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GRDC GROWNOTES™

GRDC GRAINS RESEARCH & DEVELOPMENT CORPORATION

DURUM

SECTION 9

DISEASES

DISEASES IN DURUM | STRIPE, LEAF AND STEM RUST | SEPTORIA TRITICI BLOTCH

Diseases

Key messages:

- Durum has mixed resistance to common cereal diseases.
- Durum is highly susceptible to crown rot.
- Genetic research and strategic breeding is improving durum resistance to major diseases. Annually published disease guides should be consulted for rating changes
- Key strategies for management are:
- green bridge management
- utilising resistant varieties
- seed and/or fertiliser treatments
- crop rotation
- active monitoring of crops with a view to fungicide applications if required.

9.1 Diseases in durum

Disease problems change over time as seasons vary and farm management practices evolve. More recently there has been a rapid change in rust strains that has seriously restricted the choice of varieties suitable for cultivation. These factors make it more apparent than ever that the cereal industry needs to be vigilant in its control of cereal diseases and that disease control requires integrated approaches that take into account fungal pathology, farm management systems and plant breeding. Strong promotion of Minimum Disease Resistance Standards and less reliance on fungicides are also needed as part of this approach. Without greater care there is potential in future years for a massive increase in inoculum loads that will in turn increase disease problems. With strong advocacy and effective extension activities, plant pathologists with expertise across these areas can make a big difference to the sustainability of cereal farming.

Fungal diseases of cereals are sporadic in occurrence and severity. This variation comes about from changes in seasonal conditions, farm management practices, varieties grown and pathotypes of the fungi. Where conditions are favourable any one pathogen can lead to severe losses over several years and growers are required to make significant changes to their varieties, rotations or other practices to avoid damage. In other situations a disease may cause significant losses in one year then not recur for some time. Many of these situations can be avoided through careful judgement of risks, and active promotion and implementation of effective strategies. [1]

1 GRDC (2004) Control of cereal fungal diseases. Final reports DAS336. Grains Research and Development Corporation, http://finalreports.grdc.com.au/DAS336

Table 1: *Resistance of major durum varieties to common cereal diseases in South Australia for 2016.*

Durum wheat variety	Rust			*Septoria tritici* blotch	Cereal cyst nematode resistance	Yellow leaf spot	Powdery mildew	Root lesion nematodes		Crown rot	Common root rot	Flag smut	Black point
	Stem	Stripe	Leaf					*P. neglectus*	*P. thornei*				
Aurora(D	RMR	RMR	R	MS	MS	MRMS	MR	MS	RMR	VS	MRMS	R	MS
Caparoi(D	RMR	MR	RMR	RMR	MS	MR	-	MSS	MR	VS	MS	R	MSS
Hyperno(D	RMR	MR	R	MRMS	MS	MRMS	MR	MS	RMR	SVS	MS	R	MS
Saintly(D	MR	MR	MRMS	S	MS	MRMS	MSS	MS	MR	VS	MS	R	MS
Tjilkuri(D	MR	MR	R	MSS	MS	MRMS	MRMS	MS	MR	VS	MS	R	MSS

Abbreviations					
R	Resistant	MR	Moderately resistant	MS	Moderately susceptible
S	Susceptible	VS	Very susceptible	MI	Moderately intolerant
I	Intolerant	-	Uncertain		

Source: Primary Industries and Regions South Australia

MORE INFORMATION

Cereal variety disease guide

Table 1 lists the resistance of major durum varieties to common diseases in South Australia (SA) during the 2016 season. A recent South Australian cereal variety disease guide reported that the most concerning developments in the 2015 season were an increase in Septoria tritici blotch and eyespot in wheat crops across a wide area of the state. Take-all affected many wheat crops along SA's far west coast and central Eyre Peninsula particularly in calcareous soils and in paddocks where there was a history of intensive wheat and grass weeds combined with reduced stubble breakdown. [2]

9.1.1 Crown rot

Key points:

- No in-crop control is available for crown rot.
- This fungal disease is hosted by all winter cereals and many grassy weeds.
- Crown rot survives for many years in infected plant residues and infection can occur when plants come in close contact with those residues.
- High cereal intensity and inclusion of durum wheat in cropping programs are factors which increase crown rot levels.
- Major yield losses occur when disease levels are high and there is moisture stress during grain fill. In these circumstances yield loss can be up to 90% in durum.
- Crown rot can cause increased screenings in durum. [3]

Of all the cereal diseases, crown rot has the greatest impact on durum yield. Crown rot causes crop losses in Australia estimated at $79 million, or $6.63 per hectare, per year. [4] Many growers stopped growing durum because of the high risk of crown rot. Durum wheat remains the most susceptible of the winter cereal crops to crown rot infection and yield loss.

Bread wheat yield losses can be up to 55% at high inoculum levels. Losses in durum can reached up to 90%. [5] Crown rot is caused by fungal *Fusarium spp.* [6] The

2 H Wallwork (2016) Cereal variety disease guide 2016. Primary Industries and Regions South Australia, February 2016, http://pir.sa.gov.au/__data/assets/pdf_file/0010/276841/Cereal_Variety_Disease_Guide_2016_web.pdf

3 GRDC (2009) Crown rot in cereals fact sheet. Grains Research and Development Corporation, May 2009, http://www.grdc.com.au/GRDC-FS-CrownRotCerealsSW

4 R Bowman (2012) Durum to partially resist crown rot. Ground Cover Issue 96. Grains Research and Development Corporation, January 2012, https://grdc.com.au/Media-Centre/Ground-Cover/Ground-Cover-Issue-96-January-February-2012/Durum-to-partially-resist-crown-rot

5 GRDC (2014) Managing crown rot. Grains Research and Development Corporation, June 2014, https://grdc.com.au/Media-Centre/Hot-Topics/Managing-crown-rot

6 GRDC (2006) Crown rot management in durum and bread wheats for the southern region. Final report DAS00032. Grains Research and Development Corporation, http://finalreports.grdc.com.au/DAS00032

fungus survives over summer on infected plant residues (crown and base of stem) and can persist for at least three years depending on rainfall. [7] As infected residues decompose, inoculum levels reduce. This means that where decomposition rates are low, crown rot inoculum can survive for several years. [8]

Crown rot infection occurs when infected residues come into contact with growing cereals e.g. where stubble has been knocked down by machinery or heavy grazing. [9] Even minute pieces of residue can cause infection and a paddock with little visible stubble may still have a crown rot risk. Infection occurs in the sub-crown internode, crown and/or outer leaf sheaths at the tiller bases. The fungus spreads up the stem during the season, with most inoculum being found near the base of the plant. [10]

Figure 1 demonstrates the increased yield loss, especially in durum, when exposed to increased levels of crown rot at sowing.

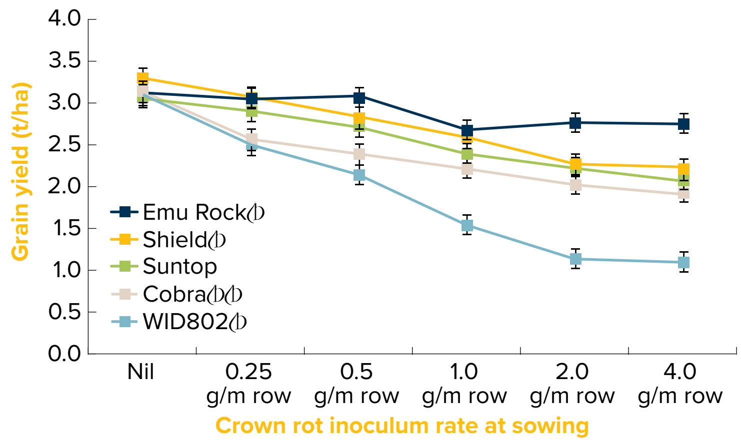

Figure 1: *Effect of increasing crown rot inoculum levels at sowing on the grain yield (t/ha) of one durum wheat (WID802ᶲ) and four bread wheat cultivars grown at Dooen during 2015.*

Source: Grains Research and Development Corporation

Where crown rot species are found in southern Australia

High levels of crown rot have been detected in soil samples across all southern states. *Fusarium* species associated with crown rot were isolated and identified from 409 wheat, barley or durum wheat crops from the eastern Australian grain belt between 1996 and 1999:

- *F. pseudograminearum* was the most common species in Victoria and SA, but *F. culmorum* was also frequently found.
- *F. culmorum* accounted for more than 70% of isolates from the Victorian high rainfall (>500 mm) region and the south-east region of SA.
- *F. culmorum* comprised 18% of isolates from the Victorian medium rainfall (350–500 mm) region, and 7% of isolates from each of the Victorian low rainfall region and the Mid-North region of SA.

7 PIRSA. Managing crop diseases. Primary Industries and Regions South Australia, http://pir.sa.gov.au/__data/assets/word_doc/0006/241584/Managing_Crop_Diseases.doc

8 GRDC (2009) Crown rot in cereals fact sheet. Grains Research and Development Corporation, May 2009, http://www.grdc.com.au/GRDC-FS-CrownRotCerealsSW

9 PIRSA. Managing crop diseases. Primary Industries and Regions South Australia, http://pir.sa.gov.au/__data/assets/word_doc/0006/241584/Managing_Crop_Diseases.doc

10 GRDC (2009) Crown rot in cereals fact sheet. Grains Research and Development Corporation, May 2009, http://www.grdc.com.au/GRDC-FS-CrownRotCerealsSW

- The proportion of *F. culmorum* among isolates of *Fusarium* from districts in Victoria and SA was strongly correlated with climatic conditions around the end of the growing season, especially with rainfall in November.
- *F. avenaceum*, *F. crookwellense* and *F. graminearum* were found very infrequently. [11]

9.1.2 Varietal resistance

Resistance is only possible in healthy, growing plants. Once a plant is stressed or starts to dry off at the end of grain fill, the crown rot fungus will take hold regardless of its resistance rating. [12]

See Table 1 in the section 1.1 Diseases in durum for varietal resistance to crown rot in SA and Victoria.

9.1.3 Damage caused by disease

Crown rot often causes whiteheads to occur which mature early and contain shrivelled grain or no grain. The impact of a bad crown rot season can make or break a crop, with bread wheat yield losses of up to 55%, and durum yield losses of up to 90% possible at high inoculum levels. [13] Because crown rot can survive in the soil for years, damage to crops can be felt over long periods.

9.1.4 Symptoms

The distinctive symptom of crown rot is the presence of whiteheads in the crop at early grainfill (Photo 1). These heads mature early and contain shrivelled grain or no grain. Whiteheads caused by crown rot are usually scattered through the crop and do not appear in distinct patches as seen with the root disease take-all. The other, and more reliable, symptom of crown rot is browning of the stem bases. [14] A brown stem base is the most reliable indicator of crown rot and this symptom becomes more pronounced from mid to late grainfill through to harvest (Photo 2). To see the honey/dark brown colour more easily the leaf sheaths should be pulled back. This symptom may not appear on all stems. [15]

Photo 1: *Whiteheads (left) caused by crown rot compared to healthy wheat (right).*

Source: Grains Research and Development Corporation

11 D Backhouse, AA Abubakar, LW Burgess, JI Dennisc, GJ Hollaway, GB Wildermuth, H Wallwork, FJ Henry 2004) Survey of *Fusarium* species associated with crown rot of wheat and barley in eastern Australia. Australasian Plant Pathology 33, 255–261, doi:10.1071/AP04010

12 GRDC (2009) Crown rot in cereals fact sheet. Grains Research and Development Corporation, May 2009, http://www.grdc.com.au/GRDC-FS-CrownRotCerealsSW

13 GRDC (2014) Managing crown rot. Grains Research and Development Corporation, June 2014, https://grdc.com.au/Media-Centre/Hot-Topics/Managing-crown-rot

14 G Hollaway, M McLean, J Fanning (2016) Cereal disease management in Victoria 2016. GRDC update papers. Grains Research and Development Corporation, February 2016, https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2016/02/Cereal-disease-management-in-Victoria-2016

15 GRDC (2009) Crown rot in cereals fact sheet. Grains Research and Development Corporation, May 2009, http://www.grdc.com.au/GRDC-FS-CrownRotCerealsSW

Photo 2: *Healthy tillers (left) and severe basal or stem browning caused by crown rot (right).*

Source: Grains Research and Development Corporation

9.1.5 Conditions favouring development

Conditions which favour crown rot development are good growing conditions at the start of the season followed by stress after head emergence. Inoculum levels have built up in many areas of SA over recent years, due to the high number of dry springs experienced, more intensive cereal rotations and stubble retention practices. [16]

Infection is favoured by moderate soil moisture at any time during the season. The expression of whiteheads is favoured by moisture stress during grainfill and there is a direct relationship with yield loss. Increases in moisture stress will increase crown rot severity; e.g. increased seeding rate can lead to more severe moisture stress and crown rot consequences. [17] The expression of whiteheads in crown rot infected tillers can also be more severe in zinc-deficient crops. [18]

Crown rot is favoured by the intensive cultivation of cereals and stubble retention practices which contribute to losses during seasons with below average spring rainfall. Whitehead expression is more common in seasons with a dry spring. [19] The presence of root-lesion nematodes exacerbates the effects of crown rot, reducing the ability of the crop to extract soil water to deal with crown rot infection. [20]

VIDEOS

WATCH: GCTV9: Crown rot and root lesion nematodes.

FAQ

9.1.6 Management of disease

For durum wheat, crown rot is by far the largest factor limiting expansion. Many growers gave up on durum because of the high risk of crown rot. The remaining growers are mostly managing it with longer rotations. [21]

Important tips for managing crown rot:

- Test paddocks for crown rot levels using PredictaB.
- If sowing in paddocks where crown rot is present, ensure that these paddock are low in infected stubbles, by use of longer rotations.

16 PIRSA. Managing crop diseases. Primary Industries and Regions South Australia, http://pir.sa.gov.au/__data/assets/word_doc/0006/241584/Managing_Crop_Diseases.doc

17 H Wallwork (2016) pers. comms.

18 GRDC (2009) Crown rot in cereals fact sheet. Grains Research and Development Corporation, May 2009, http://www.grdc.com.au/GRDC-FS-CrownRotCerealsSW

19 G Hollaway, M McLean, J Fanning (2016) Cereal disease management in Victoria 2016. GRDC update papers. Grains Research and Development Corporation, February 2016, https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2016/02/Cereal-disease-management-in-Victoria-2016

20 GRDC (2014) Managing crown rot. Grains Research and Development Corporation, June 2014, https://grdc.com.au/Media-Centre/Hot-Topics/Managing-crown-rot

21 H Wallwork (2016) pers. comms.

- Try to reduce late moisture stress by early sowing, not using high seeding rates, managing nitrogen (N) according to crop needs and not applying too much N upfront. [22]

Trigger points

Table 3 lists trigger points for making sowing decisions based on PreDicta B risk ratings for crown rot. Durum should only be sown in paddocks known to have a low crown rot level. [23]

Table 2: *Trigger points for making sowing decisions based on PreDicta B risk ratings for crown rot.*

PreDicta B risk rating	Action
Low	Unlikely to be an issue in the short term
Medium	Do not sow durum, avoid bread wheat if possible
High	Rotate to at least two non-cereal crops

Source: Primary Industries and Regions South Australia

See Section 1: Paddock selection and preparation for more information on soil testing and PreDicta B.

Paddocks at high risk should be sampled and tested using a PreDicta B test and the results taken into account when making sowing decisions. Autumn burning will only reduce inoculum levels by 40 to 50% as plant parts below the ground will be protected and host inoculum (Table 4). [24]

22 H Wallwork (2016) pers. comms.

23 PIRSA. Managing crop diseases. Primary Industries and Regions South Australia, http://pir.sa.gov.au/__data/assets/word_doc/0006/241584/Managing_Crop_Diseases.doc

24 PIRSA. Managing crop diseases. Primary Industries and Regions South Australia, http://pir.sa.gov.au/__data/assets/word_doc/0006/241584/Managing_Crop_Diseases.doc

Table 3: *Crown rot yield loss categories using PreDicta B soil tests.*

	Durum wheat	
Risk rating	**Log (DNA)**	**% Yield loss**
Below detection limit	<0.6	0–2
Low	0.6–1.4	0–5
Medium	1.4–2.0	10–30
High	>2.0	20–80

Source: Primary Industries and Regions South Australia

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

- Match N application to stored soil moisture and potential yield.
- Limit early N applications to avoid excessive early crop growth.
- Ensure zinc nutrition is adequate.
- Sow on the inter-row if this option is available. [25]

Inspections of stems for browning is best performed from mid to late grainfill through to harvest. To see the browning, leaf sheaths should be pulled back and in some cases the pink of the causal fungus may be observed. Collect representative plant samples from the paddock by walking in a large 'W' pattern, collecting five plants at 10 different locations (Figure 4). Examine each plant for basal browning, record what percentage shows the symptom and then put in place appropriate measures for next year. [26]

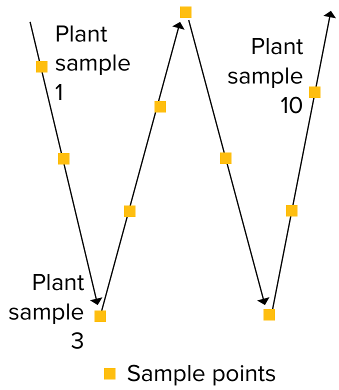

Figure 2: *'W' pattern for plant sampling in paddock.*

Source: Grains Research and Development Corporation

Crown rot must be controlled prior to sowing as there is no in-crop control available. Inspection of previous cereals for the presence of crown rot symptoms provides an indication of potential risk from crown rot. [27]

Choosing paddocks with low crown rot risk is essential for growing a successful durum wheat crop. Soil sampling methods and risk categories for DNA-based testing for crown rot mean growers can choose the best paddocks for growing durum. Soil sampling to assess DNA levels of crown rot prior to sowing is a useful paddock

25 GRDC (2009) Crown rot in cereals fact sheet. Grains Research and Development Corporation, May 2009, http://www.grdc.com.au/GRDC-FS-CrownRotCerealsSW

26 GRDC (2009) Crown rot in cereals fact sheet. Grains Research and Development Corporation, May 2009, http://www.grdc.com.au/GRDC-FS-CrownRotCerealsSW

27 G Hollaway, M McLean, J Fanning (2016) Cereal disease management in Victoria 2016. GRDC update papers. Grains Research and Development Corporation, February 2016, https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2016/02/Cereal-disease-management-in-Victoria-2016

management tool. Soil sampling is a reliable method for making this assessment and may be the only reliable option in some instances, e.g. where cereal stubble is no longer present for visual assessment of crown rot levels. Stubble sampling for crown rot using DNA technology is a useful research tool. Where it is intended to sow between old cereal rows, a soil DNA test should be used to assess crown rot risk as the between-row levels of crown rot may still be high (e.g. where there are significant residues from grassy weeds or where the cereal stubble has been moved around by grazing). The more cereals there are in the rotation the greater the risk of losses to crown rot, as all cereals will build up crown rot.

Closed canopy break crops and fallow are most effective at reducing crown rot. Closed canopy crops such as canola and vetch are more effective than medic or peas at reducing crown rot levels in the year they are sown. Long fallow is also effective at reducing crown rot levels, but is less desirable financially. Manage grassy weeds during breaks from cereals, as brome grass, ryegrass, barley grass and wild oats all carry significant levels of crown rot. Where crown rot levels are high, at least a two-year rotational break is needed before it will be safe to sow durum. Break crops will continue to be the main management tool for crown rot, but will need to be combined with other management options to achieve their full benefit. The research challenge is to reduce the break period to one year, even where crown rot levels are high.

Burning is unreliable in reducing crown rot. Hay making, straw baling, cultivation and burning will generally not reduce high crown rot to low levels in the short term but could assist in long term maintenance of low crown rot levels. The agronomic implications (reduced organic matter and soil cover) of these operations need to be considered when employing them for crown rot management. [28]

Management options which decrease crown rot levels:

- Where crown rot levels are high, at least a two-year rotational break will be needed before it is safe to sow durum:
- Good rainfall increases the effectiveness of the break, because microbial decomposition of the cereal residues harbouring the pathogen is greater in moist conditions.
- For break crops, early canopy closure and warm, damp conditions under the canopy will result in the fastest decomposition of crown rot-infected residues. [29]
- Canola, fallow and vetch are more effective than medic or peas at reducing soil crown rot levels (Figure 3).
- Soil crown rot levels take longer to decrease after triticale than after other cereal crops.
- A grass-free pasture can reduce levels of crown rot even under low rainfall conditions.
- Reducing levels of crown rot in low rainfall farming systems such as Eyre Peninsula is likely to be difficult due to limited options for grass-free breaks from cereals.
- Trace elements (zinc, copper, manganese) appear to play a minor role in managing the effects of crown rot in-season. [30]

28 GRDC (2006) Crown rot management in durum and bread wheats for the southern region. Final report DAS00032. Grains Research and Development Corporation, http://finalreports.grdc.com.au/DAS00032

29 GRDC (2009) Crown rot in cereals fact sheet. Grains Research and Development Corporation, May 2009, http://www.grdc.com.au/GRDC-FS-CrownRotCerealsSW

30 GRDC (2006) Crown rot management in durum and bread wheats for the southern region. Final report DAS00032. Grains Research and Development Corporation, http://finalreports.grdc.com.au/DAS00032

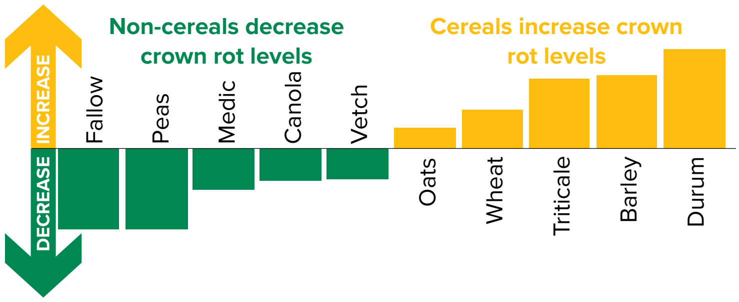

Figure 3: *Rotation effects on crown rot levels in the soil in the following year—a summary based on five trials conducted in SA and Victoria.*

Source: Grains Research and Development Corporation

Is sowing time, row spacing or plant population a viable management tool to minimise losses from crown rot?

Two crown rot trials conducted in north-west New South Wales in 2012 compared the effects of time of sowing and row spacing on losses due to crown rot in bread wheat, barley and durum varieties. The key findings were:

- In durum, low plant populations coupled with an early sowing time reduced yield loss to crown rot by 50% compared to a later sowing time with a higher plant population (25% yield loss to crown rot).
- Yield losses from crown rot in durum were 15-30%, while losses were 7-15% for wheat and minimal for barley (<5%). The losses for durum reinforce the need to avoid growing durum where there is a risk of crown rot.
- Variety selection had greater potential to affect yields than losses incurred from crown rot infection.
- In this trial using wider row spacing (500 mm) actually increased soil water use in the 0–60 cm zone and therefore did not reduce yield loss from crown rot.
- Infection with crown rot significantly reduced soil water use during the last three weeks of grainfill. [31]

Seven commercial wheat trials in 2006 showed inter-row sowing decreased both crown rot severity (average 53%) and incidence (average 48%) compared to sowing on the previous year's cereal rows. The positive effect of inter-row sowing is most beneficial when inoculum levels are low, but is still valuable where inoculum levels are severe. An average benefit of 101 kg/ha was recorded across the trials making inter-row a useful additional strategy but not a primary management tool for crown rot. Inter-row sowing will certainly not enable 'back to back' wheat production where crown rot levels are already high. [32]

Under high crown rot pressure, yield losses in durum cannot be managed by manipulating the plant population at sowing. Given the extreme susceptibility of durum wheat to crown rot, it remains critical to target durum production only in paddocks known to have low levels of inoculum. [33]

31 M Gardner, SSimpfendorfer (2013) Is sowing time, row spacing or plant population a viable management tool to minimise losses from crown rot? GRDC update papers. Grains Research and Development Corporation, March 2013, https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2013/03/Is-sowing-time-row-spacing-or-plant-population-a-viable-management-tool-for-crown-rot

32 GRDC (2014) Managing crown rot. Grains Research and Development Corporation, June 2014, https://grdc.com.au/Media-Centre/Hot-Topics/Managing-crown-rot

33 GRDC (2010) Impact of plant population on crown rot in durum wheat. GRDC update papers. Grains Research and Development Corporation, September 2010, https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2010/09/IMPACT-OF-PLANT-POPULATION-ON-CROWN-ROT-IN-DURUM-WHEAT

Stubble management for crown rot

Stubble management practices such as spreading,slashing and cultivation can increase the rate of stubble decomposition but can also spread the infected residues across the paddock. Additionally, cultivation can exacerbate crown rot by reducing soil moisture. Where there is no moisture or adequate time to enable stubble breakdown, these practices can increase infection rates in the next winter cereal crop. Grazing stubble can also spread inoculum. [34]

Crown rot infection occurs when infected residues come into contact with growing cereals, so where stubble has been knocked down by machinery or heavy grazing, stubble displacers ahead of the sowing tines/disks may be advantageous. [35]

In-crop fungicides and timing

There are no fungicide options for the control of the crown rot. [36]

Resistant disease control options

New sources of crown rot resistance have been identified, in wild relatives of durum wheat. Development of adapted germplasm has commenced. In time (possibly within a decade) this should lead to the release of varieties that are not highly susceptible to this disease. This may allow durum crops to be grown in closer rotation. [37]

VIDEOS

WATCH: What's in the crown rot breeding pipeline?

What's in the crown rot breeding pipeline?

9.1.7 Advances against crown rot

If resistance to crown rot can be improved, then the area sown to durum could rise very significantly both in existing areas and in areas where growers have discontinued production. [38]

Partial resistance in commercial durum varieties (similar to Sunco bread wheat) will be a significant contributor to managing crown rot. Improved resistance should be attainable in the next five to 10 years. [39]

Screening activities to date have failed to identify even moderately susceptible lines of durum. In contrast, partial resistance to crown rot has been identified in a number of bread wheat lines, including 2-49 and Sunco. A study from 2013 describes the successful introgression of partial crown rot resistance from each of these two wheat lines. Durum backcross populations had crown rot scores similar to 2-49. Progeny of these backcross populations included lines with field based resistance to crown rot superior to that of the parent wheat. [40]

Partial resistance will need to be coupled with an integrated approach to managing the disease. There is no total resistance to crown rot fungus infection in durum or other cereals. The genes involved provide partial resistance, which appears to slow the rate of it spreading through tissue. [41]

Durum lines have to be well adapted, as well as have resistance, because crown rot is favoured by moisture stress and durum that is not well adapted suffers greater moisture stress and resistance can be hidden due to their lack of adaptation. [42]

34 GRDC (2009) Crown rot in cereals fact sheet. Grains Research and Development Corporation, May 2009, http://www.grdc.com.au/GRDC-FS-CrownRotCerealsSW

35 PIRSA (2014) Soil-borne disease risks emerge in 2014. Primary Industries and Regions South Australia, April 2014, http://pir.sa.gov.au/alerts_news_events/news/archives/sardi_archive/soilborne_disease_risks_emerge_in_2014

36 GRDC (2009) Crown rot in cereals fact sheet. Grains Research and Development Corporation, May 2009, http://www.grdc.com.au/GRDC-FS-CrownRotCerealsSW

37 GRDC (2004) Control of cereal fungal diseases. Final reports DAS336. Grains Research and Development Corporation, http://finalreports.grdc.com.au/DAS336

38 H Wallwork (2016) pers. comms.

39 GRDC (2006) Crown rot management in durum and bread wheats for the southern region. Final report DAS00032. Grains Research and Development Corporation, http://finalreports.grdc.com.au/DAS00032

40 A Martin, S Simpfendorfer, RA Hare, MW Sutherland (2013) Introgression of hexaploid sources of crown rot resistance into durum wheat. Euphytica, 192(3), 463–470, doi:10.1007/s10681-013-0890-6

41 R Bowman (2012) Durum to partially resist crown rot. Ground Cover Issue 96. Grains Research and Development Corporation, January 2012, https://grdc.com.au/Media-Centre/Ground-Cover/Ground-Cover-Issue-96-January-February-2012/Durum-to-partially-resist-crown-rot

42 H Wallwork (2016) pers. comms.

Zinc to help buffer effects of crown rot

IN FOCUS

Response of durum wheat to different levels of zinc and *Fusarium pseudograminearum*

Durum wheat (*Triticum turgidum* ssp. *durum*) is susceptible to *Fusarium pseudograminearum* and sensitive to zinc (Zn) deficiency in Australian soils. However, little is known about the interaction between these two potentially yield-limiting factors, especially for Australian durum varieties. The critical Zn concentration (concentration of Zn in the plant when there is a 10% reduction in yield) and degree of susceptibility to *F. pseudograminearum* was therefore determined for five Australian durum varieties (Yawa⊕, Hyperno⊕, Tjilkuri⊕, WID802⊕, UAD1153303). Critical Zn concentration averaged 24.6 mg/kg for all durum varieties but differed for the individual varieties (mg/kg: Yawa⊕, 21.7; Hyperno⊕, 22.7; Tjilkuri⊕, 24.1; WID802⊕, 24.8; UAD1153303, 28.7). Zinc efficiency also varied amongst genotypes (39–52%). However, Zn utilisation was similar amongst genotypes under Zn-deficient or Zn-sufficient conditions (0.51–0.59 and 0.017–0.022 g DM/µg Zn, respectively). All varieties were susceptible to *F. pseudograminearum* but the development of symptoms and detrimental effect on shoot biomass and grain yield were significantly greater in Tjilkuri⊕. Though crown rot symptoms may still be present, the supply of adequate Zn in the soil helped to maintain biomass and grain yield in all durum varieties. However, the extent to which durum varieties were protected from plant growth penalties due to crown rot by Zn treatment was genotype-dependent. [43]

Funding for field trials in southern Australia

The Southern Australia Durum Growers Association received funding from the South Australian Grain Industry Trust in 2016 to undertake the project *Agronomic evaluation of durum wheats for crown rot resistance*. The three-year project will compare varieties and breeding lines without crown rot infection and with infection induced by different levels of crown rot inoculum applied at sowing. The trials will be conducted in the Lower North and South East regions of SA. The effects of sowing dates and/or seeding rates on disease pressure will also be explored. [44]

9.1.8 Common root rot

Common root rot, caused by the fungus *Bipolaris sorokiniana*, is often found in association with crown rot. Symptoms are a dark brown to black discoloration of whole or part of the sub-crown internode. Severely affected plants are stunted, have fewer tillers and produce smaller heads. Rotation to non-host break crops is essential to the successful management of both of these diseases. See Section 2.1 for varietal details.

43 MS Al-Fahdawi, JA Able, M Evans, AJ Able (2014). Response of durum wheat to different levels of zinc and *Fusarium pseudograminearum*. Crop and Pasture Science, 65(1), 61–73, http://dx.doi.org/10.1071/CP13306

44 Southern Australia Durum Growers Association (2016) Successful grant application. Southern Australia Durum Growers Association, June 2016, http://durumgrowerssa.org.au/news-flash-successful-grant-application/

9.2 Stripe, leaf and stem rust

Durums are generally moderately resistant to leaf stem and stripe rust in the Southern Region. They may offer a good alternative to hard wheat where rust is a risk.

Durum varieties differ little in resistance to rusts. Cereal rusts have the potential to cause heavy yield losses in some situations, depending on susceptibility of the variety sown (Table 5). [45] There is potential for up to 10% yield loss in durums in some situations as all varieties range from R-MR.

9.2.1 Varietal resistance

See Table 1 and Table 2 in section 1.1 Diseases in durum for varietal resistance to stripe, leaf and stem rust in the Southern region.

Kamilaroi⟑, Yallaroi⟑, Wollaroi⟑ and EGA Bellaroi⟑ are fully resistant to all existing field strains of stem rust. While stem rust infection is not expected, a new virulent strain may occur. Kamilaroi⟑, Yallaroi⟑, Wollaroi⟑ and EGA Bellaroi⟑ possess slow rusting resistance to all field strains of leaf rust. A small level of infection may be evident as the plant approaches maturity; however, this disease level will not affect yield. The current durum varieties all express adequate resistance to field strains of stripe rust at present. [46]

9.2.2 Symptoms

Stripe rust

Stripe rust is easiest to identify in the morning. Examine the leaves, especially the older leaves low in the canopy, and look for yellow stripes of pustules. Pustules are raised above the leaf surface and can be easily wiped off onto a white cloth or tissue leaving a yellow stain (Photo 3). Also, watch for hot spots in the crop: hot spots are often 1–10 metres in diameter, and are generally well developed just before the disease becomes widespread in the crop. [47]

Photo 3: *Stripe rust on a moderately susceptible to susceptible wheat variety.*

Source: Agriculture Victoria

Stem rust

Stem rust is characterised by reddish-brown, powdery, oblong pustules. The pustules have a characteristic torn margin that can occur on both sides of the leaves, on the stems and the glumes. Stem rust spores are much darker in colour than leaf rust spores, which are light brown and don't have torn margins (Photo 4). As the plant matures, the pustules produce black spores known as teliospores. They occur mainly on the leaf sheaths and stem. [48]

45 PIRSA. Managing crop diseases. Primary Industries and Regions South Australia, http://pir.sa.gov.au/__data/assets/word_doc/0006/241584/Managing_Crop_Diseases.doc

46 R Hare (2006) Agronomy of the durum wheats Kamilaroi⟑, Yallaroi⟑, Wollaroi⟑ and EGA Bellaroi⟑. Primefacts 140. NSW Department of Primary Industries, April 2006, http://www.dpi.nsw.gov.au/content/agriculture/broadacre/winter-crops/winter-cereals/agronomy-durum-wheats

47 G Hollaway (2008) Stripe rust of wheat. Agriculture Victoria, February 2008, http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/plant-diseases/grains-pulses-and-cereals/stripe-rust-of-wheat

48 G Hollaway (2005) Stem rust of wheat. Agriculture Victoria, February 2008, http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/plant-diseases/grains-pulses-and-cereals/stem-rust-of-wheat

Photo 4: *Symptoms of stem rust on wheat (left) and symptoms of leaf rust on wheat (right).*

Source: Agriculture Victoria

9.2.3 Conditions favouring development

In seasons with summer or early autumn rain, germination of volunteer cereals will increase the risk of stripe, leaf and stem rust. Control of volunteers by grazing or spraying is needed to prevent build up of inoculum. [49]

Stripe rust

Stripe rust is caused by *Puccinia striiformis* f.sp. *tritici*. The fungus is dispersed as wind-blown spores which produce new infections. Conditions suitable for epidemic development occur from April to December in Victoria, and stripe rust can be expected in crops by September in most years. The fungus requires temperatures of less than 18°C (optimum 6–12°C) with a minimum of three hours of leaf-wetness (for example, dew) for new infections to occur. Once an infection is established the fungus can survive short periods of temperatures higher than 40°C. Sufficient rust can survive the summer on volunteer or self-sown wheat plants resulting in a new epidemic to develop in the following season. Only one infected leaf per 30 ha of regrowth needs to survive the summer to produce severe epidemics. Stripe rust can also infect the developing head, reducing grain number and size. [50]

Stem rust

Stem rust (caused by the fungus *Puccinia graminis*) can only survive from one season to the next on a living host. It does not survive on stubble, seed or soil. The most important hosts are susceptible wheat, but it can also survive on barley, triticale, and some grasses. Carry over on wheat from one season to the next is greatest during wet summers/autumns. Rust spores are wind-blown and can be spread over large areas in a short time. Wet conditions and temperatures of approximately 15–30°C

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49 PIRSA. Managing crop diseases. Primary Industries and Regions South Australia, http://pir.sa.gov.au/__data/assets/word_doc/0006/241584/Managing_Crop_Diseases.doc

50 G Hollaway (2008) Stripe rust of wheat. Agriculture Victoria, February 2008, http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/plant-diseases/grains-pulses-and-cereals/stripe-rust-of-wheat

favour the establishment of stem rust within crops. Stem rust usually becomes evident later in the season than stripe rust. [51]

Leaf rust

Leaf rust is caused by the fungus Puccinia triticina. Leaf rust, like other cereal rusts, requires a living host to survive from one season to the next. The most important host for rusts in Australia are susceptible volunteer wheat plants growing during the summer/autumn. Rust cannot carry over from one season to the next on seed, stubble or in soil.

Wheat varieties susceptible to leaf rust enable inoculum levels to build up on volunteers during the summer and autumn. This can be a problem in seasons following wet summers that favour the growth of self-sown wheat. Plants that become heavily infected with rust in the autumn provide a source of rust for the new season's wheat crop. If these conditions are followed by a mild winter and a warm wet spring, then the chances of a leaf rust epidemic are high. Therefore, the chances of a rust epidemic are greatest following a wet summer.

In Australia, due to the absence of the alternate host, leaf rust reproduces asexually. This reduces the variability of the rusts in the field and therefore increases the likelihood that resistant varieties will be effective for a long period of time.

Rust spores are wind-blown and can be spread over large areas in a short time. The establishment of leaf rust epidemics within a crop is favoured by wet conditions and temperatures of in the range of 15-22°C. [52]

9.2.4 Management of rusts

Sowing susceptible and very susceptible varieties should be avoided. Durum varieties are generally moderately resistant or better and rust control would not be warranted but in severe seasons or if early infection is a risk some control may be needed.

In-crop fungicides and timing

Stripe rust control

Good upfront control of stripe rust by seed or in-furrow treatments can be achieved until stem elongation (GS30). In some environments control can be achieved through until flag leaf emergence.

Moderately resistant or resistant varieties: Level of resistance at adult stage is adequate to protect crop. Seedling infection may still require control.

Moderately susceptible and susceptible varieties: Upfront disease control with Jockey® or Impact® is better in seasons with early breaks (green bridge) and short seasons. Foliar sprays will be beneficial with moderately resistant to moderately susceptible or lower resistance. While unlikely, as durums generally have good late season resistance to all rusts, situations may occur when growers need to apply cheaper fungicide first at GS30-39 and better fungicide later at GS41 to protect the flag leaf.

Trigger points for stripe rust control:

- Spray moderately susceptible and lower resistant varieties.
- At GS30 spray at the first sign of disease.
- At GS39 spray at 1% infection. [53]

51 G Hollaway (2005) Stem rust of wheat. Agriculture Victoria, February 2008, http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/plant-diseases/grains-pulses-and-cereals/stem-rust-of-wheat

52 G Hollaway (2014) Leaf rust of wheat. Agriculture Victoria, February 2008, http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/plant-diseases/grains-pulses-and-cereals/leaf-rust-of-wheat

53 PIRSA. Managing crop diseases. Primary Industries and Regions South Australia, http://pir.sa.gov.au/__data/assets/word_doc/0006/241584/Managing_Crop_Diseases.doc

Why do these growth stage timings work for stripe rust control?

Five to 10 years ago, it would have been common to make decisions on fungicide applications for stripe rust based on thresholds of infection; these thresholds varied from 1-5% plants infected. A problem soon became apparent to growers and advisers that, in the paddock, it was difficult to calculate whether this disease threshold had been reached, not least because of the sporadic nature of the initial foci of the disease. Additionally, by the time growers realised that the threshold had been reached and carried out the spray operation, the crops were badly infected. When crops that are badly infected with stripe rust are treated with fungicides, control is poor, since fungicides work better as protectants than as curatives.

Trials on stripe rust control (GRDC project SFS00006-2002–04) quickly established that foliar fungicide applications based on growth stages and applied between second node (GS32) and flag-leaf emergence (GS39) or at both timings gave good control of the disease. These growth stage-based timings also gave growers the opportunity to plan disease management strategies for susceptible cultivars.

The primary reason that these timings work is that the growth stages between GS32 and GS39 coincide with the emergence of the top three leaves of the crop canopy in wheat, meaning that fungicides are applied to leaves shortly after they have emerged and before tissue becomes heavily infected. However, it is also important to note that foliar fungicide applied at first or second node (GS31–32) does not protect the flag leaf or the leaf beneath it (flag-1), since they have not emerged at this early stem elongation growth stage. Equally, a foliar fungicide applied at flag leaf (GS39) may protect the flag leaf but may be too late to protect flag-2, which emerged two to three weeks earlier. [54]

Yield loss to stripe rust at different growth stage timing of disease onset

Although growth stage timings of fungicide applications can ensure that the top three leaves of the plant are adequately protected, the growth stage of disease onset dictates the level of economic response to a fungicide. For the construction of the Rustman model, a simple relationship (derived from trial results) linked expected yield losses to the onset of stripe rust infection at particular growth stages (Table 6). This simple chart (whilst complicated by the presence of adult plant resistance which occurs in most durum varieties) remains a useful guide to potential yield loss with susceptible cultivars at different growth stages.

54 N Poole, J Hunt (2014) Advancing the management of crop canopies. Grains Research and Development Corporation, January 2014, http://www.grdc.com.au/CanopyManagementGuide

Table 4: *Expected yield losses (%) due to stripe rust based on timing of disease onset.*

Disease onset		Yield loss due to stripe rust (%)			
Growth stage		Susceptible	Moderately susceptible	Moderately resistant	Resistant
GS31	First node	85	75	55	25
GS39	Flag leaf	75	45	15	5
GS45	Booting	65	25	7	2
GS49	1st awns	50	10	3	1
GS55	Mid heading	40	5	2	0
GS65	Mid flower	12	2	1	0

(Source: GRDC

PODCAST

Disease management and crop canopies.

Note that Table 6 is based on the premise that yield loss to stripe rust is dependent on:

- the extent of stripe rust by early grain development; and
- the temperature during grainfill (responses in the table assume average temperatures; if hotter, the yield loss attributable to disease is less than expected).

Otherwise, the data illustrate that the earlier the disease infects the crop, irrespective of variety resistance rating, the greater the expected loss. The time of stripe rust disease onset not only influences the expected return from foliar fungicides, it also influences the timing of fungicide applications in order to create the greatest return. [55]

Stem rust control

Spaying for stem rust control can be economic at later growth stages than for other diseases, with 50% yield increases as late as GS71. Fungicide will prevent subsequent infection when stem rust severity is slight on the plant parts to be protected.

Trigger points for stem rust control:

- When infection found on leaf sheaths, spray at GS39–51.
- When flag leaf sheath is infected, spray GS45–51.
- When peduncle (stem to the ear) is infected, spray GS55–75
- Optimum single spray at ear emergence GS55–59

9.3 *Septoria tritici* blotch

Septoria tritici blotch (STB) also called *Septoria* leaf spot or speckled leaf blotch is a fungal disease caused by the fungus *Mycosphaerella graminicola* (asexual stage *Zymoseptoria tritici*, synonym *Septoria tritici*). It can disperse over large distances early in the year when airborne spores are produced on infected wheat stubble. Subsequent infection only spreads by rain splash within the crop leading to hotspots of disease leaves where initial infection levels were low. [56] STB is a stubble-borne foliar disease that is now the most important wheat disease in Victoria's high rainfall cropping zones. The increase in STB has been favoured by stubble retention, intensive wheat production, susceptible cultivars and favourable conditions (cool and moist) for disease. Also, strains of STB with reduced sensitivity (partial resistance) to common fungicides have been detected. [57]

55 N Poole (2011) Cereal growth stages and decision making for fungicide timing. GRDC update papers. Grains Research and Development Corporation, September 2011, https://grdc.com.au/uploads/documents/GRDC%20Cereal%20Growth%20Stages%20Guide1.pdf

56 M Evans, H Wallwork (2016) Cereal pathology watch list for 2016. GRDC update papers. Grains Research and Development Corporation, February 2016, https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2016/02/Cereal-pathology-watch-list-for-2016

57 G Hollaway (2007) *Septoria tritici* blotch of wheat. Agriculture Victoria, December 2007, http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/plant-diseases/grains-pulses-and-cereals/septoria-tritici-blotch-of-wheat

The disease had been developing as a serious problem in the south-east of SA due to increased wheat cultivation with closer rotations, although dry springs helped to greatly suppress *Septoria* damage in the two seasons prior to 2015. In 2015 the disease was observed over a wide area throughout the mid and high rainfall regions of SA. It is apparent that the disease must have become established in one or more wheat crops between the Tothill and Bluff Ranges north-west of Eudunda during 2014 or earlier. As well as increased virulence on Mace, the recently identified *Septoria* population has increased virulence on other related varieties to the point that few of the commercial varieties can now be expected to escape infection if sown early in areas where inoculum is present. Growers should therefore now take greater care with this disease, especially when growing the most susceptible varieties in *Septoria*-prone areas. [58] While Australian durum varieties have only low to moderate resistance, growers need to consult a current cereal variety disease guide for individual variety resistance ratings. [59] See Table 1 which shows Caparoi as being resistant to moderately resistant while Saintly is susceptible.

Key points:

- Distinctive black fruiting bodies on leaf lesions are a good indicator for diagnosis of STB infection.
- Long periods of leaf moisture are required for disease development.
- Early sown crops and crops sown into wheat stubbles are most likely to be infected.
- Two gene mutations in STB detected by the NSW Department of Primary Industries indicate resistance to some fungicides.
- Adoption of an integrated disease management approach that includes crop rotation and, when necessary, applied fungicides, is the most effective management tool. [60]

9.3.1 Varietal resistance

See Table 1 in the section 9.1 Diseases in durum for varietal resistance to STB in the Southern Region.

9.3.2 Damage caused by *Septoria tritici* blotch

When susceptible and very susceptible varieties are grown, STB is likely to cause annual average losses of up to 20%, with much higher individual crop losses possible. [61]

9.3.3 Symptoms

The fungus causes pale grey to dark brown blotches on the leaves, and to a lesser extent stems and heads. The diagnostic feature of *Septoria tritici* blotch is the presence of black fruiting bodies (pycnidia) within the blotches (Photo 5). These tiny black spots give the blotches a characteristic speckled appearance. When the disease is severe, entire leaves may be affected by disease lesions (Photo 6).

58 M Evans, H Wallwork (2016) Cereal pathology watch list for 2016. GRDC update papers. Grains Research and Development Corporation, February 2016, https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2016/02/Cereal-pathology-watch-list-for-2016

59 GRDC (2014) *Septoria tritici* blotch fact sheet. Grains Research and Development Corporation, February 2014, http://www.grdc.com.au/GRDC-FS-Septoria-Tritici-Blotch-Wheat

60 GRDC (2014) *Septoria tritici* blotch fact sheet. Grains Research and Development Corporation, February 2014, http://www.grdc.com.au/GRDC-FS-Septoria-Tritici-Blotch-Wheat

61 G Hollaway (2007) *Septoria tritici* blotch of wheat. Agriculture Victoria, December 2007, http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/plant-diseases/grains-pulses-and-cereals/septoria-tritici-blotch-of-wheat

Photo 5: *Septoria tritici blotch causes pale grey to dark brown blotches on leaves; the presence of black fruiting bodies within the blotches is a diagnostic feature of the disease.*

Source: Grains Research and Development Corporation

Photo 6: *In severe cases of Septoria tritici blotch, entire leaves may be affected by disease lesions and the disease can cause complete death of leaves.*

Source: Agriculture Victoria

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

The only other disease that has black fruiting bodies within the blotches is *Septoria nodorum* blotch, but this disease is rare in Victoria. [62]

9.3.4 Conditions favouring development

Septoria tritici blotch survives from one season to the next on stubble. Following rain or heavy dew in late autumn and early winter, wind-borne spores (ascospores) are released from fruiting bodies (perithecia) embedded in the stubble of previously infected plants. These spores can be spread over large distances. Early ascospore infections cause blotches on the leaves. Within these blotches a second type of fruiting body, pycnidia, are produced. Asexual spores ooze from pycnidia when the leaf surface is wet and spores are dispersed by splash to other leaves where they cause new infections. This phase of disease development depends on the rain splash of spores; therefore STB will be most severe in seasons with above average spring rainfall. A combination of wind and rain provides the most favourable conditions for spread of this disease within crops. [63]

62 G Hollaway (2007) *Septoria tritici* blotch of wheat. Agriculture Victoria, December 2007, http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/plant-diseases/grains-pulses-and-cereals/septoria-tritici-blotch-of-wheat

63 G Hollaway (2007) *Septoria tritici* blotch of wheat. Agriculture Victoria, December 2007, http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/plant-diseases/grains-pulses-and-cereals/septoria-tritici-blotch-of-wheat

9.3.5 Management of disease

The best management strategy remains the avoidance of the most susceptible varieties, particularly with early sowing. [64] An integrated approach that incorporates crop rotation/stubble avoidance, variety selection and fungicides can provide effective suppression of STB. Identification of strains with partial resistance to common fungicides highlights the need to adopt an integrated control approach to slow the further development of resistance to fungicides. Since STB is primarily a stubble-borne disease, both crop rotation and stubble management contribute to disease control. In most instances, a one-year break from wheat is effective in reducing early disease occurrence, but during dry seasons a two-season break may be required. Any tillage that reduces stubble on the surface (such as burial, burning or grazing) can reduce inoculum levels, but these practices need to be balanced with the risk of soil erosion. Stubble management will not reduce disease caused by spores blown in from other paddocks. Avoiding susceptible and very susceptible varieties (ratings of S, SVS or VS) is an effective strategy to reduce in-crop disease severity and historically has provided long term disease control. Since STB is pathogenically diverse (that is, different strains can attack different varieties), and resistance breakdown is known to occur, it is important to consult a current disease guide each year. With support from GRDC and Agriculture Victoria, a new STB screening nursery was established at Hamilton to screen Australian National Variety Trials entries and pre-breeding lines. These results contribute to the ratings published in the cereal disease guide. [65]

MORE INFORMATION

Septoria tritici blotch fact sheet – Southern region

In-crop fungicides and timing

Fungicides can contribute to STB control, especially during wet seasons. In high risk areas the timing of fungicides is important to achieve adequate disease control. In early sown susceptible varieties, where infection is established during autumn, an early fungicide application at Z31–32 may be required to suppress the disease and protect emerging leaves. Another fungicide application may be required once the flag leaf has fully emerged at Z39 to protect the upper canopy.

Foliar fungicides registered to control this disease are available, but they are not entirely effective and there is a threat of fungicide resistance developing, especially with the strobilurins if they become used too frequently and when disease levels are high. Since STB is developing resistance to fungicides, it is critical that strategies are implemented that reduce the likelihood of further resistance developing. Changes in STB resistance to fungicides have been detected in the southern grain growing region, especially where wheat is sown into wheat stubble. Variety selection and crop rotations are essential for effective disease control. [66]

MORE INFORMATION

APVMA website

Increasing resistance of *Zymoseptoria tritici* to some triazole (Group 3) fungicides was recently detected in Victoria by Dr Andrew Milgate, NSW Department of Primary Industries. Two mutations of STB giving resistance to triazole fungicides were identified. These mutations reduce the effectiveness of fungicides, rather than making them completely ineffective. However, continued use of triazole fungicides will put further selection pressure on the pathogen, and potentially new mutations will be selected. [67]

Fusarium head blight

Fusarium head blight (FHB) is a fungal disease that can occur on many grass species, including both crop and weeds. Where it occurs in crops it is most commonly in wheat, durum and barley. The crown rot fungus is a closely related species, Fusarium

64 M Evans, H Wallwork (2016) Cereal pathology watch list for 2016. GRDC update papers. Grains Research and Development Corporation, February 2016, https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2016/02/Cereal-pathology-watch-list-for-2016

65 G Hollaway, M McLean, J Fanning (2016) Cereal disease management in Victoria 2016. GRDC update papers. Grains Research and Development Corporation, February 2016, https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2016/02/Cereal-disease-management-in-Victoria-2016

66 GRDC (2014) *Septoria tritici* blotch fact sheet. Grains Research and Development Corporation, February 2014, http://www.grdc.com.au/GRDC-FS-Septoria-Tritici-Blotch-Wheat

67 G Hollaway (2007) *Septoria tritici* blotch of wheat. Agriculture Victoria, December 2007, http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/plant-diseases/grains-pulses-and-cereals/septoria-tritici-blotch-of-wheat

pseudograminearum. Durum is more susceptible to the FHB than bread wheat and barley. Durum crops should be avoided in areas where there is a likelihood of the disease developing. While FHB can be caused by several species of Fusarium, the most common species causing the disease is Fusarium graminearum. 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. Crop rotation is effective in reducing levels of FHB.

9.3.6 Damage caused by disease

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 as a result of infection. Quality reductions may also occur from seed discoloration, varying from whitish-grey and pink to brown. [68]

9.3.7 Symptoms

In wheat and durum, any part or all of the head may appear bleached (Photo 7). 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.

Photo 7: *Fusarium head blight may cause bleaching of any part or all of the durum head.*

Source: Department of Agriculture and Fisheries Queensland

A brown/purple discolouration 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. Discolouration on the stem tissue or peduncle without the bleaching may be due to other causes such as physiological melanism. Additional symptoms that occur during prolonged wet weather and heavy infection of FHB are pinhead-sized, pink to salmon-orange spore masses on infected spikelets and glumes (Photo 8).

68 DAFQ (2015) Fusarium head blight, or head scab. Queensland Department of Agriculture and Fisheries, April 2015, https://www.daf.qld.gov.au/plants/health-pests-diseases/a-z-significant/fusarium-head-blight

Photo 8: *Symptoms of Fusarium head blight may include pink to salmon-orange spore masses on infected spikelets and glumes.*

Source: Department of Agriculture and Fisheries Queensland

Depending on how soon after flowering bread and durum wheats are infected, grain can have different severities of aborted kernels, shrivelled seed, low test weight and grain discolouration. 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 (Photo 9).

Photo 9: *Fusarium-infected seed may be normal in size but it may have lost its amber translucence and will appear chalky or opaque or pink.*

Source: Department of Agriculture and Fisheries Queensland

The best rotational crops for reducing the FHB inoculum level include any non-grass species (e.g. chickpeas, faba bean, canola, field peas). Currently, no seed dressings are registered for control of seedling blight caused by the FHB pathogens.

For more information see Section 9.2.5 Management of crown rot, or Section 1 Planning and paddock preparation.