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GRAINS RESEARCH & DEVELOPMENT CORPORATION

WHEAT

SECTION 9

DISEASES

THE DISEASE TRIANGLE | CEREAL DISEASE AFTER DROUGHT | CEREAL DISEASE AFTER FLOOD EVENTS | CROWN ROT | RUSTS | STRIPE RUST (YELLOW RUST) | LEAF RUST (BROWN RUST) | STEM RUST (BLACK RUST) | TAN SPOT (YELLOW SPOT) | YELLOW SPOT V. STRIPE RUST | COMMON ROOT ROT | SMUT | LOOSE SMUT | WHEAT STREAK MOSAIC VIRUS | BOTRYOSPHAERIA HEAD BLIGHT – BHB (WHITE GRAIN DISORDER) | FUSARIUM HEAD BLIGHT

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

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. 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. [2]

More information

GRDC Report: https://www.grdc.com.au/~/media/B4063ED6F63C4A968B3D7601E9E3FA38.pdf

GRDC Fact Sheet: http://www.grdc.com.au/greenbridge_factsheet

Managing barley and wheat diseases priority issues and actions for 2015

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

[2] UNE grains course notes

9.1 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.

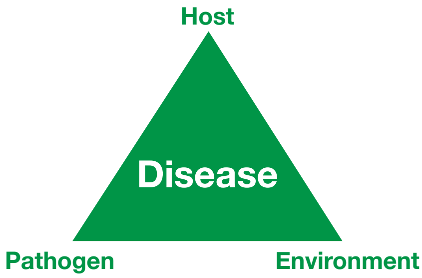

Figure 1: The disease triangle.

For disease to occur, there must be a susceptible host and a virulent pathogen, and the environment must be favourable. In practical terms, virulent pathogens are present in every field crop; however, some can be controlled through biosecurity measures, and seed-borne diseases can be controlled by the pathogen, i.e. seed treatments.

Some important examples of interactions of environmental conditions with diseases of grain crops are as follows:

- 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. [3]

9.2 Cereal disease after drought

More information

http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0004/123718/crop-diseases-after-drought.pdf

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

The NSW Department of Primary Industries (DPI) '*Cereal diseases after drought*' information sheet covers effects on crown rot, rhizoctonia root rot, inoculum, tan

3 UNE grains course notes.

(yellow) spot, rusts, wheat streak mosaic, other cereal diseases, and burning stubble to control disease. [4]

9.3 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 the floods and rain included transport of inoculum (crown rot, nematodes, leaf spots through movement of infected stubble and soil) (Figures 2 and 3), 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, in particular 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 through inspecting plants. Leaf and stem rusts produce visible pustules on leaves; while 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, while crown rot survives mainly as mycelia in straw. Soil-borne nematodes are detected through soil tests. [5]

Figure 2: Tan spot infected stubble following flood. (Photo: Rachel Bowman)

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

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

Figure 3: Tan spot infected stubble following flood. (Photo: Rachel Bowman)

9.3.1 Management options

Management options for disease control include elimination of volunteers, if possible producing 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 spray are not protected. Spray to protect the upper three or four leaves, which are the most important as they contribute to grain-fill. In general, rusts are easier to control than leaf spots. Fungicides do not make yield; 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. [6]

9.3.2 Strategies

The incidence and severity of disease will depend on the environment, but with known 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 [7]

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

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

More information

http://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2014/03/Pre-sow-assessment-of-crown-rot-risk-in-the-northern-region

http://www.dpi.nsw.gov.au/agriculture/broadacre/guides/winter-crop-variety-sowing-guide

http://www.grdc.com.au/Research-and-Development/National-Variety-Trials/Crop-Variety-Guides

Nelson KE, Burgess LW (1995) Effect of rotation with barley and oats on crown rot of wheat in the northern wheat belt of New South Wales. *Australian Journal of Experimental Agriculture* 35, 765–770: http://dx.doi.org/10.1071/EA9950765

GRDC Update Paper: 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

Crown rot an update on latest research

Crown rot - what is coming in the breeding pipeline

High crown rot risk - barley vs wheat

Crown rot tolerance in new wheat cultivars is there enough to base varietal decisions on

Fusarium crown rot of wheat – do not stress! Rick Graham, Steven Simpfendorfer, Guy McMullen, Neroli Graham.

9.4 Crown rot

Crown rot, caused predominantly by the fungus *Fusarium pseudograminearum*, is the most damaging disease of winter cereals in the northern region. Crown rot affects wheat, barley and triticale. [8] 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. [9]

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. A winter chickpea or any summer crop may be used as a disease-free rotation crop but must be kept clean of alternative grassy hosts. [10]

9.4.1 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 grain-fill, 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 grain-fill 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 root-lesion nematode (RLN) *Pratylenchus thornei*.

9.4.2 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 as 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. [11]

8 S Simpfendorfer, M Gardner (2013) Crown rot: be aware of the balancing act or the fall may be harder!, GRDC Update Papers 25 Feb. 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

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

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

11 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

More information

Improving the accuracy of PreDicta B soil testing, Steven Simpfendorfer (NSW DPI, Tamworth), Alan McKay and Shawn Rowe (SARDI, Adelaide)

Wheat variety reponses to crown rot in southern NSW

Survey of the incidence of crown rot in wheat paddocks in 2012

Video

Steven Simpfendorfer's presentation: http://www.grdc.com.au/Media-Centre/GRDC-Gallery/Video/ZvsqA-NrcNY

More information

Impact of sowing time on crown rot in barley, bread and durum wheat—Walgett 2012 (pp. 24–26; MG Gardner and S Simpfendorfer 2013)

Infection is characterised by a light honey-brown to dark brown discoloration of the base of infected tillers, while major yield loss from the production of whiteheads is related to moisture stress post-flowering. [12]

If the leaf bases are removed from the crowns of diseased plants, a honey-brown to dark brown discoloration (FIgure 4) will be seen. In moist weather, a pink-purple fungal growth forms inside the lower leaf sheaths and on the lower nodes.

Figure 4: Basal browning indicating crown rot infection.

9.4.3 Effect of sowing time

Earlier sowing within the recommended window of a given variety for a region generally brings the grain-fill period forward to where the probability of moisture stress during grain-fill 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 (Figure 5). This has been shown in previous NSW DPI research across seasons to reduce yield loss from crown rot. [13]

[12] S Simpfendorfer, M Gardner (2013) Crown rot: be aware of the balancing act or the fall may be harder! GRDC Update Papers 25 Feb. 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

[13] UNE grains course notes.

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More information

[Varietal yield response to crown rot across two sowing times – Garah 2013: Steven Simpfendorfer, Rick Graham, Guy McMullen: p132]

[Varietal yield response to crown rot across two sowing times – Garah 2014: Steven Simpfendorfer, Rick Graham, Guy McMullen p137]

More information

http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0004/468328/Northern-grains-region-trial-results-autumn-2013.pdf

http://www.grdc.com.au/Media-Centre/Ground-Cover/Ground-Cover-Issue-98-May-June-2012/Seedborne-Fusarium-tests-crown-rot-strategies

More information

Monitoring fusarium crown rot populations in spring wheat residues using quantitative real-time polymerase chain reaction. (AC Hogg *et al*. 2010): http://www.ncbi.nlm.nih.gov/pubmed/19968549#

Decomposition and chemical composition of cereal straw (BA Summerell, LW Burgess): http://www.sciencedirect.com/science/article/pii/0038071789901296

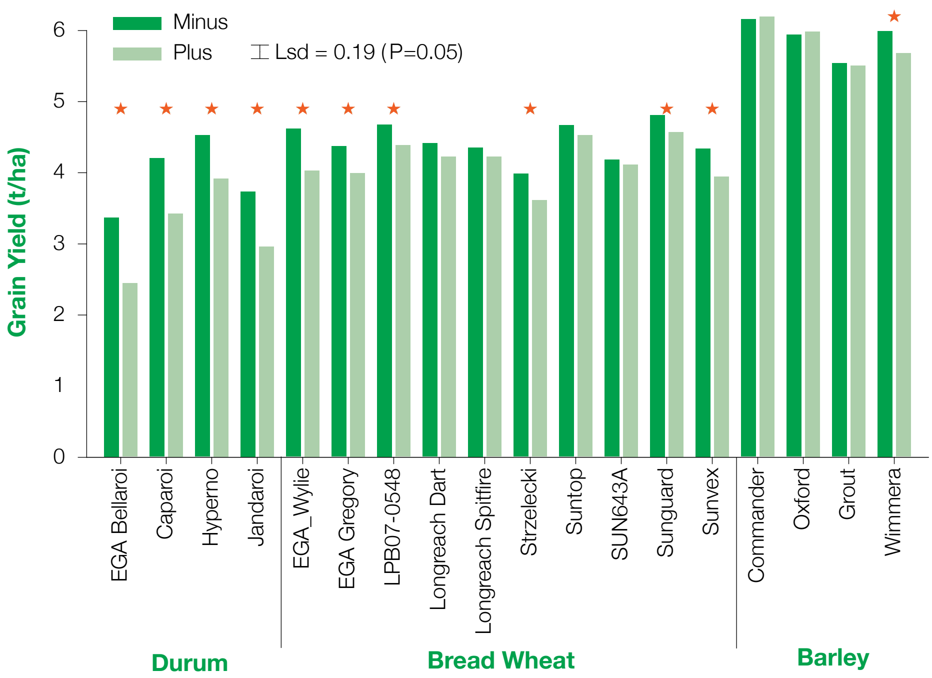

Figure 5: Effect of crown rot on the yield of 18 different varieties averaged across two sowing times at Walgett in 2012. Varieties designated with a star represent a significant yield loss from crown rot infection.

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

9.4.4 Crown rot phases

There are three distinct and separate phases of crown rot—survival, infection and expression—and management strategies can differentially effect 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 (2010, 2011 and start of 2012) 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/temperature stress around flowering and through grain-fill. 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 6) in plants infected with crown rot (i.e. still have basal browning) is restricted in wet seasons and increases greatly with increasing moisture stress during grain-fill. [14]

[14] S Simpfendorfer, M Gardner (2013) Crown rot: be aware of the balancing act or the fall may be harder! GRDC Grains Update Papers 25 Feb. 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 6: 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.

9.4.5 Management

Managing crown rot requires a three-pronged attack:

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

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.
- Crown Analytical Services (CAS), Moree, offers a commercial stubble assessment service (see https://sites.google.com/site/crownanalyticalservices/) and is an agent for PreDicta B soil testing, which is not currently calibrated for crown rot in the northern region but its application is being investigated. (Northern growers are advised to use Predicta B for nematode testing.)
- If growing cereals in crown rot-affected paddocks, select types with lower yield loss risk such as barley and some bread wheats. Avoid all durum varieties.
- Match nitrogen application to stored soil moisture and potential yield.
- Limit nitrogen application prior to and at sowing to avoid excessive early crop growth.
- Ensure zinc nutrition is adequate.
- Sow on the inter-row if possible when sowing cereal after cereal. [15]
- Current seed treatments do not offer any control.
- While cultivation can reduce inoculum loads by speeding up stubble decomposition, in years of low rainfall (and reduced stubble degradation) cultivation can increase the crown rot infection rate of subsequent winter cereals. [16]

Crop rotation

Growing non-host break crops remains an important tool for managing crown rot, as break crops allow time for decomposition of winter cereal residues that harbour the

More information

Regional crown rot management – Macalister, Queensland, 2014, Steven Simpfendorfer, Finn Fensbo, Robyn Shapland p 143

Regional crown rot management – Trangie, 2014, Steven Simpfendorfer, Finn Fensbo, Robyn Shapland, Greg Brooke, Jayne Jenkins, Scott Richards p 147

Regional crown rot management – Westmar, Queensland, 2014, Steven Simpfendorfer, Finn Fensbo, Robyn Shapland p 150

Crown rot of wheat - its importance and management in southern NSW

More information

https://sites.google.com/site/crownanalyticalservices/

http://eprints.usq.edu.au/6225/2/Malligan_2009_whole.pdf

http://www.grdc.com.au/Research-and-Development/GRDC-Update-Papers/2009/09/ECONOMICS-OF-PHOSPHORUS-AND-ZINC-NUTRITION

15 http://www.grdc.com.au/Media-Centre/Media-News/National/2011/02/Stop-the-crown-rot-Rotate-Observe-Test

16 http://www.grdc.com.au/Media-Centre/Ground-Cover-Supplements/GCS111/Cultivation-can-exacerbate-crown-rot

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 chickpea, 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 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. Table 1 lists suggested rotations under different levels of crown rot infection.

Table 1: Suggested rotations under varying crown rot conditions

LF, Long fallow; DC, double-crop. Faba bean, field pea, or canola/mustard can substitute for chickpea and other summer crops for sorghum. Barley can substitute for wheat.

High (25% diseased plants)	Medium (11–24%)	Low (10%)
LF–sorghum–DC chickpea–wheat	Pre-plant burn–chickpea–wheat	No limitation to crop choice. However, regular inclusion of break crops will prevent crown rot levels from rising
Chickpea–LF–sorghum–LF–wheat	Chickpea–pre-plant burn–wheat	
DC Mungbean–LF–sorghum–DC chickpea–wheat	LF–sorghum–wheat	
LF–sorghum–LF–wheat–chickpea	DC Summer crop–LF–wheat	
3 Years lucerne provided it is kept grass-free		

Growing barley before wheat in paddocks with high crown rot inoculum is not an option as yield loss can result.

All current barley varieties are very susceptible and 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 moisture stress interactions with infection, which result in the production of whiteheads. [17]

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 (Vic.) and in northern NSW. The experiments sought evidence for enhanced suppression of crown rot following brassica break crops compared with other non-host rotation crops, as has been previously demonstrated for take-all.

Yield was lower after cereals than after broadleaf break crops and was higher after brassicas than after chickpea. 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.

The results indicate that brassica break crops may be more effective than chickpea in reducing crown rot infection of following crops and that tolerant wheat varieties can suffer yield penalties in the absence of visible symptoms such as whiteheads. [18]

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 an increased disease management benefit under low disease conditions.

More information

http://www.regional.org.au/au/asa/2003/c/6/kirkegaard.htm

More information

http://www.grdc.com.au/Media-Centre/Ground-Cover/Ground-Cover-Issue-70-September-October-2007/Crown-rot-Stubble-avoidance-lessens-crown-rot

http://www.nga.org.au/results-and-publications/browse/1/grdc-update-papers-diseases

http://www.nga.org.au/results-and-publications/browse/45/complete-summary

[17] 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

[18] 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

Videos

http://www.grdc.com.au/Media-Centre/GroundCover-TV/2013/01/GCTV9

http://www.grdc.com.au/Media-Centre/GRDC-Gallery/Video/ZvsqA-NrcNY

Podcast

http://www.grdc.com.au/Media-Centre/GRDC-Podcasts/Northern-Weekly-Update/2013/10/17-North

More information

http://www.grdc.com.au/~/media/4CA071540A0F4E28AE0FF786D8BCB1DA.pdf

http://www.grdc.com.au/Media-Centre/Ground-Cover/Ground-Cover-Issue-107-NovDec-2013/Stubble-management-still-a-burning-question

More information

http://www.dpi.nsw.gov.au/agriculture/broadacre/guides/winter-crop-variety-sowing-guide

http://www.grdc.com.au/Research-and-Development/National-Variety-Trials/Crop-Variety-Guides

- Inter-row sowing resulted in a useful, but relatively modest, 5% increase in average yield compared with on-row sowing.
- Inter-row sowing is not a tool to enable back-to-back wheat production under moderate–high crown rot risk.
- Inter-row sowing will provide best benefit by incorporation into a crown rot disease management package based on sound crop rotation. [19]

Stubble burning

Burning removes the above-ground portion of crown rot inoculum but the fungus will still survive in infected crown tissue below-ground; 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 as it minimises the negative impacts on soil moisture storage while still reducing inoculum levels.

9.4.6 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.

Details on crown rot resistance or tolerance among bread wheats can be found in the annual *NSW Winter Crop Variety Sowing Guide*, the GRDC/Department of Agriculture, Forestry and Fisheries Queensland (DAFF) *Wheat Variety Guide*, and the National Variety Trials (NVT) website, www.nvtonline.com.au.

In 2007–2009, NGA ran a series of trials across north-western NSW to assess the impact of crown rot on winter cereal yields (Figure 7); 2007 had a very hot, dry finish and the trials showed some significant yield losses from the addition of crown rot inoculum. The years 2008 and 2009 had milder springs and crown rot had less impact on yield.

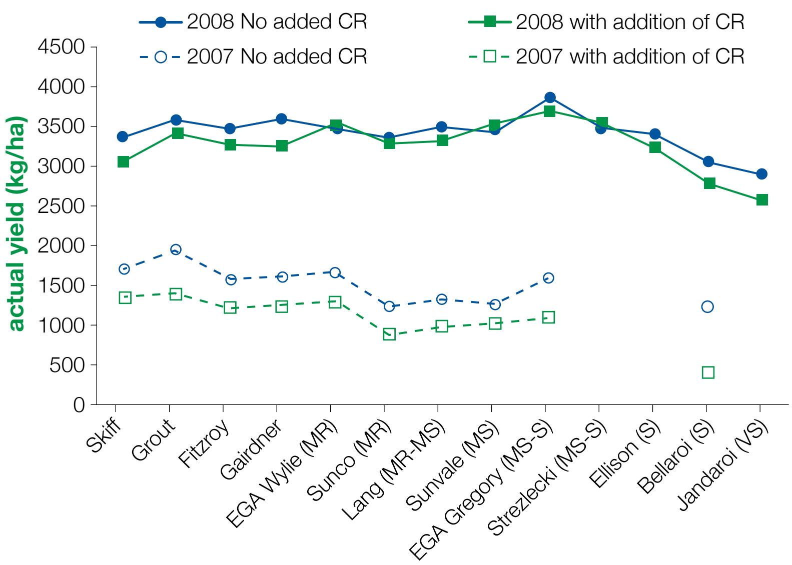

Figure 7: Percentage yield loss by crop 2007 and 2008.

Key findings:

- The level of crown rot yield loss was minimal in the 2008 trials. This highlights the impact of conditions late in the season in determining the level of yield loss due to crown rot.

[19] 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

http://www.grdc.com.au/Research-and-Development/GRDC-Update-Papers/2008/06/The-Impact-of-crown-rot-on-winter-cereal-yields

https://www.grdc.com.au/Research-and-Development/GRDC-Update-Papers/2009/09/THE-IMPACT-OF-CROWN-ROT-ON-WINTER-CEREAL-YIELDS-YEAR-2

Yield response of wheat, barley and durum varieties to crown rot – Rowena 2013, Steven Simpfendorfer, Rick Graham p140-142

Crown rot tolerance in new wheat cultivars is there enough to base varietal decisions on

- Yield loss in barley was similar to that in bread wheat.
- Despite the favourable finish, durum losses were still of concern and more than triple the average loss in barley.
- There was no clear pattern of yield loss difference within either the barley or wheat varieties under the lower crown rot yield loss conditions in 2008. [20]

In 2011 and 2012, CAS, in collaboration with Australian Grain Technologies Pty Ltd, LongReach Plant Breeders and Heritage Seeds, replicated this trial methodology to screen selected current and future cultivars for yield performance in the presence of a known amount of crown rot inoculum.

The crown rot inoculum was added as sterilised durum seed colonised with the fungus *Fusarium pseudograminearum* and applied at a rate of 2 g/m row.

Fourteen new varieties plus five check varieties (EGA GregoryΦ, EGA WylieΦ, Sunco Φ, EGA BellaroiΦ and StrzeleckiΦ) were assessed. EGA GregoryΦ was chosen as the 'standard' with which all others were compared, because of its current commercial popularity (Figure 8). Key results were:

- EGA BellaroiΦ showed significant yield losses in the presence of crown rot at all three sites, which is to be expected with a durum variety.
- Yield performance for a number of new wheat varieties look promising relative to EGA GregoryΦ in the presence of crown rot.
- Current ratings are a fair representation of crown rot index and percentage yield loss.

- The current rating system does not take into account a variety's inherent yield capability; therefore, variation exists between the ratings and actual yield under disease pressure. There is merit in establishing a crown rot tolerance rating system that does account for the yield potential of a variety when exposed to low, medium or high risk of crown rot. [21]

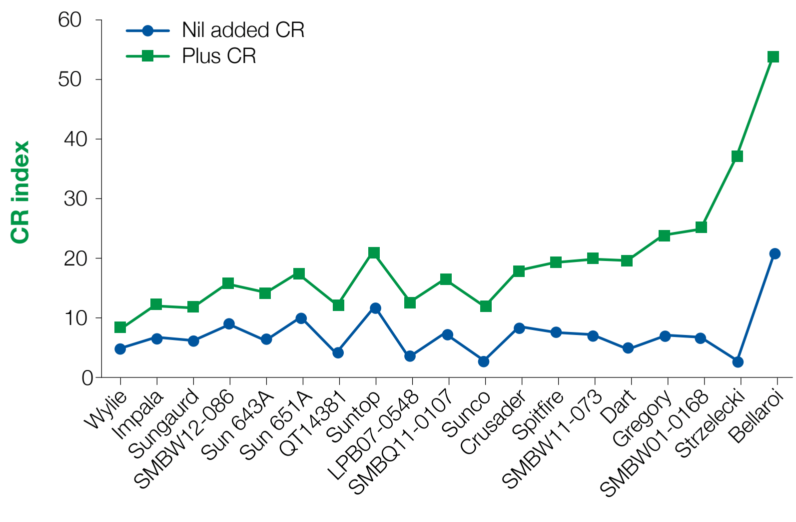

Figure 8: Crown rot (CR) index by variety in 2012 (three sites combined).

Other results to note (Table 2, Figures 9-12):

- Crown rot index/100 is a measure of crown rot incidence and severity.
- All varieties showed an increase in crown rot index with added crown rot inoculum.

[20] GRDC (2009) The impact of crown rot on winter cereal yields—year 2. GRDC Update Papers 17 Sept. 2009, https://www.grdc.com.au/Research-and-Development/GRDC-Update-Papers/2009/09/THE-IMPACT-OF-CROWN-ROT-ON-WINTER-CEREAL-YIELDS-YEAR-2

[21] R Long, D Penberthy (2013) Crown rot tolerance levels in current and future cultivars. GRDC Update Papers 26 Feb. 2013.

- Suntop⚬ had high incidence readings at one site.
- EGA Wylie⚬ was the least affected by crown rot, and EGA Bellaroi⚬ was the worst.
- EGA Bellaroi⚬ durum performance was significantly affected by crown rot.
- Average bread wheat yield loss due to crown rot: was103 kg/ha (2.6%).
- Average EGA Bellaroi⚬ durum yield loss due to crown rot was 830 kg/ha (26.7%).
- EGA Wylie⚬ was the second lowest yielding bread wheat despite not losing yield to crown rot.
- EGA Gregory⚬ had strong yield under lower crown rot pressure.
- EGA Gregory⚬ is shown as the standard due to its current commercial popularity.
- There were positive yield trends for most of the new suite of varieties relative to EGA Gregory⚬ in the presence of higher crown rot. In other words, the more crown-rot-tolerant varieties outperformed EGA Gregory⚬ when exposed to higher inoculum levels.

Table 2: Yield loss for each crop–crown rot inoculum (CR) combination and CR index at each site, 2012

	Bellata		Weemelah		Rowena	
	CR Index	Yield	CR Index	Yield	CR Index	Yield
Average for bread wheat						
–CR	2.8	3.75	4.0	3.37	9.0	3.40
+CR	5.0	3.66	13.4	3.27	28.4	3.32
		–2.6%		–2.7%		–2.5%
Average for durum wheat						
–CR	20.7	3.50	20.4	3.03	16.9	2.68
+CR	58.9	2.49	48.9	2.25	48.7	1.99
		–28.9%		–25.6%		–25.7%

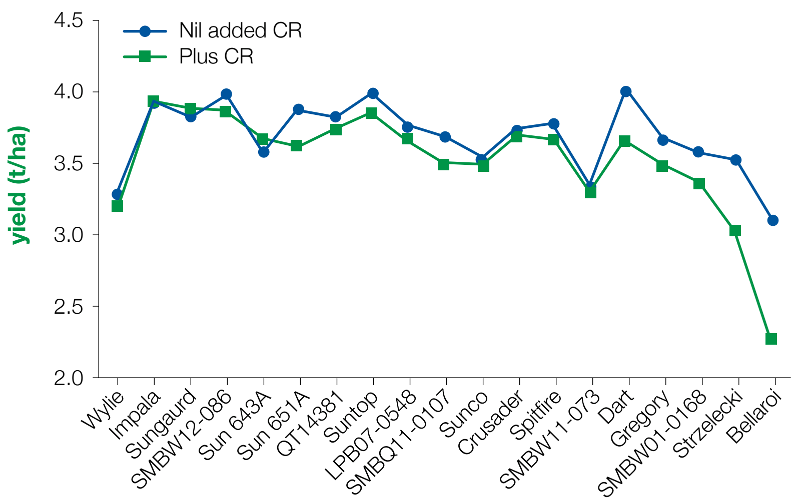

Figure 9: Actual yield by variety with and without crown rot (CR) inoculum (three sites combined).

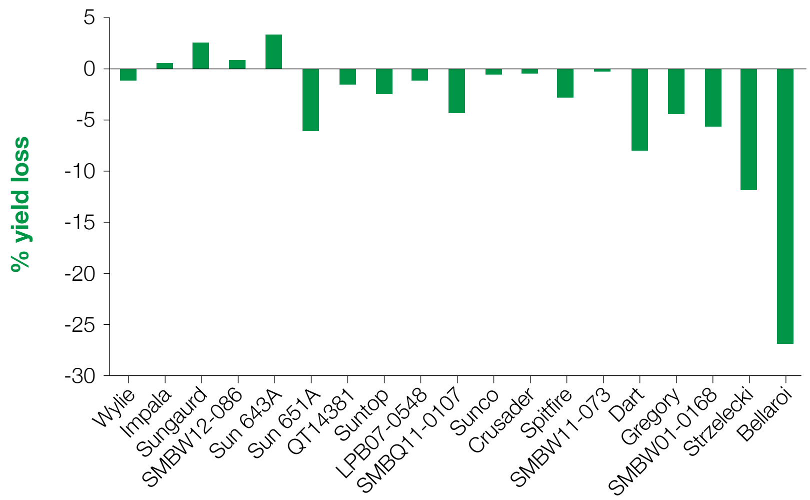

Figure 10: Yield loss by variety with crown rot (CR) inoculum, 2012 (three sites combined).

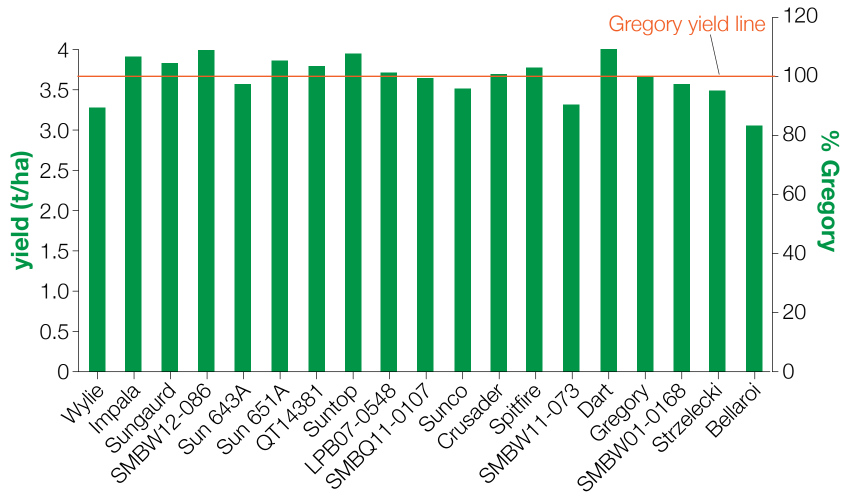

Figure 11: Yield (t/ha) by variety compared with EGA Gregory⚌, without added crown rot (CR) inoculum, at three sites.

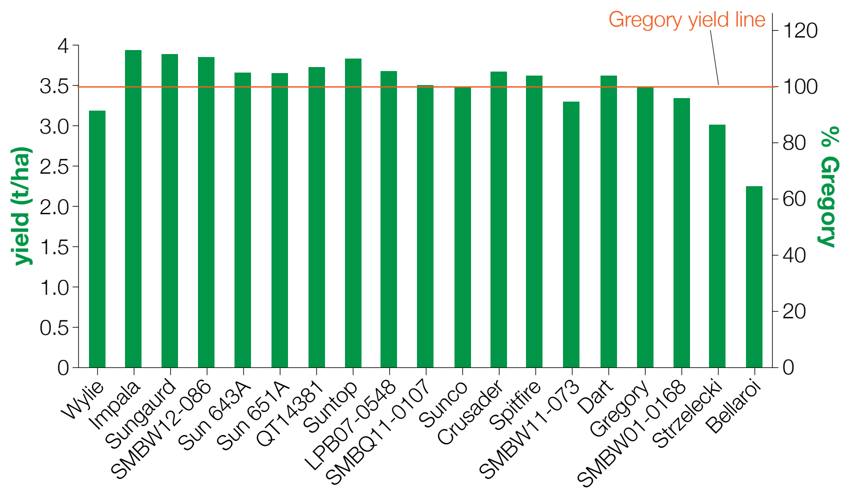

Figure 12: Yield (t/ha) by variety compared with EGA Gregory⚌, with crown rot (CR) inoculum added, at three sites.

Quality

Screenings doubled in EGA Bellaroi⚼ durum due to added crown rot, but trends were inconsistent in bread wheat (Figure 13). Test weight was not affected in EGA Bellaroi⚼ durum (Figure 14).

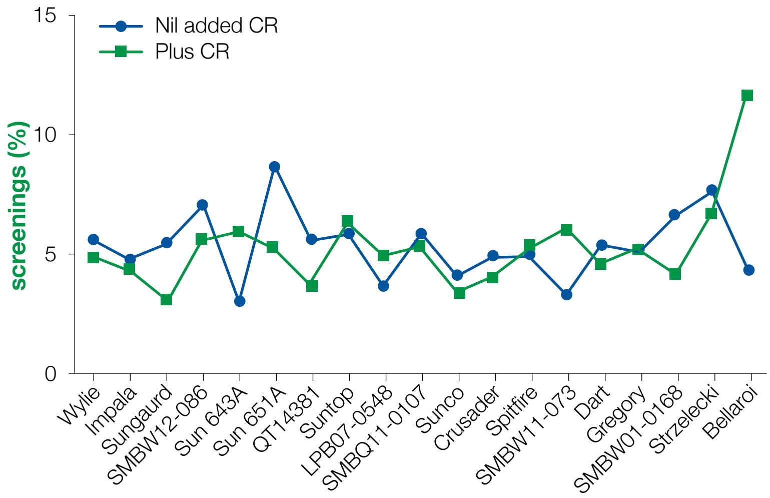

Figure 13: Influence of crown rot (CR) on screenings percentage at three sites.

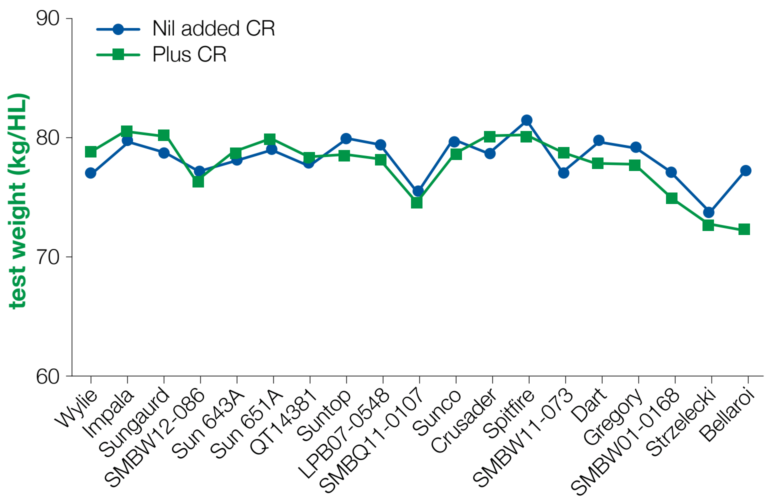

Figure 14: Influence of crown rot (CR) on test weight (kg/HL) at three sites.

How well do the current ratings stack up?

Table 3: Current crown rot (CR) resistance ratings v. CAS 2012 yields

S, Susceptible; MS, moderately susceptible; R, resistant, MR, moderately resistant

Variety	NSW rating	Qld rating	CAS plus CR yield 2012
EGA Wylie⟮D	MR–MS	MR–MS	91.9
Sunguard⟮D	MR-MS(p)	MS	111.2
Suntop⟮D	MR–MS	–	110.3
Sunco	MS	MS	99.9
LongReach Crusader⟮D	MS	S	105.5
LongReach Spitfire⟮D	MS	MS	104.4
LongReach Dart⟮D	MS–S	–	104.4
LongReach Impala⟮D	MS–S	MS	112.5
EGA Gregory⟮D	S	S	100.0
Strzelecki⟮D	S	S	86.3
EGA Bellaroi⟮D	VS	VS	64.6

Table 3 presents a comparison of current crown rot resistance ratings with the results from the CAS trials:

- Current ratings are a fair representation of crown rot index and percentage yield loss.
- The current rating system does not take into account a variety's inherent yield capability; therefore, there is variation between the ratings and actual yield under disease pressure.
- There is merit in establishing a crown rot tolerance rating system that accounts for the yield potential of a variety when exposed to low, medium or high risk of crown rot.
- More work will be required to define what constitutes low, medium and high risk of crown rot. It will be a combination of inoculum load, plant-available water content at sowing and a selection of soil physical and chemical parameters that influence the crops water extraction capability during grain-fill.

Seven GRDC funded trials run from 2012 to 2014 by NSW DPI and CAS found recently released varieties demonstrated improved yield performance in the presence of crown rot relative to EGA Gregory. These were: Sunguard (+17%), Suntop (+16%), LRPB Lancer (+15%), Spitfire (+12%) (Table 4).

Each variety had either added or no added crown rot inoculum as millet (or durum) grain colonised by Fusarium pseudograminearum at a rate of 2g/metre row into the seed furrow at planting. Background disease levels for crown rot and root lesion nematodes were assessed using Predicta B®.

More information

http://www.grdc.com.au/Research-and-Development/GRDC-Update-Papers/2013/02/Crown-rot-tolerance-levels-in-current-and-future-cultivars

Video

http://www.grdc.com.au/Media-Centre/GRDC-Gallery/Video/e66yzXFCe_M

Table 4: Summary of yield responses to added crown rot inoculum relative to EGA Gregory from 7 trials (2012-2014)

Variety	No Added CR	Added CR
Sunguard (MS#)	103% (7*)	117% (7)
Sunco (MS)	97% (5)	101% (5)
LRPB Spitfire (MS)	102% (7)	112% (7)
LRPB Lancer (MS-S)	101% (7)	115% (7)
Mitch (MS)	104% (7)	110% (7)
Suntop (MS-S)	108% (7)	116% (7)
EGA Gregory (S)	100% (7)	100% (7)
EGA Bellaroi	82% (7)	61% (7)

CAS data for 2012 (Bellata,Weemelah, Rowena) 2013 (Bellata, Weemelah) and NSW DPI data for 2014 (Garah and Tamworth). Caparoi was used instead of Bellaroi at Garah and Tamworth)

*denotes number of trials

# denotes CR resistance rating

Note: Viking, Gauntlet and Sunmate were only assessed on two trials in 2014 and more testing is required.

This data is consistent with that of NSW DPI (S Simpfendorfer) who in 2013 found that when averaged across 11 sites under high crown rot pressure (added CR), Suntop was 0.42 t/ha, LRPB Lancer 0.51 t/ha, Sunguard 0.61 t/ha and LRPB Spitfire 0.63 t/ha higher yielding than EGA Gregory.

Crown rot tolerance data coupled with the resistance ratings provides growers and advisors with information to select varieties based on yield as well as its ability to combat the disease. Tolerance data helps to discriminate yield performance within the resistance ratings. Sunco for instance is rated MS, yet most varieties with a MS-S rating will outperform Sunco in terms of yield, even in the presence of the disease. [22]

A NSW DPI variety trial was conducted at Gurley in northern NSW in 2012. The site had faba beans in 2011 and barley in 2010, and was cultivated using a Kelly-chain prior to sowing in 2012. The trial site was soil-cored (0–30 cm) for PreDicta B to determine background pathogen levels at sowing in 2012. The site had high levels of the RLN *Pratylenchus thornei* (*Pt*) (9,183 *Pt*/kg soil) and medium risk of crown rot (140 pg *Fusarium*/kg soil). Ten bread wheat varieties and one durum variety were sown in replicated plots and evaluated for their relative tolerance to both *Pt* and crown rot. The tolerance and resistance rating of each variety to *Pt* or crown rot and yield outcomes are outlined in Table 5.

22 http://www.grdc.com.au/Research-and-Development/GRDC-Update-Papers/2015/03/Crown-rot-tolerance-in-new-wheat-cultivars-is-there-enough-to-base-varietal-decisions-on

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More information

http://www.grdc.com.au/Resources/Factsheets/2011/02/Wheat-Breeding

http://www.nga.org.au/results-and-publications/download/50/grdc-update-papers-diseases/root-lesion-nematodes-in-winter-cereals/grdc-grower-update-paper-moree-august-2010.pdf

http://www.grdc.com.au/~/media/AAB89810FC2344D4AFC029BC48D2C0C0.pdf

http://www.grdc.com.au/uploads/documents/GRDC-FS-CrackingWheatsToughestNuts.pdf

Table 5: Pratylenchus thornei tolerance, crown rot resistance ratings and yield of 10 bread wheat and one durum variety evaluated at Gurley in 2012

T, Tolerant; MT, moderately tolerant; I, intolerant, MI, moderately intolerant; VI, very intolerant; S, susceptible; MS, moderately susceptible; R, resistant, MR, moderately resistant; VS, very susceptible. Yield values followed by the same letter are not significantly different at P = 0.05

Variety	*Pt* tolerance	Crown rot resistance	Yield (t/ha)
Suntop⚛	MT	MS	2.95a
Sunguard⚛	T–MT	MR–MS	2.64ab
LongReach Spitfire⚛	MT	MS	2.51ab
Baxter⚛	MT–MI	MS	2.38b
Livingston⚛	MT–MI	MS–S	2.36b
Ventura⚛	MT–MI	MS–S	2.27bc
LongReach Crusader⚛	MI–I	MS	2.22bc
EGA Gregory⚛	MT	S	1.90cd
Sunzell⚛	MT–MI	S	1.56de
Ellison⚛	I–VI	S–VS	1.41e
Caparoi⚛	MT–MI	VS	0.89 f

Both *Pt* and crown rot had significant impact alone and as did the combination, with the clear message that varieties that are very susceptible or intolerant of either of these two pathogens should not be grown in medium- to high-risk situations. [23]

For more information see: *Section 8: Nematodes*.

9.5 Rusts

In the northern region, there are three rust diseases of wheat:

- stripe rust
- stem rust
- leaf rust

They are caused by three closely related fungi, all belonging to the genus *Puccinia*.

The rusts are so-named because the powdery mass of spores that erupt through the plant's epidermis have the appearance of rusty metal. These spores can be spread over considerable distances by wind but may also be spread on clothing and equipment.

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 only survive on green, growing plant tissue. Plants facilitating the survival of rust fungi (alternative hosts as show in Table 6 or volunteer cereals) through the summer are known as the 'green bridge'.

[23] S Simpfendorfer ,M Gardner (2013) Crown rot: be aware of the balancing act or the fall may be harder!, GRDC Update Papers 25 Feb. 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

A 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18

Table 6: *Alternative hosts for cereal rusts* [24]

Disease	Pathogen	Primary hosts	Alternate 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 triticiduri*	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

More information

www.nvtonline.com.au

http://www.grdc.com.au/GCS110

Stem rust control in wheat

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.

Rust diseases occur throughout the wheat-growing northern regions, frequently causing economic damage. In Queensland in recent times, stripe rust has been the most important of these diseases.

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

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 monitored for foliar diseases on a regular basis. See the University of Sydney's Plant Breeding Institute (PBI) site and publications for more information. Download: http://sydney.edu.au/agriculture/documents/pbi/cereal_rust_report_2010_vol_8_1.pdf.

Monitoring should start no later than GS32, 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 that these leaves are protected from diseases. [25]

To keep up to date with rust incursions throughout the winter crop season, subscribe to the PBI '*Cereal Rust Report'* at: http://sydney.edu.au/agriculture/plant_breeding_institute/rust_alert.shtml

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

9.5.1 Key points to reduce the risk of rusts in wheat

- Destroy volunteer wheat plants by March, as 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.

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

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

- 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 DAFF fact sheets, charts, website 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; be protective of 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 any 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 MRMS (the minimum disease resistance standard) or better. In high-risk regions, varieties rated MR or better are recommended.

Where 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. [26]

For more information, download the GRDC Fact Sheet '*Adult plant resistance'* from: http://www.grdc.com.au/GRDC-FS-AdultPlantResistance

More information

http://www.daff.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/wheat/diseases/wheat-disease-photo-gallery

http://www.daff.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/wheat/diseases

9.5.2 Diagnosing leaf diseases in wheat

Refer to Table 7 and the following websites for the symptoms of leaf diseases in wheat.

Table 7: Diagnosing leaf diseases in wheat [27]

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

26 GRDC (2012) Adult plant resistance. GRDC Fact Sheet Nov. 2012, http://www.grdc.com.au/GRDC-FS-AdultPlantResistance

27 DAFF (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

9.5.3 Recommended fungicides for rusts

To keep up to date with the latest recommended fungicides for rusts, visit www.apvma.gov.au.

Inclusion of a fungicide when performing an in-crop weed spray around mid-tillering (GS25) in wheat crops has become common practice commercially in much of northern NSW for managing stripe rust. The three top leaves in wheat are the highest yield contributors, 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 variety Ellison⁽ᴾ⁾.

Up-front options are not used widely in central and northern NSW. In particular, the use of flutriafol (Intake) on starter fertiliser and to a lesser extent Triad in-furrow provided good levels of disease control and return on investment under both high and moderate disease pressure in 2011. These were the cheaper options examined so also had the lowest risk exposure under low disease pressure where, due to a lack of significant stripe rust infection, none of the fungicide strategies provide a yield benefit. For these trials, good coverage of the starter fertiliser (Granulock 12Z) was obtained with the various in-furrow treatments due to the ability to rapidly dry the wet fertiliser after treatment because of the small volumes required. This can present a logistical problem commercially but these in-furrow treatments appear worthy of consideration and further evaluation.

Finally, no significant yield benefit was obtained at any of the 13 sites in 2011 from any of the fungicide strategies aimed at controlling stripe rust in the MR variety EGA Gregory⁽ᴾ⁾. Even at North Star, which had the highest pressure from stripe rust in 2011, there was no benefit from even the full disease control (Intake + GS32 + GS39). None of these sites had the complication of infection from yellow spot, a different stubble-borne leaf disease to which EGA Gregory⁽ᴾ⁾ is susceptible. In terms of stripe rust alone, management in the MR variety EGA Gregory⁽ᴾ⁾ was not warranted in 2011. [28]

9.6 Stripe rust (yellow rust)

Figure 15: Stripe rust in wheat. (Photo: QDAFF)

[28] S Simpfendorfer, Z Taylor (2012) Fungicide management of strip rust in wheat: upfront vs incorporations. GRDC Update Papers 10 April 2012, http://www.grdc.com.au/Research-and-Development/GRDC-Update-Papers/2012/04/Fungicide-management-of-stripe-rust-in-wheat-upfront-vs-incrop-options-in-2011

More information

http://www.grdc.com.au/Research-and-Development/GRDC-Update-Papers/2008/07/STRIPE-RUST-MANAGEMENT-PREVENTION-IS-GENERALLY-BEST

http://www.grdc.com.au/Research-and-Development/GRDC-Update-Papers/2012/04/Fungicide-management-of-stripe-rust-in-wheat-upfront-vs-incrop-options-in-2011

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 15). The spores occur on the upper surface of the leaves, the leaf sheaths, awns and inside of the glumes. See photos of stripe rust in wheat.

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 moderately susceptible (= 5, MR–MS) or lower. This is 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, on if 'money' leaves (the flag leaf and the two leaves below it) require protection, recommended foliar fungicides can be applied for the control of stripe rust.

In Queensland, stripe rust pathotypes 134 E16 A+ and 134 E16 A+17+ were prevalent during 2011. Grain growers should refer to the wheat varieties guide when selecting stripe rust resistant varieties as there is a threat from additional stripe rust pathotypes 134 E16 A+J+ and 134 E16 A+J+ T+ which have been identified in Queensland and NSW. [29]

9.7 Leaf rust (brown rust)

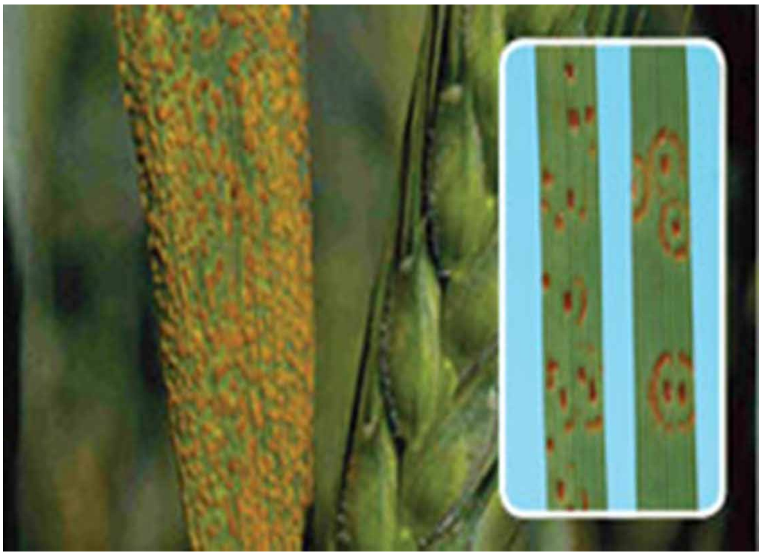

Figure 16: Leaf rust in wheat. (Photo: QDAFF)

Leaf rust (Figure 16) 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-coloured spores that occur in small, 1.5-mm, circular to oval-shaped pustules. These are found on the top surface of the leaves, distinguishing leaf rust from stem rust, which is found on both surfaces of the leaf.

The spores require 15–20°C temperature and free moisture (dew/rain/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.

29 DAFF (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

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Find out about the use of foliar fungicides to control leaf rust. [30]

A new strain of leaf rust was detected in South Australia in August 2014. Tests by the Plant Breeding Institute, Cobbitty, NSW, indicate that this rust was an exotic incursion which, for the first time, combined virulence for three popular resistance genes present in some commercial varieties. This strain was detected as far north as Narrabri, NSW, in the 2014 season. Results from NVT trials in South Australia and Victoria were used to provide resistance ratings for 2015. Some varieties appear more susceptible than previously rated. Growers are advised to monitor crops rated MS or higher.

There were no reports of significant leaf rust in 2014. Leaf rust is often rare in Queensland, but farmers in the region should keep a watch on their crop's development that have good resistance, or that develop severe disease. In either case contact your local agronomist or a pathologist for advice. [31]

With the presence of the new leaf rust pathotype in NSW, growers should check the new variety ratings as many have been downgraded and now may be susceptible to leaf rust. [32]

9.8 Stem rust (black rust)

Figure 17: Stem rust in wheat. (Photo: QDAFF)

Stem rust is caused by the fungus *Puccinia graminis* f. sp. *Tritici* (Figure 17). 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.

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.

Queensland wheat varieties have reasonable resistance to stem rust (rating 5 or higher). However, stem rust has had the ability to cause significant economic damage (50–100%

30 DAFF (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

31 New reference: NVT Queensland Wheat Variety Guide 2015: www.grdc.com.au/Resources/Publications/2015/03/NVT-Queensland-Wheat-Variety-Guide-2015

32 New reference: Winter crop variety sowing guide 2015: http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0011/272945/winter-crop-variety-sowing-guide-2015.pdf

of yield). This has happened when conditions are conducive for the disease and susceptible varieties are grown, or a new stem rust pathotype has developed that has overcome the wheat's resistance.

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

More information

http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0006/158964/stripe-rust-in-wheat.pdf

http://www.grdc.com.au/Resources/Links-Pages/RustLinks/Update-papers

9.9 Tan spot (yellow spot)

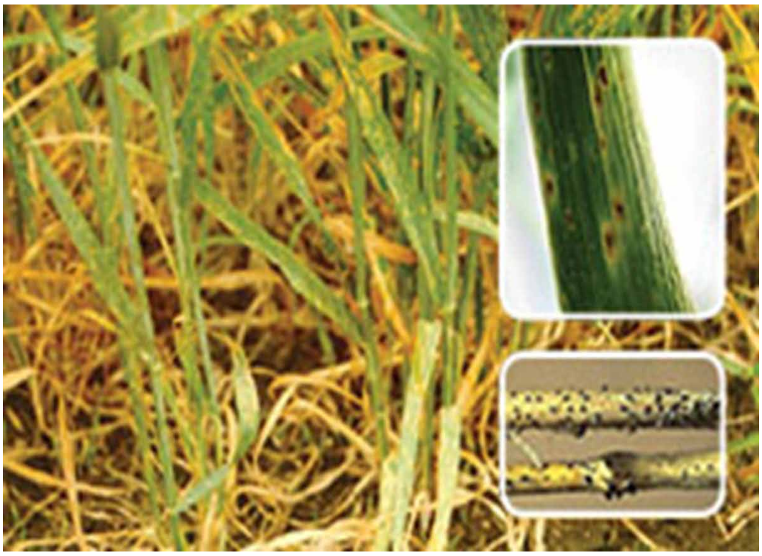

Figure 18: Yellow/tan spot in wheat. (Photo: QDAFF)

Tan spot or yellow spots causes tan-brown flecks turning into yellow-brown, oval-shaped spots/lesions surrounded by yellow margins (Figure 18); lesions may expand to 10-12 mm in diameter. Large lesions coalesce with dark brown centres. Spot develops on both sides of leaves. Temperatures 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. [33]

More information

http://www.dpi.nsw.gov.au/agriculture/broadacre/guides/winter-crop-variety-sowing-guide

http://www.grdc.com.au/Research-and-Development/National-Variety-Trials/Crop-Variety-Guides

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.

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.

[33] DAFF (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

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 chickpea
- 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.

Fungicides used against yellow spot in Australia include:

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

More information

http://www.daff.qld.gov.au/__data/assets/pdf_file/0009/54738/AgChem-UsersManual.pdf

Images:
http://www.daff.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/wheat/diseases/wheat-disease-photo-gallery

Timing for applying the chosen fungicide is crucial, and growers can use short-term weather forecasts to assist in the timing of fungicides. 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. [34]

9.10 Yellow spot *v.* stripe rust

Yellow spot is caused by the fungus *Pyrenophora tritici-repentis* and is what is termed a 'necrotrophic' pathogen. This means that the fungus feeds on dead plant cells. By contrast, stripe rust is caused by a 'biotrophic' fungal pathogen, which means it feeds off living cells. Why is this difference important?

Being a necrotroph, the yellow spot fungus has to kill the wheat cells before it can feed on them. To do this, the fungus produces a toxin that, in the process of killing the cells, makes them appear yellow. This is why a discrete yellow margin is seen around a lesion. It is the fungus killing cells just in advance of where it is going to feed next. As the fungus continues to grow in the leaf, the lesions get bigger and the previously fed-on tissue dries and takes on the characteristic tan (dried dead leaf tissue) appearance.

True yellow spot lesions are therefore distinct, in that they are tan surrounded by a tight yellow margin (halo) where the fungus is producing more toxin to feed next. It would not be to its advantage to mass-produce toxin and kill all the leaf at once, which would appear as more widespread yellowing within leaves, as this would open the tissue up to colonisation by a range of other competing saprophytes (which feed off already dead tissue) naturally present in every paddock. Being a necrotrophic leaf pathogen also influences the efficacy of fungicides.

All fungicides, once inside the leaf, travel in the xylem and only travel in one direction—towards the leaf tip. As xylem only flows one way, from the base of the leaf towards the tip, the fungicides cannot move back down a leaf. Therefore, only leaves that have

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

emerged at the time of a fungicide application are protected and the length of protection is dictated by how quickly the fungicides move in the xylem to the leaf tips.

Stripe rust, being a biotroph, feeds off living tissue and it does not interrupt the xylem activity through its infection process. Mobile DMI fungicides applied to a wheat leaf infected with stripe rust can move through leaf cells and the xylem and effectively kill off the whole infection if applied early enough. DMI fungicides typically have 4–7 days of 'kick-back' activity on stripe rust. This means they can control infection for up to 4–7 days after spores land on the leaf. This is still long before any symptoms of disease can be seen.

By contrast, cells that are killed by the toxin released by the yellow spot fungus include the xylem, so in a tan spot lesion (dried dead leaf tissue), there is no longer xylem activity and no way for a fungicide to penetrate this region (remember fungicides only move in xylem). Consequently, fungicides have difficultly accessing an established yellow spot infection to kill it. The process of killing wheat cells in advance of where the fungus feeds gives the yellow spot fungus the added advantage that it prevents the movement of fungicides into that region of the leaf.

Another key issue is that unlike the longer 'kick-back' period for DMI fungicides on a disease such as stripe rust, the level of kick-back on tan spot is very poor, 0–2 days at best. For an applied fungicide to control an existing infection, it needs to be applied almost immediately after the infection starts. This issue is compounded by potentially continual release of spores from primary and secondary infections on stubble and on the lower leaves of the plant.

9.10.1 Hosts and risk factors

Bread wheat is the primary host of yellow spot. It can also infect durum and triticale, but current varieties tend to have moderate levels of resistance. Besides being a pathogen, the yellow spot fungus is a very effective saprophyte (it likes to feed on dead tissue). Hence, as wheat, durum or triticale plants naturally senesce late in the season they become more prone to saprophytic infection irrespective of their resistance rating.

Therefore, any wheat variety and for that matter barley, which is not infected when green, can saprophytically host the yellow spot fungus and generate inoculum for the following season. Generally, however, significantly more inoculum will be generated on stubbles of more susceptible wheat varieties (e.g. EGA Gregory⫯). Hence, sowing a susceptible wheat variety on stubble of a previously infected susceptible variety (e.g. Gregory⫯-on-Gregory⫯) represents a much higher risk for developing high levels of yellow spot.

The yellow spot fungus is a stubble-borne pathogen; hence, minimum tillage, stubble retention, wheat-on-wheat rotations and growing susceptible wheat varieties (particularly in sequence) dramatically increase the risk of developing damaging levels of yellow spot. However, weather conditions are the overriding risk factor. Yellow spot can develop across a relatively wide temperature range, with 15°–28°C being optimal. More than 6 hours of leaf wetness or dew is also required for both infections and sporulation (further inoculum production) on old lesions. The incidence and severity of yellow spot therefore increases as moisture periods lengthen, such that it takes repeated rain events to drive the disease from the lower to the upper canopy later in the season. Yellow spot is therefore generally considered a significant disease in very wet seasons (e.g. 1998 and 2010), where yield losses of up to 30% have been recorded in susceptible wheat varieties.

9.10.2 Correct identification

Yellow spot is frequently misdiagnosed within industry, so if you think your paddocks have yellow spot or you have been advised that they have yellow spot and that you need to spray a fungicide, do some simple checks first.

Is there wheat stubble visible in the paddock? Yellow spot is essentially a disease of wheat-on-wheat rotations as it is a stubble-borne pathogen. Burning, stubble grazing and cultivation can be effective in reducing yellow spot inoculum but depend on completeness of stubble removal. If wheat stubble is still visible, then yellow spot inoculum may also still be present.

Are black fruiting bodies (pseudothecia) visible on the stubble? By autumn–winter, black, pinhead-sized, raised structures with hair-like projections (rough if rubbed with finger) will be visible on wheat stubble. These are responsible for the initial leaf infections at seedling stages and establishing lesions in the lower canopy, which drives secondary disease development later in the season.

Do the lesions 'spots' look right? Are they initially small, brown spots with discrete yellow margins, becoming more elongated and tan (dead dried leaf tissue) with age, still with a very tight yellow (toxin production) margin. Yellow spot does not cause extensive general yellowing of leaves.

Is the distribution on individual leaves and within leaves on a tiller right? Yellow spot spores (ascospores or conidia) land randomly on individual wheat leaves and require adequate moisture for >6 h to germinate and infect. Hence, symptoms are randomly distributed across an individual leaf. Yellow spot does not concentrate towards the leaf tip. Inoculum generally comes from lower down in the canopy (stubble or old leaf lesions). Hence, pulling off an individual infected tiller, you will see a clear pattern of distribution on the leaves. More and larger lesions will occur on the lowest leaves (they have been emerged longer so prone to more infection events and greater time for fungal growth to spread through leaf) and fewer and smaller lesions progressively higher up the tiller to the next leaf.

If you are unsure, then consider getting a second opinion from a plant pathologist, who can force the yellow spot fungus to sporulate in the laboratory. They have microscopes powerful enough to observe the distinctive spores and to provide a definitive diagnosis, which is not practical in the field. [35]

9.10.3 Why are fungicides less effective against yellow spot?

The yellow spot fungus is a necrotroph (feeds on dead cells). By killing the wheat cells in advance of where it spreads in a leaf, the fungus effectively limits fungicide penetration into the lesion, as there is no xylem activity. Hence, a yellow spot lesion is never killed by a fungicide. After fungicide application, the production of conidia from the lesions is reduced, but not eliminated, and generally, the lesions do not elongate further when the active ingredient is still in the leaf (2–4 weeks).

All fungicides have very limited kick-back activity against yellow spot. Recent German data demonstrate that the main fungicides (and a huge range of experimental actives) only provide 0–2 days kick-back activity.

Fungicides have much stronger protectant activity against yellow spot—again from the German study, 15–30 days at full registered rates of common actives. An important consideration is: when are they being applied in relation to infection events (i.e. rainfall)?

None of the up-front, seed or in-furrow fungicides has activity against early yellow spot infections. [36]

9.10.4 What about early fungicide sprays?

Yellow spot is commonly a problem in wheat-on-wheat situations at seedling growth stages (emergence through tillering) in the northern region when susceptible varieties are grown (e.g. EGA Gregory⫽, Spitfire⫽ etc). It is less common that yellow spot progresses into the upper canopy to affect the top three leaves, the main contributors to grain yield, as this requires frequent (often prolonged) rainfall events during the season.

[35] 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

[36] 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

Recent research data (NGA and Grain Orana Alliance) show that early fungicide applications during these seedling stages are not economical, for the following reasons.

During tillering, the key yield-contributing leaves (top three) have not emerged yet and they will not be protected by a fungicide application at this earlier stage. Fungicides only protect the leaves that they contact and can only move one way towards the leaf tips, with the water (xylem) flow.

Infection from ascospores on the previous wheat stubble can occur over a protracted period, as the fruiting bodies do not all mature at the same time. Canadian research has shown that ascospores can be continually released from the stubble from tillering right through to grain-fill (Figure 19). Infected stubble is a source of inoculum throughout the season. New leaves that emerge after a fungicide application are unprotected and can become rapidly infected off the stubble if there is adequate moisture.

Any inoculum reduction gained through limiting the number of early leaf infections in the lower canopy is quickly swamped by the mass of ascospores released from continually maturing fruiting bodies on the stubble throughout the season, given conducive weather conditions. [37]

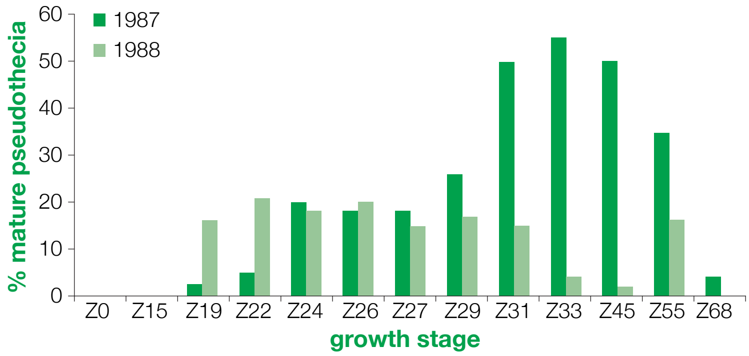

Figure 19: Release of ascospores from yellow spot fruiting bodies on wheat stubble across the season in Canada 1987–1988. (Source: Wright et al. (1990) Canadian Journal of Plant Pathology.)

9.10.5 Make management decisions at or before sowing

- Do not sow wheat-on-wheat.
- If you are going 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, as 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, as they have reduced efficacy against this leaf disease. [38]

More information

http://www.grdc.com.au/Research-and-Development/GRDC-Update-Papers/2013/03/Management-of-yellow-spot-in-wheat-decide-before-you-sow

[37] 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

[38] 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

9.11 Common root rot

Common root rot is a soil-borne fungal disease that attacks wheat, barley and triticale. 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 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.

Common root rot symptoms:

- a 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.

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. Summer crops such as sorghum, sunflower, or white French millet can be used for this purpose.

More information

http://www.dpi.nsw.gov.au/agriculture/broadacre/guides/winter-crop-variety-sowing-guide

http://www.grdc.com.au/Research-and-Development/National-Variety-Trials/Crop-Variety-Guides

9.12 Smut

9.12.1 Bunt or stinking smut

This disease affects mature wheat ears, in which a mass of black fungal spores replaces the interior of the grain and forms a bunt ball. Infected plants are shorter and have darker green ears 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 has not been recorded in commercial wheat crops in Queensland for >30 years. This is probably because of the widespread use of fungicidal seed dressings.

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.
- All seed entering Queensland should be treated with a fungicidal seed dressing that will control bunt.
- Grain from a crop with bunt should not be used for seed.
- On farms where a crop has been affected by bunt, all wheat seed should be treated with fungicidal seed dressing for at least 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. [39]

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

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9.13 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. [40]

More information

[Cereal disease update - net blotch, eyespot, wheat streak mosaic virus and white grain](#)

9.14 Wheat streak mosaic virus

Wheat streak mosaic virus (WSMV) was found in commercial wheat crops in Queensland during the 2003 season. However, its geographic distribution throughout the region is still unknown, as are the potential impacts from the virus on yield.

Surveys have confirmed WSMV is established and widespread in south-eastern Australia.

Wheat plants infected with WSMV have discontinuous, yellow-streaked and mottled leaves. 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*.

WSMV is unable to 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 microscopic, about 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 periods away from living plant material.

WSMV cannot survive outside a host plant or the vector, the wheat curl mite. 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 green plant material should be dead, as a minimum, 2 weeks before sowing the next wheat crop. [41]

9.15 Botryosphaeria head blight—BHB (white grain disorder)

White grain was conspicuous in harvested samples of wheat in the 2010 season. This symptom is the result of infection with one of principally two fungal pathogens:

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

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

More information

http://www.grdc.com.au/Research-and-Development/GRDC-Update-Papers/2011/04/Wheat-and-barley-disease-management-in-2011-Yellow-spot-and-head-diseases-in-wheat-Strategies-and-products-for-barley-leaf-rust

Fusarium graminearum and *Botryosphaeria zeae*. Fusarium head blight (FHB) or head scab is the disease that causes white grain and head blight from infection by *Fusarium* species. White grain or white grain disorder is the terminology currently used to describe the disease caused by *B. zeae*. It is proposed that this disease be known in future as Botryosphaeria head blight (BHB). [42]

9.16 Fusarium head blight

The extensive rain and warm conditions during flowering of the crop in 2010 resulted in the first widespread significant occurrence of FHB in wheat, durum and barley crops in southern Queensland. This caused significant downgrading of some crops. Until recently, FHB has been reported irregularly and in isolated areas of Australia´s northern region. The most significant infections in the past occurred in durum crops on the Liverpool Plains in the late 1990s.

Fusarium head blight is a fungal disease that can occur on many grass species, including crop and weeds. Where it occurs in crops, it is most common in wheat, durum and barley. It is a frequent and widespread disease of major wheat-production areas of North America, Asia and Europe, where much research into its control has been ongoing for >20 years.

Fusarium head blight can cause significant yield losses and quality reductions. Major yield losses occur mainly from floret sterility. Additional yield and quality losses can occur when damaged and shrivelled lightweight grains are produced because of infection. Quality reductions may also occur from seed discoloration, varying from whitish grey, pink to brown. Fungal infection can sometimes be associated with the production of a toxin (mycotoxins).

If fungal toxins are produced in infected seed, the grain is often unacceptable for certain end uses and downgraded in the marketplace depending on the concentration of toxin present. Toxin levels and fungal infection cannot be accurately estimated from visual appearance. [43]

9.16.1 Symptoms

Bread wheat and durum

In wheat and durum, any part or all of the head may appear bleached (Figure 20). Heads that are partly white and partly green are one of the diagnostic symptoms in wheat for the disease, but can easily be confused with ´white grain disorder´.

Figure 20: Head bleaching. (Photo: QDAFF)

A brown/purple discoloration on the stem tissue or on the peduncle (immediately below the head) in infected heads is another distinguishing factor that can be seen in heavily FHB-infected crops. Discoloration on the stem tissue or peduncle without the bleaching may be due to other causes such as physiological melanism.

[42] G Platz (2011) Wheat and barley disease management in 2011. Yellow spot and head diseases in wheat Strategies and products for barley leaf rust. GRDC Update Papers 19 April 2011, http://www.grdc.com.au/Research-and-Development/GRDC-Update-Papers/2011/04/Wheat-and-barley-disease-management-in-2011-Yellow-spot-and-head-diseases-in-wheat-Strategies-and-products-for-barley-leaf-rust

[43] DAFF (2012) Fusarium head blight (FHB) or head scab. Department of Agriculture, Fisheries and Forestry Queensland, http://www.daff.qld.gov.au/plants/health-pests-diseases/a-z-significant/fusarium-head-blight

Additional symptoms that occur during prolonged wet weather and heavy infection of FHB are pin-head-sized, pink to salmon-orange spore masses on infected spikelets and glumes (Figure 21).

Figure 21: Infected spikelets and glumes. (Photo: QDAFF)

Depending on how soon after flowering bread wheat or durum is infected, grain can have different severities of aborted kernels, shrivelled seed, low test weight and grain discoloration. If disease infection occurs later in grain development, *Fusarium*-infected seed may be normal in size but it may have lost its amber translucence and will appear chalky or opaque or pink (Figure 22). [44]

Figure 22: Fusarium-infected seed. (Photo: QDAFF)

Barley

In barley, infected seed may show a bleached appearance or a browning or water-soaked appearance (Figure 23). Severely infected barley grain at harvest may show a pinkish discoloration in the sample, and although rare, salmon-orange spore masses of the fungus can be seen on the infected spikelet and glumes during prolonged wet weather. [45]

Figure 23: Infected barley heads and seed. (Photo: QDAFF)

[44] DAFF (2012) Fusarium head blight (FHB) or head scab. Department of Agriculture, Fisheries and Forestry Queensland, http://www.daff.qld.gov.au/plants/health-pests-diseases/a-z-significant/fusarium-head-blight

[45] DAFF (2012) Fusarium head blight (FHB) or head scab. Department of Agriculture, Fisheries and Forestry Queensland, http://www.daff.qld.gov.au/plants/health-pests-diseases/a-z-significant/fusarium-head-blight

9.16.2 Identity, survival and spread

Pathogen

Several species of *Fusarium* can caused FHB. The most common species causing FHB is *Fusarium graminearum*. This fungus can also cause stalk and cob rot of corn.

The crown rot fungus is a closely related species, *Fusarium pseudograminearum*. The crown rot fungus can occasionally affect heads but this is rare. The infections in Queensland during the 2010 season have been almost 100% *Fusarium graminearum*. [46]

For details of testing services, see *Section 1: Planning and paddock preparation*.

Survival and spread

The fungi persist and produce spores on previous crop residues of wheat, barley and corn (Figure 24*a*, *b*), although other grass weeds and crops can also be a source of inoculum. During moist weather, sexual spores are produced in microscopic, black, flask-shaped structures on old crop and weed debris on the soil surface.

Figure 24: Persistent fungal spores from previous crops. (Photos: QDAFF)

The most favourable conditions for spore production and infection are 48–72 h of high humidity and temperatures of 23–29°C. Longer periods of high humidity can compensate for lower temperatures if optimum temperatures are not experienced. These conditions do not have to be continuous and spore production will still take place if 1 or 2 dry days punctuate the humid periods.

With continued high humidity, the spores are windblown or splashed onto the heads of cereal crops where they germinate in the humid conditions and infect the plant. If prolonged favourable conditions persist, asexual spores are produced on the head and they result in even more spores and secondary infections. Spores from within a crop are the major inoculum source, but spores blown from surrounding crops, sometimes long distances away, can also be a source of infection.

Wheat and durum crops are susceptible to infection from the flowering (pollination) period to hard dough stage of kernel development, but the flowering period is when most infection occurs. Spores landing on the extruded anthers at flowering grow into the developing kernels. The anthers are a major source of infection in wheat as they exude chemicals that attract the fungus.

Infection by spores landing on glumes or other parts of the head is also possible. Once a floret is infected, the fungus can grow into the rachis and then grow up and down in the rachis, infecting adjacent kernels. Infection of adjacent kernels can also occur through the fungus growing over the surface of the glume to an adjacent floret.

Barley flowers when the head is in the boot. Often the anthers are not extruded, so in barley, infection is most common after the head emerges from the leaf sheath and through penetration of the glume. Barley is resistant to growth in the rachis but infection of adjacent kernels can occur with the fungus growing over the surface of the glume to

[46] DAFF (2012) Fusarium head blight (FHB) or head scab. Department of Agriculture, Fisheries and Forestry Queensland, http://www.daff.qld.gov.au/plants/health-pests-diseases/a-z-significant/fusarium-head-blight

an adjacent floret. Under favourable environmental conditions for the disease, infection can continue in barley until grain maturity. [47]

9.16.3 Management

Fusarium head blight is best managed by integrating multiple management strategies. Use of a single strategy often fails when the environment favours severe disease. Management strategies to reduce FHB should include a combination of as many of the following practices as possible.

A disease will develop into a serious epidemic when three important factors all occur at once. These are:

- a susceptible host
- adequate inoculum
- conducive weather conditions

As there is no demonstrated resistance in Australian cultivars and weather cannot be controlled, management of the disease should revolve around reducing inoculum. [48]

9.16.4 Resistance

All current varieties of wheat, barley and durum grown commercially in Australia are likely to be susceptible to FHB. Although some level of resistance does exist in germplasm around the world, resistance to FHB is a very complex trait without simple inheritance. Even in countries where FHB occurs more extensively and frequently, after many years of breeding, commercial varieties have only moderate levels of resistance.

Durum is more susceptible to the disease than bread wheat and barley. Durum should be avoided in areas where there is likelihood of the disease developing. [49]

9.16.5 Seed treatment

There has been no evidence that the fungus can grow from infected seed up through the stem and into the developing head to produce head blight. However, infected seed can result in seedling blight and dead seedlings when the seed is planted.

No seed dressings are currently registered for control of seedling blight caused by the FHB pathogens. Research conducted by the Department of Industry and Investment in NSW in the 1990s showed that the most effective seed treatment to prevent seedling blight was thiram + carboxin. Tests are under way to determine the effectiveness of more modern fungicides as seed dressings.

If grain from an infected source is to be used as seed, it should be cleaned and only used if it has high germination and vigour. [50]

9.16.6 Tillage

Because the fungus survives on residue left on the soil surface, any tillage practices that bury, destroy or promote faster decomposition of residue from a host crop will reduce the potential inoculum for future host crops. Before removing or destroying residues, consideration should be given to any effect of these practices on ground cover, water infiltration and soil organic matter. [51]

[47] DAFF (2012) Fusarium head blight (FHB) or head scab. Department of Agriculture, Fisheries and Forestry Queensland, http://www.daff.qld.gov.au/plants/health-pests-diseases/a-z-significant/fusarium-head-blight

[48] DAFF (2012) Fusarium head blight (FHB) or head scab. Department of Agriculture, Fisheries and Forestry Queensland, http://www.daff.qld.gov.au/plants/health-pests-diseases/a-z-significant/fusarium-head-blight

[49] DAFF (2012) Fusarium head blight (FHB) or head scab. Department of Agriculture, Fisheries and Forestry Queensland, http://www.daff.qld.gov.au/plants/health-pests-diseases/a-z-significant/fusarium-head-blight

[50] DAFF (2012) Fusarium head blight (FHB) or head scab. Department of Agriculture, Fisheries and Forestry Queensland, http://www.daff.qld.gov.au/plants/health-pests-diseases/a-z-significant/fusarium-head-blight

[51] DAFF (2012) Fusarium head blight (FHB) or head scab. Department of Agriculture, Fisheries and Forestry Queensland, http://www.daff.qld.gov.au/plants/health-pests-diseases/a-z-significant/fusarium-head-blight

9.16.7 Crop rotation

Crop rotation is effective in reducing FHB levels. Sowing a susceptible crop after 1 year or more of non-host crops will reduce inoculum levels. The greatest risk of FHB infection is when small grains are planted on last year´s FHB-infected wheat, barley or corn.

Corn in a rotation is a significant risk, as *Fusarium graminearum*—the major cause of FHB—also attacks corn, causing stalk, root and cob rot, and the fungus can survive for more than one season in corn residue. Although it does not appear to exhibit any significant disease symptoms, sorghum can also host *Fusarium graminearum*, which may infect following winter cereal crops. However, the two major species of *Fusarium* that attack sorghum, *F. thapsinum* and *F. andiyazi*, are not pathogens of winter cereals.

The best rotational crops for reducing the inoculum level include any non-grass species (e.g. sunflower, cotton, soybean, chickpea, mungbean, faba bean, canola, field peas). [52]

9.16.8 Planting date

As infection requires moisture during flowering or head emergence, staggering the planting period or planting varieties with varying maturity should spread the risk in years where there are not continuous or repeated periods of high humidity. [53]

9.16.9 Fungicide

Currently, no fungicide sprays are registered in Queensland for control of FHB. However, fungicides have proven a useful tool in reducing infections in other countries; reductions in FHB severity of 50–60% can be achieved when the most effective fungicides are applied at early flowering for wheat and durum, and at early head emergence for barley. If conditions are favourable for FHB infection in coming seasons, emergency registration for chemicals should be able to be obtained prior to the crop flowering.

When applying fungicide to control FHB, the target is the vertical head rather than the more horizontal flag leaf. Modify application techniques for best effectiveness. Spray coverage and disease control for FHB is improved when the sprays are directed at a 30° angle from horizontal either both forward and backward, or less optimally with single nozzles directed toward the grain head. Also, a higher water volume is recommended for good head coverage and ground application is more effective than aerial application. [54]

More information

www.grdc.com.au/diseaselinks

www.apvma.gov.au

Pathology Service: http://www.dpi.nsw.gov.au/aboutus/services/das/plant-pests-diseases

[52] DAFF (2012) Fusarium head blight (FHB) or head scab. Department of Agriculture, Fisheries and Forestry Queensland, http://www.daff.qld.gov.au/plants/health-pests-diseases/a-z-significant/fusarium-head-blight

[53] DAFF (2012) Fusarium head blight (FHB) or head scab. Department of Agriculture, Fisheries and Forestry Queensland, http://www.daff.qld.gov.au/plants/health-pests-diseases/a-z-significant/fusarium-head-blight

[54] DAFF (2012) Fusarium head blight (FHB) or head scab. Department of Agriculture, Fisheries and Forestry Queensland, http://www.daff.qld.gov.au/plants/health-pests-diseases/a-z-significant/fusarium-head-blight