC, http://www.grdc.com.au/GRDC-FS-BYDV

[36] GRDC (2013) Management tips to avoid yield penalties. Southern Region. Barley Yellow Dwarf Virus Fact Sheet, GRDC, http://www.grdc.com.au/GRDC-FS-BYDV

More information

Cereal Leaf and Stem Diseases (2000 Edition) (GRDC012) GRDC Bookshop Free Phone: 1800 110044 Email: ground-cover-direct@canprint.com.au; also available from the National Library of Australia

Agriculture Victoria Notes: Barley yellow dwarf virus

Agriculture Victoria: Victorian winter crop summary

GRDC Fact Sheets: Barley yellow dwarf virus

MFMG: Wheat agronomy trials

PIRSA: Cereal seed treatments

Green bridge

Management of the green bridge (volunteer cereals and grass weeds) with appropriate herbicides is important for managing BYDV, in addition to the associated benefits of moisture and nutrient conservation. On top of summer weed control, spraying out perennial grasses near and around cereal paddocks at least 3 weeks before sowing may reduce aphid numbers. [37]

9.6.9 Eyespot

Eyespot is a fungal disease caused by *Oculimacula yallundae* (*Tapesia yallundae*). The fungus infects the lower stems of wheat plants, resulting in stem breakage, lodging, yield loss and high screenings.

The fungus requires rain to splash spores from the stubble and prolonged moisture or high humidity at the stem base to allow infection to occur. For these reasons, the disease is more prevalent where wheat is grown in medium–high-rainfall areas.

Eyespot has been an occasional problem in south-eastern Australia for at least 30 years. It was most commonly found where tall wheat varieties were grown for hay and where rotations were short. [38] Eyespot has increased in importance on the Lower Eyre Peninsula and on the Adelaide Plains over the last 2–3 years and is being detected in the South-East.

Eyespot is favoured by high rainfall, thick crops to maintain humidity, close rotations and stubble retention.

Inoculum survives in stubble for up to 2 years and infects the lower stems. Damage is mainly caused by lodging, which is more likely to occur in taller varieties and varieties with weaker stems. Lodging typically occurs in all directions because stems break according to where the fungal lesion occurs. This makes the crop more difficult to harvest. Losses can also occur from reductions in head numbers and grain size.

Symptoms include greyish, eye-shaped lesions (usually difficult to detect until stem elongation) at the bases of stems and lodging during grainfill (Figure 9).

Conditions in 2014 were ideal for eyespot development, with rain and high humidity during tillering and stem elongation. Growers should consider protective sprays at GS31 in paddocks where eyespot inoculum has been observed in the past 2 years.

No fungicides are currently registered for use against eyespot in Australia. Growth regulants can help to reduce lodging.

Research funded by GRDC is assessing varietal resistance and fungicide efficacy for managing this disease. [39]

37 GRDC (2013) Management tips to avoid yield penalties. Southern Region. Barley Yellow Dwarf Virus Fact Sheet, GRDC, http://www.grdc.com.au/GRDC-FS-BYDV

38 GRDC (2013) Eyespot in medium and high rainfall zones. Southern Region. Eyespot in Wheat Fact Sheet, GRDC, http://www.grdc.com.au/GRDC-FS-Eyespot-Wheat

39 H Wallwork, M Evans (2014) Cereal disease update—net blotch, eyespot, wheat streak mosaic virus and white grain. GRDC Update Papers, 20 August 2014, http://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2014/08/Cereal-disease-update-net-blotch-eyespot-wheat-streak-mosaic-virus-and-white-grain

Figure 9: Eyespot, named for its eye-shaped lesion at the base of wheat stems, is a fungal disease infecting crops in South Australia's Mid North, Lower Eyre Peninsula and South East as well as Tasmania, Victoria's Western District and parts of the New South Wales Riverina. (Photo. Hugh Wallwork, SARDI)

Infection has been on the rise in recent years, due to shorter rotations and retention of stubbles and because early sowing and increased use of nitrogen (N) has led to denser crop canopies.

In many cases, plants lodge in all directions with each stem falling according to the side where the fungal lesion has weakened the stem (Figure 10). This results in a tangled mass of plants that is hard to lift during harvest.

Figure 10: Lodging that occurs due to eyespot results in stems laying in random directions, compared with lodging from wind and rain in which stems tend to lay in one direction. (Photo: Mick Faulkner, Agrilink Agricultural Consultants)

If left untreated, eyespot can result in yield losses of >50% through damage from lodging, high screenings, smaller grain and grain loss.

Eyespot tends to be more devastating in years of high production, where there is more moisture and rainfall during vegetative growth leading up to and around GS30. Yield losses are higher and smaller grains more common in high production years. [40]

Symptoms

Eyespot lesions weaken the stem, which is frequently kinked or broken at the mid-point of the lesion (Figure 11). To see the eyespot clearly, strip back the leaf sheath to reveal the bare stem. A sooty mould should be apparent around the area of stem damage.

Young eyespot lesions are brown but turn a more bleached white on older stems. Older lesions can surround the entire stem and be up to 4 cm long. The lesion blocks the plant's vascular system, restricting plant growth and grain filling. Lesions also weaken the outer cell walls of the stem. [41]

Figure 11: Eyespot lesions weaken the stem, which is frequently kinked or broken at the mid-point of the lesion. A sooty mould is present around the area of stem damage. (Photo: Hugh Wallwork, SARDI)

Life cycle

The eyespot fungus can survive in plant stubbles for ≥2 years if the stubbles have not broken down. Fungal spores produced on the stubbles are rain-splashed over short distances in autumn and winter. Infection of leaf sheaths occurs when moisture levels

[40] GRDC (2013) Eyespot in medium and high rainfall zones. Southern Region. Eyespot in Wheat Fact Sheet, GRDC, http://www.grdc.com.au/GRDC-FS-Eyespot-Wheat

[41] GRDC (2013) Eyespot in medium and high rainfall zones. Southern Region. Eyespot in Wheat Fact Sheet, GRDC, http://www.grdc.com.au/GRDC-FS-Eyespot-Wheat

remain high for extended periods. The early stages of infection cannot be detected visually. Lesions can only be detected after 6–8 weeks on stems, and by then, it will be too late to avoid yield losses.

The eyespot fungus does have a sexual stage, which takes the form of a tiny cup fungus on stubbles. These fruiting bodies produce airborne spores, which allow the fungus to spread over long distances. These cup fungi are not easily observed in the field but they help to explain the disease's distribution. [42]

Risk factors

The key risk factors for eyespot damage include:

- previous infection in a paddock and the presence of cereal and grass stubbles
- receiving frequent rain and long periods of moist conditions to allow spores to spread and infect plants during early growth stages
- sowing wheat varieties that are tall and/or have weak stems, making them more likely to lodge when infected
- lush crops with closed canopies that keep the base of the plant wet
- high rates of application of N fertiliser [43]

Variety choice

Useful resistance has been bred into some northern European varieties; however, it is not a priority in Australian breeding programs and resistance has not been assessed. There are anecdotal reports that some varieties may be more resistant than others, although most variation is likely to be related to plant height and straw strength.

Losses have not been detected in durum wheat but research is yet to determine whether that is because the crop has some level of resistance or whether there has been reduced disease pressure because of the rotations used for durum wheat. [44]

Management issues

Eyespot is a difficult disease to manage because infection is hard to identify for early treatment. Unlike rust (a communal disease), eyespot is a property-by-property disease. Different rotations, farming practices and environmental conditions can make the difference between infection and healthy crops.

Management must focus on preventative measures. Grain growers need to anticipate how often conditions conducive to eyespot occur on their property. This means the frequency of rainfall of ~3 mm/day for several days in July and early August, combined with days when humidity is high at the base of the plant. [45]

Chemical treatments

No chemical options are registered for treatment of eyespot in Australia, but the GRDC and private industry are funding research into a range of chemical products to determine their activity against eyespot.

Growth regulants can be used to shorten and strengthen plant stems and thus reduce the risk of infected plants lodging. [46]

[42] GRDC (2013) Eyespot in medium and high rainfall zones. Southern Region. Eyespot in Wheat Fact Sheet, GRDC, http://www.grdc.com.au/GRDC-FS-Eyespot-Wheat

[43] GRDC (2013) Eyespot in medium and high rainfall zones. Southern Region. Eyespot in Wheat Fact Sheet, GRDC, http://www.grdc.com.au/GRDC-FS-Eyespot-Wheat

[44] GRDC (2013) Eyespot in medium and high rainfall zones. Southern Region. Eyespot in Wheat Fact Sheet, GRDC, http://www.grdc.com.au/GRDC-FS-Eyespot-Wheat

[45] GRDC (2013) Eyespot in medium and high rainfall zones. Southern Region. Eyespot in Wheat Fact Sheet, GRDC, http://www.grdc.com.au/GRDC-FS-Eyespot-Wheat

[46] GRDC (2013) Eyespot in medium and high rainfall zones. Southern Region. Eyespot in Wheat Fact Sheet, GRDC, http://www.grdc.com.au/GRDC-FS-Eyespot-Wheat

Cultural options

Various practices influence the risk of eyespot infection.

Stubble

Modern farming practices involve retaining more standing stubble. Thick stubble that stands 10–20 cm high affects the environment around the base of subsequent crops. Wheat in standing stubble will have a higher risk of infection. Burning stubble can reduce inoculum but does not eliminate the disease.

Rotation

Reducing the frequency of growing wheat reduces eyespot infection. Although the fungus can survive in stubble for ≥2 years, the amount of inoculum will be reduced with each year out of wheat. Barley has not been observed to lodge, but it can be infected and thereby help the fungus to survive.

Nitrogen timing

The development and severity of the disease depends on moisture at the stem base; therefore, keeping the canopy open for as long as possible can help to reduce risk of eyespot infection. This would mean a later rather than early application of N to avoid promoting excessive canopy growth at GS30–32.

Seeding rate

Higher seeding rates tend to create a denser canopy earlier in the season. Although it is not a large risk, when added to the other infection factors, it could be a factor.

Time of sowing

Early sowing tends to create crops with more biomass and this increases the risk of eyespot. However, the yield losses from delaying sowing could outweigh the potential losses from eyespot. Other control options should be used in preference. [47]

More information

GRDC Fact Sheets: Eyespot in wheat

GRDC Update Papers: Cereal disease update—net blotch, eyespot, wheat streak mosaic virus and- white grain

9.6.10 Powdery mildew

Powdery mildew is currently under effective control in the Southern Region when treated seed or fertiliser is used and resistant cultivars are grown. However, care is needed to maintain this situation to minimise the risk of the pathogen developing into a threat to the industry. [48]

Disease life cycle

Wheat powdery mildew is a fungal disease caused by *Blumeria graminis* f. sp. *tritici*, whereas barley powdery mildew is caused by *B. graminis* f. sp. *hordei* and is specific to barley and barley grass.

Infections appear as white fluffy patches on the surface of leaves, leaf sheaths, glumes and awns (Figure 12). These colonies produce windborne spores that spread the disease during the growing season (Figure 13).

Mildew that survives over summer on stubble releases new spores under cool, wet conditions during autumn to infect the new crop. The disease can increase rapidly from early tillering.

The fungus consumes carbohydrates needed by the plant for grain filling. Severe early infections of susceptible varieties can result in costly yield losses and quality downgrades from tiller abortion, reduced grain size and crop lodging through weakened stems. [49]

[47] GRDC (2013) Eyespot in medium and high rainfall zones. Southern Region. Eyespot in Wheat Fact Sheet, GRDC, http://www.grdc.com.au/GRDC-FS-Eyespot-Wheat

[48] GRDC (2014) Powdery mildew in barley and wheat. Southern Region. Barley Powdery Mildew Fact Sheet, GRDC, http://www.grdc.com.au/GRDC-FS-PowderyMildewBarleyWheat

[49] GRDC (2014) Powdery mildew in barley and wheat. Southern Region. Barley Powdery Mildew Fact Sheet, GRDC, http://www.grdc.com.au/GRDC-FS-PowderyMildewBarleyWheat

Figure 12: Barley powdery mildew infections appear as white fluffy patches on the leaf surface. These colonies produce windborne spores that spread the disease during the growing season. (Photo. Ryan Fowler, DAF Qld)

Figure 13: A powdery mildew infection showing the black fruiting bodies (cleistothecia) that allow the disease to survive on stubbles.

Disease conditions

Most infection occurs during early crop growth in autumn and winter. The disease tends to diminish as temperatures rise and humidity declines.

Powdery mildew epidemics are favoured by the following factors:

- infection in the previous season's barley or wheat crop and the fungus carrying over on stubble (only a risk in wheat-on-wheat or barley-on-barley situations)
- infected barley volunteers (for barley crops) or wheat volunteers (for wheat crops), which produce inoculum early in the season
- susceptible varieties
- cool, wet conditions, which activate the release of stubble-borne spores
- mild temperatures (15–22°C)
- high humidity >70% (note dew or rainfall not needed for infection)
- low light intensity
- high N nutrition
- dense crop canopies
- growers upwind not using control treatments at seeding

Historically, powdery mildew has been less common in wheat, but it has been causing damage for several years on the Lower Eyre Peninsula and in other areas where the susceptible variety Wyalkatchem⫯ was widely grown.

It also occurs where thick crops allow high humidity to be maintained over extended periods. [50]

Choose the best variety

The best way to minimise losses and slow or prevent the development of fungicide resistance is to plant the varieties that are more resistant and thereby minimise the need for foliar sprays.

However, the pathogen is capable of evolving and overcoming the resistance of some varieties. This is more likely if the disease is not controlled, because higher populations of the fungus will result in more mutations, which may lead to loss of resistance.[51]

Monitor the crop

Crops of susceptible varieties should be monitored for powdery mildew when conditions for infection are favourable. Early protective fungicide sprays are much more effective at controlling the disease than sprays that are aimed at eliminating or reducing existing infections.

This is particularly the case where mildew occurs on the leaf sheaths around the lower stems or low in a thick crop canopy. Mildew in the head can be very damaging and it can be effectively treated only if it is controlled in the crop canopy beforehand. If the disease is detected in the early stages, treat to protect the upper leaves and reduce head infection.

At later stages, consider the individual crop and its circumstances including growth stage, potential yield, level of infection and weather when deciding whether to treat. [52]

[50] GRDC (2014) Powdery mildew in barley and wheat. Southern Region. Barley Powdery Mildew Fact Sheet, GRDC, http://www.grdc.com.au/GRDC-FS-PowderyMildewBarleyWheat

[51] GRDC (2014) Powdery mildew in barley and wheat. Southern Region. Barley Powdery Mildew Fact Sheet, GRDC, http://www.grdc.com.au/GRDC-FS-PowderyMildewBarleyWheat

[52] GRDC (2014) Powdery mildew in barley and wheat. Southern Region. Barley Powdery Mildew Fact Sheet, GRDC, http://www.grdc.com.au/GRDC-FS-PowderyMildewBarleyWheat

Fungicides and treatment of crops

Yield losses can be significant if an early infection is not properly brought under control. Fungicides are more efficient as protectants than eradicants, so apply them before the disease becomes established.

Wheat crops are best treated with in-furrow fungicides because seed treatments may shorten coleoptiles and cause emergence problems.

Treatments applied at seeding on seed or in-furrow can give protection for 6–12 weeks from sowing.

If powdery mildew is detected in crops where the variety is rated MS or lower, consider applying an appropriate fungicide immediately to slow the epidemic. A second spray may be required where the fungus persists.

More information

[Australian Pesticides and Veterinary Medicines Authority]

Where a fungicide is required, use a different chemical than that used at seeding or used previously as a spray. Always use recommended label rates. This will help to reduce the risk of fungicide resistance developing.

A good option is a QoI–DMI (quinone outside inhibitor–demethylation inhibitor) mix for the first foliar spray and a DMI for the second.

Fungicide resistance in the Southern Region

In Western Australia, resistance in powdery mildew populations in barley to some of the older fungicides has already developed. This situation arose from the low adoption of effective seed treatments, repeated use of the DMI fungicides tebuconazole, flutriafol and triadimenol as foliar sprays, and widespread use of varieties rated VS. [53] Similar changes are likely to occur in eastern Australia.

Growers can significantly reduce the chances of this happening, or at least delay the occurrence, by avoiding the use of susceptible varieties, using effective fungicide treatments at seeding and taking care over the use of foliar fungicides.

Growers should avoid using 'weaker' Group 3 DMI foliar fungicides (triadimefon, flutriafol, tebuconazole and triadimenol) for control of powdery mildew (Figure 14) and instead consider triazole fungicides such as epoxiconazole, prothioconazole, propiconazole or cyproconazole.

The Group 11 QoIs such as azoxystrobin and pyraclostrobin can also be used in combination with triazoles. Experience in Europe shows that the Group 11 QoIs can lose their effectiveness very quickly if used alone. [54]

53 GRDC (2014) Powdery mildew in barley and wheat. Southern Region. Barley Powdery Mildew Fact Sheet, GRDC, http://www.grdc.com.au/GRDC-FS-PowderyMildewBarleyWheat

54 GRDC (2014) Powdery mildew in barley and wheat. Southern Region. Barley Powdery Mildew Fact Sheet, GRDC, http://www.grdc.com.au/GRDC-FS-PowderyMildewBarleyWheat

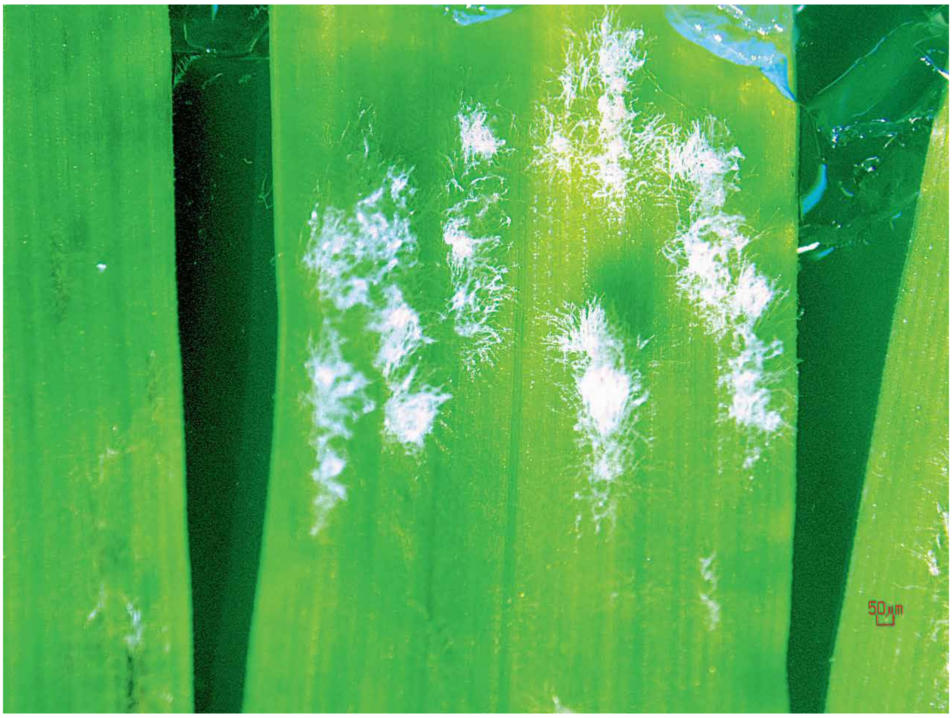

Figure 14: Triazole resistance in powdery mildew means that barley growers should not use tebuconazole alone, flutriafol, triadimefon or triadimenol if powdery mildew is the target disease or if there is a likelihood of it occurring in the season. (Photo: Richard Oliver, Curtin University)

More information

[Agriculture Victoria Notes: Wheat disease management in the Wimmera]

9.6.11 Wheat streak mosaic virus

Wheat plants infected with WSMV have discontinuous, yellow-streaked and mottled leaves (Figure 15). Plants infected before tillering are often stunted, discoloured and rosetted. The host range of WSMV is wheat, barley, oats, rye, maize and some grass species including brome grass, barley grass, ryegrass, phalaris and liverseed grass. In Australia, the virus has been found on wheat, *Setaria* and *Urochloa*.

Figure 15: Symptoms of Wheat streak mosaic virus in a young wheat plant. (Photo: CSIRO)

WSMV cannot spread without the aid of a vector to transmit it from a diseased plant to a healthy plant. The wheat curl mite (*Aceria tosichella*) is the vector for WSMV. Wheat curl mites are ~0.2 mm long and can only be seen with magnification.

The mite consumes plant sap from a diseased plant and the virus remains alive in the mite's mouthparts, being transmitted to other plants as the mite feeds and moves between plants. Wheat curl mites cannot survive for long away from living plant material.

WSMV cannot survive outside a host plant or the vector. Therefore, between summer harvest and planting of the next wheat crop, WSMV persists in the 'green bridge' of volunteer wheat plants and other grasses.

Disease management should involve eliminating the 'green bridge' by controlling:

- wheat volunteers between crops
- grass hosts growing on the borders of areas to be sown to wheat
- grasses in fallows

This means that any green plant material should be dead at least 2 weeks before sowing the next wheat crop. [55]

More information

GRDC: Wheat streak virus

GRDC Fact Sheets: Wheat curl mite

GRDC Update Papers: Cereal disease update—net blotch, eyespot, wheat streak mosaic virus and white grain

GRDC: Protecting the Australian wheat industry for the Wheat streak mosaic virus

9.7 Root and crown diseases

Most cereal root and crown diseases (take-all, crown rot, cereal cyst nematode and root-lesion nematode, RLN) can be controlled with a 1- or 2-year break from susceptible hosts. Break crops must be kept free of grass weeds to be effective. [56]

Wheat can incur root and crown diseases, including:

- take-all
- crown rot
- *Pythium*
- *Rhizoctonia*
- cereal-cyst nematode (CCN)
- RLN (*Pratylenchus*) (see GrowNotes Wheat South Section 8. Nematodes)
- common root rot

9.7.1 Take-all

Take-all is a soilborne disease of cereal crops and is most severe on wheat crops throughout southern Australia. The disease is caused by two variants of the fungus *Gaeumannomyces graminis* var. *tritici* (Ggt) 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 that minimise carry-over of the disease from one cereal crop to the next.

The take-all fungus survives the Australian summer in the residue of the previous season's grass host. Cooler temperatures and rainfall in late autumn to early winter encourage the fungus into action. The fungus infects the roots of the emerging crop during this period.

Higher rainfall in winter is likely to increase take-all disease pressure. Lower soil moisture will decrease the chance of severe development of take-all in susceptible plants.

Take-all is suppressed in low pH soils; consequently, paddocks may suffer a sudden increase in take-all severity after they are limed to alleviate soil acidity. Growers planning

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

56 G Hollaway, M McLean, J Fanning (2015) Cereal disease guide. AG1160. Revised February 2015. DEDJTR Victoria, http://agriculture.vic.gov.au/__data/assets/pdf_file/0007/252664/Vic-Cereal-Disease-Guide-AG1160-Feb-2015-V2.pdf

to apply lime should check the take-all status of paddocks so that they can plan to manage these risks in future cereal crops.

Affected plants tend to occur in patches that vary in size from a few plants up to several metres across. Infection causes stunting, with the degree of stunting depending on severity. Severe infections may cause premature death of plants after head emergence when the crop becomes water-stressed, resulting in dead plants in an otherwise green crop. In the paddock, take-all is much more obvious on wheat than on barley.

Roots of affected plants are dark brown to black through fungal invasion (Figure 16). As the plant matures, the roots become rotten and brittle and the plant can be easily pulled from the soil. Infected plants may have dark brown to black streaks or spots on the base of the stem when the infection is severe.

Whiteheads occur where the head is starved of adequate moisture and nutrients. Both take-all and crown rot cause such extensive damage to the plant roots or lower stems that they are unable to transport these essential supplies up the plant. Take-all damage affects the whole plant and in the paddock usually occurs in patches, whereas whiteheads caused by crown rot are frequently confined to single tillers on plants and patches are less obvious, and the crowns are distinctly golden brown. Whiteheads can also be caused by drought, zinc deficiency or early frosts, and will not have the crown or root symptoms caused by disease. [57]

For images and detailed information on identifying cereal root and crown diseases, see the GRDC Cereal root and crown diseases: Back Pocket Guide.

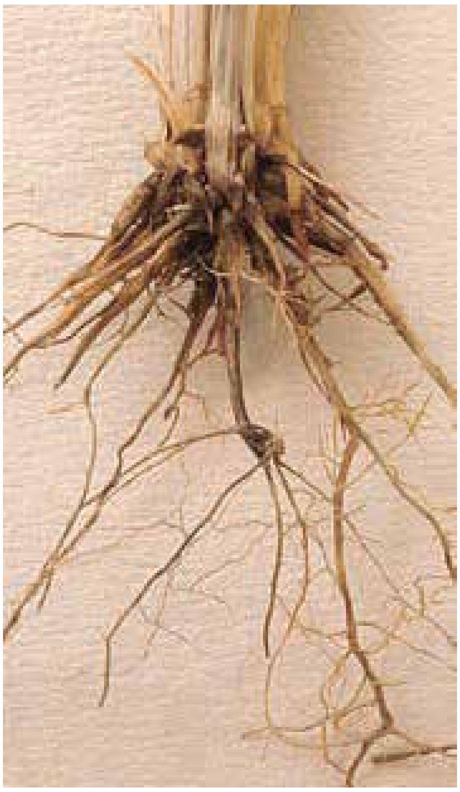

Figure 16: The sub-crown internode is the narrow portion of stem that links the old seed and primary root system to the crown and secondary root system just below the soil surface. Take-all causes a blackening of the sub-crown internodes, and primary and secondary roots. Take-all is best identified by breaking a piece of infected root and observing that the core is jet black. Common root rot specifically attacks the sub-crown internode causing it to darken brown. The fungus can also cause darkening of crowns when severe. (Source: GRDC Cereal and root and crown diseases: The Back Pocket Guide)

57 GRDC (2014) Take-all. GRDC Media Centre, 26 June 2014, http://grdc.com.au/Media-Centre/Hot-Topics/Take-all

Control

No varieties of wheat and barley are available that are resistant to take-all. By far the most effective method of reducing take-all is to remove grasses early in the year before the crop, with a grass-free pasture or break (non-host) crop.

Widespread adoption of minimum tillage has significantly increased the time required for residue to breakdown, and take-all management must reflect this. Burning only decreases the amount of surface residue but does not affect the infected material belowground.

Fungicides, applied as fertiliser, in-furrow or seed treatments, are registered for use and they suppress take-all.

Acidifying fertilisers can reduce disease severity but not control the disease.

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, but the effect can be negated by poor weed control during this period. Cereal weeds become infected, enabling *G. graminis* to survive until crop establishment. In addition, rapid drying of the topsoil due to weeds decreases the survival of competitive soil organisms, thereby slowing *G. graminis* decline.

Any practice that encourages crop growth will help to overcome the effects of take-all. These include good weed control and the application of adequate fertiliser. The ammonium form of nitrogenous fertiliser reduces take-all.

Diagnosing root diseases in your crop

Look at the distribution of symptomatic plants throughout the whole crop. To determine whether a fungal or nematode root disease is affecting a cereal crop, look for patchy areas of poor crop growth associated with localised disease build-up.

Next, carefully dig up samples of apparently diseased, as well as nearby healthy, plants. Thoroughly wash the soil from the roots and then examine them for indicative symptoms of root and crown diseases. Unthrifty plants may have smaller root mass, fewer root branches, root browning, root clumping or damaged root tips (spear tips) compared with thrifty or well-grown plants nearby. If you are sending plant samples to a diagnostic laboratory, send plants that have not been washed . [58]

More information

Soil Quality Fact Sheets: Take-all disease

9.7.2 Crown rot

Crown rot is caused predominantly by the fungus *Fusarium pseudograminearum*. Crown rot affects wheat, barley and triticale. [59] It survives from one season to the next in the stubble remains of infected plants and grassy hosts. The disease is more common on heavy clay soils.

Infection is favoured by high soil moisture in the 2 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. [60]

The disease may be managed through planting partially resistant varieties, inter-row sowing or crop rotation. If the disease is severe, rotation to a non-susceptible crop for at least 2 years, and preferably 3 years, is recommended.

More information

NSW DPI: Winter crop variety sowing guide

GRDC: NVT Queensland wheat variety trial 2015

Research paper: Effect of rotation with barley and oats on crown rot of wheat in the northern wheat belt of New South Wales

58 GRDC (2014) Take-all. GRDC Media Centre, 26 June 2014, http://grdc.com.au/Media-Centre/Hot-Topics/Take-all

59 S Simpfendorfer, M Gardner (2013) Crown rot: be aware of the balancing act or the fall may be harder. GRDC Update Papers, 25 February 2013, http://www.grdc.com.au/Research-and-Development/GRDC-Update-Papers/2013/02/Crown-rot-be-aware-of-the-balancing-act-or-the-fall-may-be-harder

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

More information

[GRDC Update Papers: Crown rot: be aware of the balancing act or the fall may be harder](http://www.grdc.com.au/Research-and-Development/GRDC-Update-Papers/2013/02/Crown-rot-be-aware-of-the-balancing-act-or-the-fall-may-be-harder)

GRDC Video

GRDC video: Crown rot—it's all a balancing act

Damage caused by crown rot

The impact of crown rot on yield and quality is influenced by inoculum levels and available soil water. The primary factor increasing the impact of crown rot is moisture stress at grainfill, yet most management strategies focus heavily on combating inoculum, sometimes to the detriment of soil water storage or availability, which in turn exacerbates the effect of moisture stress.

Any management strategy that limits storage of soil water or creates constraints (e.g. nematodes or sodicity) that reduce the ability of roots to access water increases the probability of moisture stress during grainfill and therefore the severity of crown rot.

Some of the newer wheat varieties appear promising in that they provide improved tolerance to both crown rot and the RLN *Pratylenchus thornei*.

Symptoms

- Tiller bases are always brown, often extending up 2–4 nodes.
- Some tillers on diseased plants may not be infected.
- Whitehead formation is most severe in seasons with a wet start and dry finish.
- Plants often break off near ground level when pulled up.
- Plants are easy to pull up in good moisture situations because they have little root structure.
- Cottony fungal growth may be found inside tillers.
- Pinkish fungal growth may form on lower nodes, especially during moist weather.
- Pinched grain is observed at harvest. [61]

Infection is characterised by a light honey-brown to dark brown discoloration of the base of infected tillers (Figure 17). In moist weather, a pink-purple fungal growth forms inside the lower leaf sheaths and on the lower nodes.

Major yield loss from the production of whiteheads is related to moisture stress post-flowering. [62]

Figure 17: Basal browning indicating crown rot infection.

61 K Moore, B Manning, S Simpfendorfer, A Verrell (2005) Root and crown diseases of wheat and barley in northern NSW. NSW Department of Primary Industries, http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0019/159031/root-crown-rot-diseases.pdf

62 S Simpfendorfer, M Gardner (2013) Crown rot: be aware of the balancing act or the fall may be harder. GRDC Update Papers, 25 February 2013, http://www.grdc.com.au/Research-and-Development/GRDC-Update-Papers/2013/02/Crown-rot-be-aware-of-the-balancing-act-or-the-fall-may-be-harder

More information

[NSW DPI: Northern grains region trial results. Autumn 2013. Impact of sowing time on crown rot in barley, bread and durum wheat—Walgett 2012 (pp. 24–26)]

[GRDC Ground Cover: Seedborne fusarium tests crown rot strategies]

Effect of sowing time

Earlier sowing within the recommended window of a given variety for a region generally brings the grainfill period forward to where the probability of moisture stress during grainfill is reduced. Earlier sowing may also increase the extent of root exploration at depth, which could provide greater access to deeper soil water later in the season, buffering against crown rot expression. This has been shown in NSW DPI research across seasons to reduce yield loss from crown rot. [63]

Agronomists report anecdotal accounts of early sowing dates with long-season varieties resulting in greater soil moisture deficits during grainfill than later sowing dates. They say this combination has resulted in major yield loss and they reported a number of cases of this in 2013.

Crown rot phases

There are three distinct and separate phases of crown rot—survival, infection and expression. Management strategies can differentially affect these phases:

- Survival. The crown rot fungus survives as mycelium (cottony growth) inside winter cereal (wheat, barley, triticale and oats) and grass weed residues that it has infected. The crown rot fungus will survive as inoculum inside the stubble for as long as the stubble remains intact, which varies greatly with soil and weather conditions; decomposition is generally a very slow process.
- Infection. Given some level of soil moisture, the crown rot fungus grows out of stubble residues and infects new winter cereal plants through the coleoptile, sub-crown internode or crown tissue, which are all below the soil surface. The fungus can also infect plants above the ground right at the soil surface through the outer leaf sheathes. However, with all points of infection, direct contact with the previously infected residues is required, and infections can occur throughout the whole season given moisture. Hence, wet seasons favour increased infection events, and when combined with the production of greater stubble loads, disease inoculum levels build up significantly.
- Expression. Yield loss is related to moisture and temperature stress around flowering and through grainfill. Expression is also affected by variety. Moisture stress is believed to trigger the crown rot fungus to proliferate in the base of infected tillers, restricting water movement from the roots through the stems, and producing whiteheads that contain either no grain or lightweight, shrivelled grain. The expression of whiteheads (Figure 18) in plants infected with crown rot (i.e. that still have basal browning) is restricted in wet seasons and increases greatly with increasing moisture stress during grainfill. [64]

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63 UNE Agronomy of Grains Production course notes.

64 S Simpfendorfer, M Gardner (2013) Crown rot: be aware of the balancing act or the fall may be harder. GRDC Grains Update Papers, 25 February 2013, http://www.grdc.com.au/Research-and-Development/GRDC-Update-Papers/2013/02/Crown-rot-be-aware-of-the-balancing-act-or-the-fall-may-be-harder

Figure 18: The expression of whiteheads is restricted in wet seasons, so they are not considered the best indicator of crown rot; look for signs of basal browning instead.

More information

[extensionAUS: Crown rot in winter cereals]

[Research paper: Monitoring fusarium crown rot populations in spring wheat residues using quantitative real-time polymerase chain reaction]

[Research paper: Decomposition and chemical composition of cereal straw]

Management

Managing crown rot requires a three-pronged attack:

1. Rotate crops.
2. Observe plants for basal browning.
3. Test stubble and/or soil.

More information

[Thesis: Crown rot (*Fusarium pseudograminearum*) symptom development and pathogen spread in wheat genotypes with varying disease resistance]

[GRDC Update Papers: Economics of phosphorus and zinc nutrition]

Top tips:

- Although many growers look for whiteheads to indicate crown rot, basal browning is a better indicator of the presence of inoculum.
- Keep crown rot inoculum levels low by rotating with non-host crops and ensuring a grass-free break from winter cereals. Consider crops with dense canopies and early canopy closure such as mustard, canola or faba beans.
- If growing cereals in crown-rot-affected paddocks, select types with lower risk of yield loss such as barley and some bread wheats. Avoid all durum varieties.
- Match N application to stored soil moisture and potential yield.
- Limit N application prior to and at sowing to avoid excessive early crop growth.
- Ensure zinc nutrition is adequate.
- Sow on the inter-row if possible when sowing cereal after cereal. [65]
- Current seed treatments do not offer any control.

Crop rotation

Growing non-host break crops remains an important tool for managing crown rot, because break crops allow time for decomposition of winter cereal residues that harbour the crown rot inoculum. Canopy density and rate of canopy closure can affect the rate of decomposition and these vary with different break crops (i.e. faba bean and canola). Crops that are sparser in nature, such as chickpeas, are not as effective.

Row spacing and seasonal rainfall during the break crop also affect decomposition and hence survival of the crown rot fungus. Break crops can further influence the expression

65 GRDC (2011) Stop the rot: rotate, observe, test. GRDC Media Centre, 22 February 2011, http://www.grdc.com.au/Media-Centre/Media-News/National/2011/02/Stop-the-crown-rot-Rotate-Observe-Test

of crown rot in the following winter cereal crop through the amount of soil water they use (and therefore leave) at depth and their impact on the build-up of RLN.

Growing barley before wheat in paddocks with high crown rot inoculum is not an option because of risk of yield loss. All current barley varieties are very susceptible and they will encourage considerable build-up of inoculum. However, barley rarely suffers significant yield loss from crown rot, largely because its earlier maturity limits the impact of the moisture stress interactions with infection that result in the production of whiteheads. [66]

More information

Effect of previous crops on crown rot infection and yield of wheat

The effect of previous crops on the incidence and severity of crown rot and yield of wheat was investigated in field studies in the Wimmera (Victoria) and in northern New South Wales. Evidence was sought for enhanced suppression of crown rot following *Brassica* break crops compared with other non-host rotation crops, as has been demonstrated for take-all.

Yield was lower after cereals than after broadleaf break crops and was higher after brassicas than after chickpeas. In the crown-rot-susceptible durum wheat, the yield response to previous crops was closely associated with the levels of crown rot infection.

In the tolerant bread wheat, the response to previous crops was similar to that of durum wheat despite lower disease levels and a weaker association with some of the disease measurements. No other explanation for the impacts of previous crops was obvious.

More information

GRDC Ground Cover: Crown rot stubble avoidance lessens crown rot

NGA: GRDC Update Papers—diseases

NGA Results and Publications: Complete summary

GRDC Video

GRDC GCTV9: Crown rot & root lesion nematodes

GRDC Podcast

GRDC Podcasts: Crown rot, root disease and WeedSmart

The results indicate that *Brassica* break crops may be more effective than chickpeas in reducing crown rot infection of following crops, and tolerant varieties of wheat can suffer yield penalties in the absence of visible symptoms such as whiteheads. [67]

Inter-row sowing

Northern Grower Alliance (NGA) research shows:

- Inter-row sowing will reduce the level of crown rot incidence and severity (measured as inoculum in residues, not as whitehead expression), on average, by ~50%.
- Inter-row sowing provides increased disease-management benefit under conditions of low disease.
- Inter-row sowing is not a tool to enable back-to-back wheat production under moderate–high risk of crown rot.
- Inter-row sowing will provide best benefit by incorporation into a crown rot disease-management package based on sound crop rotation. [68]

Stubble burning

Burning removes the aboveground portion of crown rot inoculum but the fungus will still survive in infected crown tissue belowground; therefore, stubble burning is not a 'quick fix' for high-inoculum situations. Removal of stubble residues through burning will increase evaporation from the soil surface and affect fallow efficiency. A 'cooler' autumn burn is therefore preferable to an earlier 'hotter' burn because it minimises the negative impacts on soil moisture storage while still reducing inoculum levels.

More information

GRDC Fact Sheets: Stubble management—strategies to manage winter crop stubbles without reaching for the matches

GRDC Ground Cover: Stubble management still a burning question

Varietal resistance or tolerance

Resistance is the ability to limit the development of the disease, whereas tolerance is the ability to maintain yield in the presence of the disease. Published crown rot ratings are largely based on the evaluation of resistance.

66 K Moore, B Manning, S Simpfendorfer, A Verrell (2005) Root and crown diseases of wheat and barley in northern NSW. NSW Department of Primary Industries, http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0019/159031/root-crown-rot-diseases.pdf

67 J Kirkegaard *et al.* (2003) Effect of previous wheat crops on crown rot infection and yield of wheat. Australian Agronomy Conference. Australian Society of Agronomy/The Regional Institute Ltd, http://www.regional.org.au/au/asa/2003/c/6/kirkegaard.htm

68 G Rummery, R Daniel, S Simpfendorfer (2007) Inter-row crown rot management—the results are in. Northern Grower Alliance, http://www.nga.org.au/results-and-publications/download/42/australian-grain-articles/diseases-1/crown-rot-inter-row-sowing-results-march-2007-.pdf

More information

[GRDC Update Papers: Crown rot tolerance levels in current and future cultivars]

[GRDC Fact Sheets: Wheat breeding]

[GRDC Update Papers: Root lesion nematode and crown rot—double trouble]

[GRDC Fact Sheets: Cracking wheats toughest nuts]

GRDC Video

[GRDC Video: Crown rot tolerance levels in current and future cultivars]

Details on crown rot resistance or tolerance ratings among bread wheats can be found in the annual NSW Winter crop variety sowing guide, National Variety Trials (NVT) website, the NVT Queensland wheat variety guide, NVT Victorian winter crop summary 2015, and South Australian sowing guide 2015.

For more information see: GrowNotes Wheat South Section 8. Nematodes.

9.7.3 Pythium root rot

Pythium root rot (caused by several species of *Pythium*) is a widespread fungal root disease that attacks seedlings but rarely causes large yield losses.

Symptoms

In the paddock, look for patches or whole paddocks of very poor growth (Figure 19). Affected plants occur in patches where soil is wetter.

Seedlings are pale and stunted (Figure 20). Older plants have fewer tillers and may rot and die. Roots are stunted, short and stubby with few laterals (Figure 21). Root tips often water soaked and develop a soft yellow to light brown rot.

Figure 19: Symptoms of Pythium root rot: patches of poor growth.

Figure 20: Symptoms of Pythium root rot: seedlings are pale and stunted.

Figure 21: Symptoms of Pythium root rot: roots are stunted.

What else could it be?

Rhizoctonia root rot in cereals presents similar patches of stunted plants and dead roots. However, Rhizoctonia root rot has 'spear-tipped' roots and patches are more distinct.

Like Pythium root rot, waterlogging in cereals causes stunted plants with dead or dying roots. However, waterlogged roots are not stubby and have water-soaked tips.

Where does it occur?

Pythium root rot occurs:

- in cold, wet situations
- in wet soils and areas of poor drainage
- where seeding is done directly into areas of dense, dying weeds

Management strategies

Use good weed control in the paddock and delay seeding until weeds have decomposed.

Fungicide seed dressings with a *Pythium*-selective chemical such as metalaxyl-M can be applied. [69]

9.7.4 Rhizoctonia disease

Rhizoctonia root rot is an important disease of cereals in both the southern and western regions of the Australian grainbelt. This is especially the case in the lower rainfall zones and on lighter soils. Yield losses in crops affected by bare patches can be >50%, and crops with uneven growth (Figure 22) may lose up to 20%. The disease is caused by *Rhizoctonia solani* AG8, a fungus that grows on crop residues and soil organic matter and is adapted to dry conditions and lower fertility soils.

The fungus causes crop damage by pruning newly emerged roots (spear-tipped roots), and this can occur from emergence to crop maturity (Figure 23). The infection results in water and nutrient stress to the plant, because the roots have been compromised in their ability to translocate both moisture and nutrients. [70]

69 DAFWA (2015) Diagnosing Pythium root rot in cereals. Department of Agriculture and Food Western Australia, https://www.agric.wa.gov.au/mycrop/diagnosing-pythium-root-rot-cereals

70 GRDC (2016) Rhizoctonia. Southern Region. GRDC Tips and Tactics.

Figure 22: Aboveground symptoms of crop unevenness (left panel) are seen when Rhizoctonia damages crown roots, even when seminal roots escape the infection (right panel).

Figure 23: Symptoms of Rhizoctonia disease: left: healthy roots; middle: seedling severely infected; right, crown root fully infected. (Photos: Sjaan Davey)

Management options

Summer weed control

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

Crop choice and rotations

Cereals (especially barley) and grassy fallows promote the build-up of *Rhizoctonia* inoculum.

Crop rotation with a grass-free non-cereal crop is one of the best available management strategies to reduce the impact of Rhizoctonia disease. Trials across the lower rainfall cropping region of southern Australia have indicate that grass-free oilseeds, pulses, pasture legumes and fallow can result in significant reductions in *Rhizoctonia* inoculum in a cropping sequence.

Non-cereal crops can be infected by *Rhizoctonia*; however, most do not allow the build-up of inoculum. Lupins may be a less effective break crop and can suffer from yield damage in the presence of *Rhizoctonia*. The beneficial effect of rotation on reducing inoculum generally lasts for one cereal crop season.

Fungicide treatments

Fungicide treatments need to be used as part of an integrated management strategy.

Responses in barley are greater than in wheat. Yield responses can vary between seasons, with the greatest responses occurring when spring rainfall is above average. In GRDC-funded trials in southern Australia and Western Australia, on average, seed treatments gave yield responses of 5% (0–18%) in wheat and barley.

Several products have been registered for liquid banding. GRDC-funded research has shown that: product(s) registered for dual-banding (in-furrow 3–4 cm below the seed and on the surface behind the press-wheel) gave the most consistent yield and root-health responses across seasons.

Seed treatment combined with in-furrow application can provide intermediate benefit between seed treatment alone and split application.

Nitrogen

Nitrogen-deficient crops are more susceptible to Rhizoctonia disease. Intensive cropping with cereals and stubble retention result in very low levels of mineral N over summer because soil microbes temporarily utilise all available N while breaking down the low-N stubble residues.

Application of adequate N fertiliser at sowing is necessary to ensure early seedling vigour so that plants can push through the layer of inoculum concentrated in the top 10 cm.

Therefore, ensure good N nutrition. Crops with adequate N will be less affected by the disease.

Seeding systems and tillage

- Soil openers can have a significant influence on disease severity.
- Disturbance below seeding depth helps roots to escape infection and reduces disease impact.
- Disease risk is greater with single-disc seeders than knife-points.
- Tillage can redistribute inoculum to deeper in the soil. [71]

Table 5 presents a management sequence to deal with Rhizoctonia disease in cereal crops.

[71] GRDC (2016) Rhizoctonia. Southern Region. GRDC Tips and Tactics.

Table 5: Management of Rhizoctonia disease in cereal crops.

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

More information

GRDC Update Papers: Rhizoctonia control improved by liquid banding of fungicides

Australian Pesticides and Veterinary Medicines Authority

MSFP: Management of soilborne Rhizoctonia disease risk in cropping systems

9.7.5 Disease identification

Identifying risk

PreDicta B is a unique, DNA-based service that identifies soilborne pathogens such as *Rhizoctonia* so that cropping programs can be adjusted before seeding to include strategies to minimise soilborne risk.

Paddocks at high risk of Rhizoctonia disease can also be identified by examining crown roots of cereals in areas of poor growth (not necessarily bare patches) in the previous spring.

Bare patches

Severe seedling infection causes patches of poor crop growth from very small to several metres across (Figure 24). This can occur in cold or dry soils and conditions that restrict seminal root growth (e.g. compaction, lack of moisture, herbicide residues).

Uneven growth at tillering

Warmer soil temperatures and adequate moisture are less conducive to the disease because crops escape seminal root infection, but crown roots can be affected by Rhizoctonia disease under low soil temperatures and poor nutrition, leading to uneven growth at tillering.

Figure 24: Rhizoctonia infection of seminal roots results in distinct patches of poor growth. (Photo. Gupta Vadakattu)

9.7.6 Why is Rhizoctonia disease a problem?

Rhizoctonia root rot is difficult to control because the fungus can survive in soil in the absence of a live plant host, on cereal stubbles; this is termed 'saprophytic ability'. [72]

Biology

Rhizoctonia solani AG8 generally occurs in the top 0–5 cm of soil on decaying crop residues. During the growing season, levels increase throughout the profile.

It grows through soil as a network of fungal hyphae or filaments. Inoculum levels increase on the roots of living host plants and decomposing crop residues. This ability to survive on crop residues is strongly influenced by soil conditions including soil type, fertility, moisture, temperature and biological activity.

Although Rhizoctonia disease has often been a problem in low-fertility, sandy or calcareous soils of southern and Western Australia, with the increased adoption of conservation tillage and intensive cereal cropping, it now occurs in a wider range of environments from Western Australia to southern New South Wales.

The pathogen can infect, and cause spear tips in, a wide range of crops and weeds, but multiplies most on cereals and grasses. Of the cereals, oats are most tolerant followed by triticale, wheat and then barley. [73], [74]

Key factors influencing occurrence and severity

Although the fungus is likely to be present in many soils, it does not necessarily cause disease symptoms. One reason for this is that beneficial soil microorganisms and high microbial activity have been shown to suppress the expression and reduce the level of disease.

72 GRDC (2016) Rhizoctonia. Southern Region. GRDC Tips and Tactics.

73 GRDC (2016) Rhizoctonia. Southern Region. GRDC Tips and Tactics.

74 GRDC (2015) Rhizoctonia. Western Region. GRDC Tips and Tactics, https://www.grdc.com.au/Resources/Factsheets/2015/11/Rhizoctonia-Western-Region

The shift towards minimal tillage has resulted in conditions more favourable to the disease. Crown root infection late in the crop season results in the build-up of inoculum in cereal crops.

In cereals, *R. solani* AG8 inoculum builds up from sowing to maturity and generally peaks at crop maturity. Rain post-maturity of a crop and over the summer fallow causes a decline in inoculum (Figure 25).

In the absence of host plants including weeds, summer rainfall events of >20 mm in a week can substantially reduce the level of inoculum. Dry spells, on the other hand, offer little opportunity for pathogen inoculum to break down, with disease levels likely to remain stable if a host, or stubble, are present.

In cropping systems with stubble retention, suppressive activity has been shown to increase over 5–8 years. Biological suppression can provide complete control of Rhizoctonia disease and presently provides the best long-term control option. [75]

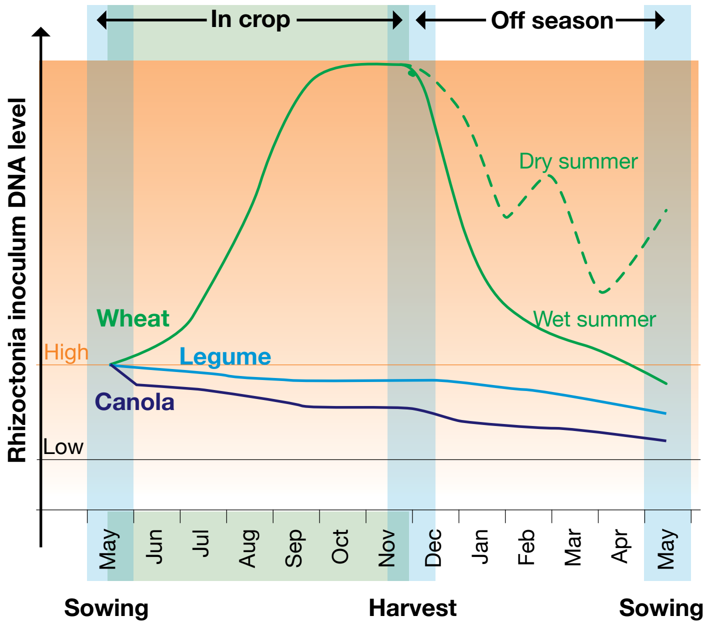

Figure 25: Rhizoctonia solani AG8 inoculum in soil build up in-crop and decline during summer following rainfall under wheat. By comparison, inoculum levels decline in-crop under grass-free canola and legume crops.

9.7.7 Common root rot

Common root rot is a soil-borne fungal disease that attacks wheat, barley and triticale. It is caused by the fungus *Cochliobolus sativus*. It survives from one season to the next through fungal spores, which remain in the top layer of the soil. The disease increases in severity with continuous wheat or with wheat–barley sequences.

Barley increases the soil population of fungal spores rapidly. Infection is favoured by high soil moisture for 6–8 weeks after planting.

Symptoms of common root rot:

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

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

[75] GRDC (2016) Rhizoctonia. Southern Region. GRDC Tips and Tactics.

More information

[GRDC: Cereal root and crown diseases. The Back Pocket Guide](#)

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 2 years is recommended.

9.7.8 Smut

Seed treatments provide cheap and effective control of bunt and smut diseases. Seed should be treated every year with a fungicide. Without treatment, bunt and smut can increase rapidly, resulting in unsaleable grain. Good product coverage of seed is essential and clean seed should be sourced if a seedlot is infected. Note that fertiliser treatments do not control bunt and smuts, so seed treatments are still required.

Bunt or stinking smut

This disease affects mature wheat ears. 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 than healthy plants, and gaping glumes. Bunt is usually only noticed at harvest, when bunt balls and fragments are seen in the grain. Grain deliveries with traces of bunt balls are not accepted by AWB Ltd.

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.

Bunt control recommendations:

- 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.
- 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 6 years.

These recommendations could be adopted in one of two ways:

- Treat all wheat seed with a fungicidal seed dressing every second year.
- Treat a small quantity of seed of each variety with a fungicidal seed dressing every year and use the grain from this as planting seed in the following year. [76]

Loose smut

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.

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 other treatments and should only be used when a high incidence of loose smut is expected. [77]

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

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