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DURUM

SECTION 5

DISEASES

CROWN ROT | TAKE-ALL ROOT DISEASE | PYTHIUM ROOT ROT | LEAF SPOT, RUST AND OTHER FUNGAL DISEASES | FUSARIUM HEAD BLIGHT | ROOT LESION NEMATODES

MORE INFORMATION

GRDC 'Tips and Tactics Crown Rot in Cereals — Western Region, GRDC': www.grdc.com.au/TT-CrownRotWinterCereals

NSWDPI 'Crown Rot, an Update on Latest Research': https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2015/07/Crown-rot-an-update-on-latest-research

Diseases

5.1 Crown rot

Figure 1: *Severe crown rot affecting wheat plants.*

(SOURCE: GRDC)

Crown rot, caused by the fungus *Fusarium pseudograminearum*, is a major disease of durum and bread wheat in eastern Australia.

While it is not as significant in Western Australian wheat crops, its incidence appears to be increasing.[1]

The crown rot fungus enters the plant through the roots and blocks water movement from root to stem, causing grain to shrivel or fail to form.

Crown rot infection in wheat crops is characterised by a light honey-brown to dark brown discolouration of the base of infected tillers.

Major yield loss that results from the production of whiteheads is related to moisture stress post-flowering.

There are three distinct and separate phases of crown rot disease in wheat — survival, infection and expression. Management strategies can differentially affect each phase, as outlined below:[2]

1 Huberli, D (2014) Relative Yield Loss of Wheat Varieties to Crown Rot 2014 Trial Report, DAFWA, https://www.agric.wa.gov.au/wheat/yield-loss-response-curve-trial-crown-rot-2016-trial-report

2 Simpfendorfer, S (2015) Crown Rot an Update on Latest Research, NSW DPI Tamworth, GRDC 2015 Update Papers, https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2015/07/Crown-rot-an-update-on-latest-research

Survival

- Crown rot fungus survives as mycelium (cottony growth) in crop residues
- Hosts are winter cereals (wheat, barley, durum, triticale and oats)
- Grass weed residues also host disease
- Fungus will survive as inoculum inside stubble while intact
- This will vary due to soil and weather conditions
- Stubble decomposition is a slow process.

Infection

- Fungus will grow out of stubble residues
- It infects new winter cereal plants if there is soil moisture
- Infection occurs through the coleoptile, sub-crown internode or crown tissue (sub-surface)
- Fungus can infect plants above ground through outer leaf sheathes
- This requires direct contact with the previously infected residues
- Infections can occur right through the season if there is soil moisture
- Wet seasons favour increased infection
- High stubble loads tend to build-up inoculum levels.

Expression

- Yield loss is related to moisture/temperature stress
- This is particularly around flowering and grain fill
- Fungus proliferates in the base of infected tillers
- This restricts water movement from the roots through the stems
- Whiteheads are produced
- These contain either no grain or lightweight shrivelled grain
- Whiteheads can increase with moisture/temperature stress at grain fill
- Crops near trees in paddocks and along tree lines likely to show whiteheads.

Crown rot is often not detected until after heading, when whiteheads (those that are prematurely ripened) are seen scattered through a crop .

Most wheat varieties are susceptible or very susceptible to crown rot and it is recommended to avoid growing durum wheat immediately after a bread wheat crop to avoid this disease.

5.1.1 Durum wheat crown rot resistence

A five-year research program, to be carried out until 2018, has been established to transfer crown rot resistance genes from bread wheat and other tetraploid wheat sources into durum wheat varieties.[3]

Crossing durum wheat lines with bread wheat lines presents technical challenges because of the different genomics of the two species.

Bread wheat has three genomes and durum wheat has only two, so making successful crosses and then back-crossing to ensure the progeny are pure durum wheats takes some time.

Bread wheat crosses to three elite durum wheat breeding lines, including EGA Bellaroi⦹, have been advanced to the point where stable resistance has been identified over several generations in multiple families within these crosses.

3 Paterson, J (2014) Crown Rot Resistance in Cereal Breeding Pipeline: Durum Crown Rot Resistance, GRDC Ground Cover, Issue 111, GRDC, https://grdc.com.au/Media-Centre/Ground-Cover-Supplements/GCS111/Crown-rot-resistance-in-cereal-breeding-pipeline

MORE INFORMATION

NSWDPI 'Guide to Producing Durum Wheat': http://www.nvtonline.com.au/wp-content/uploads/2013/03/Crop-Guide-NSW-Durum-Wheat-Production.pdf

5.1.2 Tackling crown rot on-farm

A summary of diagnosis and management strategies that can be used for crown rot in cereal crops is outlined in Table 1.

Table 1: Diagnosing and managing crown rot in wheat.[4]

Diagnosis	Symptoms	Management
Use PREDICTA® B to monitor soil inoculum levels and guide wheat management decisions: http://www.sardi.sa.gov.au/diagnostic_services/predicta_b/why_test/crown_rot	To diagnose crown rot incrop use the GRDC-DPIRD MyCrop web tool: https://agric.wa.gov.au/n/2131	High nitrogen environments create large crops that can collapse with a large crown rot outbreak. A grass-free break from cereals is the best way to lower crown rot inoculum levels. There are no registered post-emergent chemical treatments to control crown rot. A registered fungicide-based seed treatment is available. More information on managing crown rot: www.grdc.com.au/GRDC-FSCrownRotCerealsSW New GRDC-funded research by DPIRD is evaluating the crown rot resistance of new and upcoming wheat varieties: https://agric.wa.gov.au/n/3774

There are no registered post-emergent chemical treatments to control crown rot in durum wheat crops.

The registered fungicide-based seed treatment for durum wheat is Rancona® Dimension, containing the Group 3 active ingredient ipconazole.

If disease levels are high and there is moisture and/or evaporative stress during grain fill, yield losses from crown rot can be up to 90 percent in durum wheat and 50 percent in bread wheat.[5]

The crown rot fungus can persist in infected cereal residues for up to two years and be carried into wheat crops from infected grass weeds.

Rotating cereals with non-susceptible crops, such as pulses, oilseeds, lupins or grass-free pastures — and maintaining good grass weed control — can reduce crown rot inoculum.

Inter-row sowing using GPS guidance in no-tillage systems has been shown to halve the number of plants infected with crown rot, resulting in a 5-10 percent yield increase.[6]

Cultivation (even when this is shallow) distributes infected residue more evenly across paddocks and into the infection zones below ground for crown rot management.

PREDICTA® B tests

Soil testing using the PREDICTA® B DNA-based diagnostic service is a good tactic to identify level of risk for crown rot (and other soil-borne pathogens) prior to sowing wheat.

4 GRDC 'Tips and Tactics Crown Rot in Cereals — Western Region, GRDC': www.grdc.com.au/TT-CrownRotWinterCereals

5 GRDC (2016) Tips and Tactics, Crown Rot in Cereals — Western Region, GRDC, www.grdc.com.au/TT-CrownRotWinterCereals

6 GRDC (2016) Tips and Tactics, Crown Rot in Cereals — Western Region, GRDC, www.grdc.com.au/TT-CrownRotWinterCereals

However, this requires a dedicated sampling strategy and is not a simple add-on to a soil nutrition test.[7]

PREDICTA® B detects levels of a range of cereal pathogens, including the main *Fusarium* species that cause crown rot.

It is accessed through accredited advisers and agronomists and correct sampling guidelines include:

- Collect three soil sample cores of 1 centimetre diameter and at 10 cm soil depth
- If the core is wider, take fewer cores per location
- Core at 15 different locations in the target paddock or production zone
- Take the soil cores from along/in the rows of previous cereal crop if still visible
- Retain any stubble collected by the core
- If the rows can't be seen, take the cores at random
- Add one piece of cereal stubble (if present) to the sample bag at each of the 15 sample sites
- Each stubble piece should be from the base of the plant and include the crown to the first node
- Maximum sample weight should not exceed 500 grams.

A commercial plant disease diagnosis service is also available through the Department of Primary Industries and Regional Development (DPIRD) Diagnostic Laboratory Services (DDLS)-Plant Pathology service at https://www.agric.wa.gov.au/bacteria/ddls-plant-pathology-services for crown rot and other pathogens.8

Crown rot paddock assessment

The most effective way to reduce crown rot inoculum is to include non-susceptible crops in the rotation sequence, as the fungus can survive for two or three years in stubble and soil.

Growing a non-host crop for at least two seasons is recommended to reduce inoculum levels.[9]

This allows time for decomposition of winter cereal residues that host the crown rot fungus.

Stubble decomposition varies with:

- » Type of break crops grown
- » Canopy density
- » Rate of canopy closure
- » Row spacing
- » Amount of soil water used
- » Seasonal rainfall.

Check cereal crops for crown rot between grain filling to harvest.

It is recommended to collect plant samples in the paddock by walking in a large W pattern and picking out five plants at 10 different locations, as shown in Figure 2.[10]

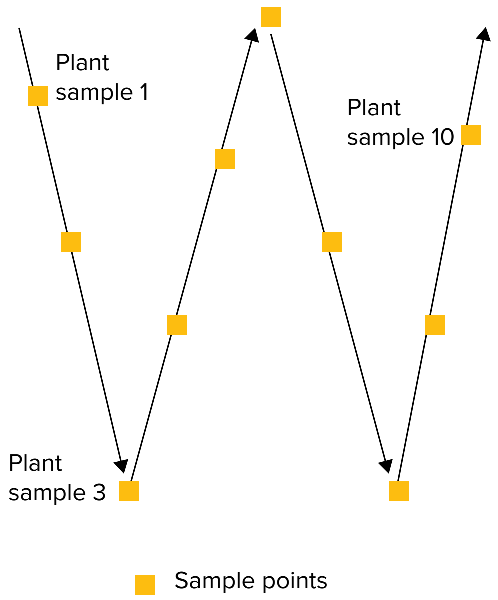
7 Simpfendorfer, S (2015) Crown Rot an Update on Latest Research, NSW DPI Tamworth, GRDC 2015 Update Papers, https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2015/07/Crown-rot-an-update-on-latest-research

8 GRDC (2016) Tips and Tactics, Crown Rot in Cereals — Western Region, GRDC, www.grdc.com.au/TT-CrownRotWinterCereals

9 Simpfendorfer, S (2015) Crown Rot an Update on Latest Research, NSW DPI Tamworth, GRDC 2015 Update Papers, https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2015/07/Crown-rot-an-update-on-latest-research

10 GRDC (2016) Tips and Tactics, Crown Rot in Cereals — Western Region, GRDC, www.grdc.com.au/TT-CrownRotWinterCereals

Figure 2: *The W pattern recommended for plant sampling to check for disease in cereal crops.*[11]



When sampling, examine each plant for basal browning, record the percentage that show the symptom and then put in place appropriate measures for the next year.

As a general rule, the risk for a cereal crop in the subsequent season will be:

- Low — less than 10 percent of plants infected
- Medium — 11-24 percent of plants infected
- High — more than 25 percent of plants are infected.[12]

If crown rot has caused yield loss, or is suspected to have caused loss, there are several ways to minimise disease risk for the coming season. But actual yield loss will be mostly determined by seasonal conditions.

For example, a paddock may have a high inoculum load but the cereal crop may only suffer small yield losses if there is good spring rainfall and mild temperatures.

Paddock history can also provide clues. Risk of crown rot tends to be high in paddocks following:

- High infection levels in a winter cereal crop in the past three years
- High frequency of winter cereals in the rotation
- Stubble retention with no tillage
- Low rainfall during the last fallow or break crop from cereals (where dry conditions have made residue decomposition slow)
- Poor grass weed control
- Stubble cultivated close to sowing
- Paddocks with low stored soil moisture at sowing/soil types with low water holding capacity.[13]

Stubble and crown rot fungus survival

- Stubble decomposition is a microbial process
- It is driven by temperature and moisture

11 GRDC (2016) Tips and Tactics, Crown Rot in Cereals — Western Region, GRDC, www.grdc.com.au/TT-CrownRotWinterCereals

12 GRDC (2016) Tips and Tactics, Crown Rot in Cereals — Western Region, GRDC, www.grdc.com.au/TT-CrownRotWinterCereals

13 GRDC (2016) Tips and Tactics, Crown Rot in Cereals — Western Region, GRDC, www.grdc.com.au/TT-CrownRotWinterCereals

- Cultivating stubble can increase rate of decomposition
- Cultivation reduces stubble particle size
- It will bury stubble particles in the soil where microbial activity is higher
- Cultivation dries out the soil in the cultivation layer
- This limits the potential for decomposition of the incorporated stubble
- Decomposition of cereal stubbles is a very slow process
- It requires adequate moisture for an extended period of time
- A summer fallow tends to be too short.

Stubble and crown rot infection

- The bulk of crown rot infection sites are below ground
- Infection requires physical contact between infected residue and plant parts
- Stubble cultivation breaks the inoculum into smaller pieces
- It spreads these more evenly through the cultivation layer across the paddock
- The fungus may contact the major infection sites below ground as the next winter cereal crop germinates and develops
- In a no-tillage system, fungus is confined to the previous cereal rows
- Fungus is more reliant on infection through outer leaf sheathes at the soil surface
- Inter-row sowing with GPS guidance can halve the number of plants infected with crown rot when used in a no-till cropping system.[14]

Stubble and crown rot expression

- Cultivation dries out the soil to the depth of cultivation
- This reduces water infiltration rate due to the loss of structure
- Lack of cereal stubble cover can increase soil evaporation
- With poorer infiltration and higher evaporation, fallow efficiency is reduced (cultivated systems compared to no-tillage stubble retention)
- Moisture availability can buffer against crown rot expression late in the season
- Cultivation is a balancing act between perceived benefits and costs.

Burning stubble removes the above-ground portion of crown rot inoculum, but the fungus typically survives in infected crown tissue below ground and this is not a quick fix for high inoculum situations.[15]

Removal of stubble through burning can increase evaporation from the soil surface and impact on fallow efficiency.

A cooler autumn burn is preferable to an earlier hotter burn, as this minimises the negative impacts on soil moisture storage while still reducing inoculum levels.

Inoculum level is important in limiting the potential for yield loss from crown rot. But the overriding factor dictating the extent of yield loss is moisture/temperature stress during grain fill.[16]

Soil moisture conservation tactics

Any management strategy that limits storage of soil water, or creates constraints that reduce the ability of roots to access this water, will tend to increase the probability and/or severity of moisture stress during grain fill and exacerbate the impact of crown rot.

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14 Simpfendorfer, S (2014) Cultivation Can Exacerbate Crown Rot, NSW DPI Tamworth, GRDC Ground Cover, Issue 111, GRDC, https://grdc.com.au/Media-Centre/Ground-Cover-Supplements/GCS111/Cultivation-can-exacerbate-crown-rot

15 Simpfendorfer, S (2015) Crown Rot an Update on Latest Research, NSW DPI Tamworth, GRDC 2015 Update Papers, https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2015/07/Crown-rot-an-update-on-latest-research

16 Simpfendorfer, S (2015) Crown Rot an Update on Latest Research, NSW DPI Tamworth, GRDC 2015 Update Papers, https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2015/07/Crown-rot-an-update-on-latest-research

Grass weeds are ideally controlled in fallow periods and in-crop. This is especially important in break crops, as these host the crown rot fungus and can significantly reduce soil moisture storage.

In pasture situations, grass weeds are best controlled well in advance of a following cereal crop, as these are a host for the crown rot fungus.

In a no-till system, the crown rot fungus becomes confined to the previous cereal rows and is more reliant on infection through the outer leaf sheathes at the soil surface.

This is a key reason inter-row sowing with GPS guidance has been found to reduce the number of plants infected with crown rot by up to 50 percent when used in a no-till cropping system.[17]

Further research has also demonstrated the benefits of row placement in combination with crop rotation and the relative placement of break crop rows and winter cereal rows within the sequence to limit disease and maximise yield.[18]

Sowing break crops between standing wheat rows, that are kept intact, and then sowing the following wheat crop directly over the row of the previous year's break crop tends to result in there being four years' break between wheat rows being sown in the same row space.

This has been found to substantially reduce the incidence of crown rot in wheat crops, improve establishment of break crops (especially canola) and benefit chickpeas from reduced virus incidence in standing wheat stubble.

In WA, inter-row sowing using accurate ±2 cm differential GPS autosteer has been shown to reduce the number of infected plants by about 50 percent, resulting in a 5-10 percent yield advantage in the presence of crown rot.[19]

Soil type does not appear to differentially affect the survival or infection phases of crown rot.

However, the inherent water holding capacity of each soil type interacts with expression by potentially buffering against moisture stress late in the season. Yield loss can be worse on red soils due to their generally lower water holding capacities.[20]

Any other subsurface constraint, such as sodicity, salinity or shallower soil depth, effectively reduces the level of plant available water which can increase the expression of crown rot.

Cereal crop and variety choice for crown rot management

All winter cereal crops host the crown rot fungus. Yield loss in subsequent crops varies between crop type. The approximate order of increasing loss from disease is oats, barley, triticale, bread wheat and durum wheat.

Bread wheat varieties appear to vary significantly in the level of yield loss to crown rot. Varietal resistance and tolerance to crown rot exist but are not the only solutions, according to researchers.[21]

Resistance is the plant's ability to limit the development of the crown rot fungus in living tissue. Tolerance is the plant's ability to maintain yield in the presence of crown rot infection.

Some of the new durum wheat lines show promise of improved resistance to crown rot compared to current commercial varieties.

MORE INFORMATION

'Crown Rot Resistance and Yield Loss': http://www.hartfieldsite.org.au/media/2013%20TRIAL%20RESULTS/21_Crown_rot_resistance__yield_loss_2013HartTrialResultsBook.pdf

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17 Simpfendorfer, S (2015) Crown Rot an Update on Latest Research, NSW DPI Tamworth, GRDC 2015 Update Papers, https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2015/07/Crown-rot-an-update-on-latest-research

18 Verrell, A (2014) Managing Crown Rot Through Crop Sequencing and Row Placement, NSW DPI, GRDC 2014 Update Paper, https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2014/07/Managing-crown-rot-through-crop-sequencing-and-row-placement

19 GRDC (2016) Tips and Tactics, Crown Rot in Cereals — Western Region, GRDC, www.grdc.com.au/TT-CrownRotWinterCereals

20 Simpfendorfer, S (2015) Crown Rot an Update on Latest Research, NSW DPI Tamworth, GRDC 2015 Update Papers, https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2015/07/Crown-rot-an-update-on-latest-research

21 GRDC (2016) Tips and Tactics, Crown Rot in Cereals — Western Region, GRDC, www.grdc.com.au/TT-CrownRotWinterCereals

Further field screening is needed to validate these findings, but the progress toward improved resistance to crown rot being made in durum breeding programs is encouraging, according to researchers.[22]

Crop Variety Guides and the National Variety Trials (NVT) website at: www.nvtonline.com.au provide crown rot ratings that are predominantly based on the evaluation of resistance.

The latest information about the relative yield of varieties in the presence of crown rot can be found on the GRDC website at www.grdc.com.au

However, researchers advise variety choice is not a solution to this disease. Even the best varieties tend to suffer up to 40 percent yield loss from crown rot under high infection levels and when there is a dry/hot seasonal finish in many areas of southern Australia.[23]

Sowing time and crown rot

Earlier sowing in the recommended window of a given wheat variety for a region can bring the grain fill period forward and reduce the probability of moisture and temperature stress during grain fill.

Earlier sowing can also increase plant root length/depth and provide more access to deeper soil water later in the season, which can buffer against crown rot expression.

This has been shown in previous research across seasons to reduce yield loss from crown rot. However, earlier sowing can place a crop at risk of frost damage during its most susceptible time.

Sowing time for cereal crops in WA is a balancing act between the risk of frost and heat stress.

However, when managing crown rot, increased disease expression due to delayed sowing can have just as big an impact on yield as frost.

There is the additional detrimental impact of later sowing on grain size in the presence of crown rot infection.

5.1.3 Crop nutrition and crown rot

Bulky crops are more likely to experience moisture stress during grain filling than less bulky crops, which makes these more vulnerable to yield losses from crown rot.

It is advised to match nitrogen (N) rates and timing to stored soil moisture and targeted potential yield. This can avoid excessive early crop growth that can diminish soil water reserves prior to the critical grain filling period.

Zinc (Zn) nutrition is important, as the expression of whiteheads in tillers infected with crown rot can be more severe in Zn deficient crops. But applying Zn above recommended rates will not typically provide further protection from crown rot.[24]

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

- Select a cereal type with lowest potential yield loss
- Select wheat varieties with improved tolerance[25]
- Match N nutrition to stored moisture and seasonal forecast
- Ensure Zn nutrition is adequate
- Sow on the inter-row on loams and heavier soil types if possible (not an option for water repellent sandy soils)
- Avoid sowing late in the planting window.

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22 Evans, M and Wallwork, H (2013) Hart Field Site 2013 Results: Crown Rot Resistance and Yield Loss, SARDI, http://www.hartfieldsite.org.au/media/2013%20TRIAL%20RESULTS/21_Crown_rot_resistance__yield_loss_2013HartTrialResultsBook.pdf

23 GRDC (2016) Tips and Tactics, Crown Rot in Cereals — Western Region, GRDC, www.grdc.com.au/TT-CrownRotWinterCereals

24 GRDC (2016) Tips and Tactics, Crown Rot in Cereals — Western Region, GRDC, www.grdc.com.au/TT-CrownRotWinterCereals

25 GRDC (2016) Tips and Tactics, Crown Rot in Cereals — Western Region, GRDC, www.grdc.com.au/TT-CrownRotWinterCereals

Registered fungicide seed dressings alone are unlikely to provide consistent or significant yield improvements, but may be beneficial when used with other management options.

Note that growing a cereal, particularly a susceptible variety, may increase inoculum levels for subsequent crops.

5.2 Take-all root disease

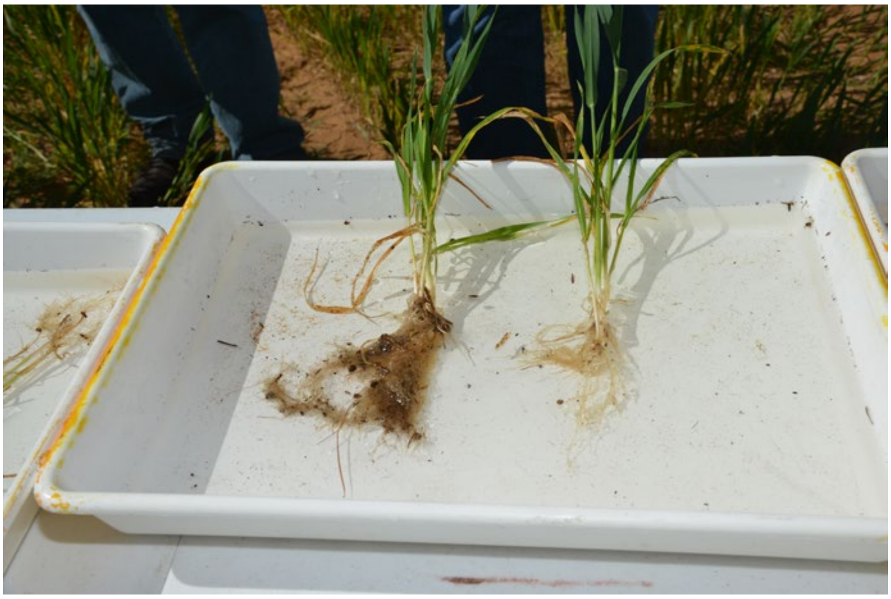

Figure 3: *Take-all disease can stunt root growth of wheat plants.*

(SOURCE: GRDC)

- Seed, fertiliser or in-furrow applied fungicides are registered
- Actives include flutriafol, fluquinconazole and triadimefon
- Acidifying fertilisers may slightly reduce disease severity
- Disease severity may increase after liming
- Control volunteer grasses and cereals
- Delay sowing following opening rains by implementing a short chemical fallow
- High rainfall in winter can increase disease pressure.

Take-all is a soil-borne disease of cereal crops and, in WA, is caused by two variants of the *Gaeumannomyces graminis* fungus. These are *G. graminis var. tritici* (Ggt) and *G. graminis var. avenae* (Gga).

Take-all restricts water and nutrient flow up the crop's root system and, under periods of moisture stress, causes infected plants to die prematurely.

While it remains a relatively minor disease in WA, take-all is most severe in high rainfall areas, including southern cropping regions and areas close to the coast.

Currently there are no available resistant wheat or barley varieties to take-all.

The most effective management strategy to control take-all is to deny the fungus the ability to survive in the paddock by eliminating hosts, using tactics summarised in Table 2.[26]

26 GRDC (2014) Hot Topic — Take All, GRDC, https://grdc.com.au/Media-Centre/Hot-Topics/Take-all

Table 2: Diagnosing and managing take-all in wheat.[27]

Monitor	Diagnose	Manage
Use PREDICTA® B to monitor take-all inoculum levels and guide wheat management decisions: www.sardi.sa.gov.au/diagnostic_services/predicta_b/why_test/take-all PREDICTA® B take-all map: www.sardi.sa.gov.au/diagnostic_services/predicta_b/disease_distribution	To diagnose take-all in crop use the GRDC-DPIRD MyCrop web tool: https://www.agric.wa.gov.au/n/2153	The most effective way to reduce take-all is to use a non-cereal break crop, grass-free pasture or chemical fallow to remove grasses in the year before wheat: www.soilquality.org.au/factsheets/take-all-disease There are no post-emergent fungicide treatments to control take-all. Check current registered seed dressings at: https://www.agric.wa.gov.au/n/1794

Take-all management tactics include using a non-cereal break crop, such as lupins, canola or field peas, and ensuring effective grass weed control during autumn.

Pastures containing low levels of grass species will also have reduced take-all carry-over levels in the following season.

Widespread adoption of no-till tillage has significantly increased the time required for stubble residue to break down and disease management should take this into account.

Burning stubbles can reduce the amount of surface residue infected with the take-all fungus, but typically the burn is not hot enough to affect the infected material below ground.

High rainfall in winter can increase take-all disease pressure.

If there is a soft finish to the season, cereal yield losses from take-all might not be as high. But the fungus will keep developing until the crop matures and pose an even greater risk to subsequent cereals.

27 GRDC (2014) Hot Topic — Take All, GRDC, https://grdc.com.au/Media-Centre/Hot-Topics/Take-all

FEEDBACK

5.3 Pythium root rot

Figure 4: *Using DNA analysis, CSIRO researchers Dr Paul Harvey and Rosemary Warren have identified that different crops are selecting to host different strains of pythium.*

(SOURCE: GRDC)

- No post-emergent treatments registered for suppression
- There are registered pythium-selective seed dressings
- Seed dressing actives are flutriafol and metalaxyl
- Diagnosis based on above-ground symptoms is difficult
- Moderate-severe disease often misdiagnosed as rhizoctonia.[28]

All major grain crops and pastures can host and be infected by pythium root rot. Wheat and barley are significantly less susceptible than pulses and canola.

Disease incidence tends to be higher after long-term legume pastures and repetitive wheat-canola rotations.

Pythium is often distributed relatively evenly in soils. This means that, in the absence of a protective treatment, all plants can be affected by pythium to a similar extent and severe infection can go undetected.[29]

Pythium is more prevalent in regions with an annual average rainfall above 350 millimetres and is often associated with waterlogging damage.

The effects of pythium root rot are often underestimated.

Guidelines for diagnosing, monitoring and managing pythium in wheat crops are outlined in Table 3.

28 GRDC (2010) Fact Sheet, Root Disease — Pythium Root Rot, GRDC, www.grdc.com.au/GRDC-FS-PythiumRootRot

29 GRDC (2010) Fact Sheet, Root Disease — Pythium Root Rot, GRDC, www.grdc.com.au/GRDC-FS-PythiumRootRot

Table 3: Diagnosing and managing pythium root rot in wheat.[30]

Monitor	Diagnose	Manage
PREDICTA® B pythium map: www.sardi.sa.gov.au/diagnostic_services/predicta_b/disease_distribution	Pythium is frequently misdiagnosed as rhizoctonia. To diagnose pythium in-crop use the GRDC-DPIRD MyCrop tool: https://www.agric.wa.gov.au/n/2142	Good weed control and the use of diverse rotations and fungicide seed dressings can help manage pythium: www.grdc.com.au/GRDC-FSPythiumRootRot Check currently registered fungicides or pythium at: https://www.agric.wa.gov.au/n/1794

5.4 Leaf spot, rust and other fungal diseases

Early sown wheat crops, including durum wheat varieties, can be particularly vulnerable to leaf spot and rust fungal diseases.

High disease pressure in continuous and early sown wheat crops before stem elongation can make it economical to apply a fungicide at — or before — early stem elongation (Zadoks Growth Scale stage GS31, or first node), particularly in medium and high rainfall areas.

Registered seed dressing and in-furrow fungicides can suppress leaf or stripe rust on wheat seedlings for four to six weeks, depending on the product and rate and — in some cases — can replace the need for a foliar spray before flag leaf emergence.[31]

Severe late season *septoria nodorum* blotch (SNB) can be an issue in WA wheat crops, as disease can spread from the leaves to infect wheat heads during grain fill to cause glume blotch.[32]

In these late-season infections, fungicide needs to be applied before crop heading is complete to reduce risks of head infection.

Spraying after heading is sub-optimal and spraying after crop flowering has finished is generally not economical.

Glume blotch results in dark patches on the glumes and can result in shrivelled grain and even complete loss of seed. Care needs to be taken to distinguish glume blotch from other causes of glume darkening, including pseudo black chaff, loose smut, frost and copper deficiency.

It is advised to send suspected glume blotch samples to DPIRD Diagnostic Laboratory Services (DDLS)-Plant Pathology at https://www.agric.wa.gov.au/bacteria/ddls-plant-pathology-services-for-diagnosis.

30 GRDC (2010) Fact Sheet, Root Disease — Pythium Root Rot, GRDC, www.grdc.com.au/GRDC-FS-PythiumRootRot

31 GRDC (2016) Western Wheat GrowNotes™, Section 5.8 Pg 18 Potassium, GRDC, www.grdc.com.au/GrowNotes

32 DPIRD (2016) Septoria Nodorum Blotch of Wheat, https://www.agric.wa.gov.au/crops/grains/wheat

5.4.1 Leaf spot disease treatment options

Yellow spot

Figure 5: *Yellow spot symptoms on a wheat leaf.*

(SOURCE: GRDC)

The registered in-furrow fungicide for the leaf spot disease yellow spot (caused by the fungus *Pyrenophora tritici-repentis*), is Uniform® (with the actives azoxystrobin and metalaxyl-M).

Foliar fungicides registered for control of yellow spot in wheat include:

- Azoxystrobin
- Tebuconazole
- Propiconazole
- Sulphur
- Prothioconazole
- Cyproconazole.

Septoria nodorum blotch, or spot-type net blotch

Figure 6: *Spot-type net blotch on leaf.*

(SOURCE: GRDC)

There are no registered seed treatments or in-furrow fungicides registered for control of SNB in wheat.

Foliar fungicide options for SNB control include:

- Azoxystrobin
- Tebuconazole
- Propiconazole
- Epoxiconazole
- Sulphur
- Prothioconazole
- Cyproconazole.

Septoria tritici blotch

Figure 7: *Septoria tritici blotch.*

(SOURCE: Evan Collis Photography)

Seed treatments registered for suppression of *septoria tritici* blotch (STB) are fluquinconazole-based.

Foliar fungicides that can be used for STB in wheat include the actives:

- Azoxystrobin
- Tebuconazole
- Propiconazole
- Sulphur
- Cyproconazole.

All wheat crops are vulnerable to air-borne spores of yellow spot and SNB.

Early sown crops are exposed to infection before later sown crops, which can provide these diseases with a head start.

Typically, milder conditions usually experienced in April and May also enable fungal diseases to mature more quickly on earlier sown crops.

Moderate to severe leaf disease in young wheat crops can reduce early growth, but the main impact of early disease is as a source of infection later in the season.

Leaf spot diseases are difficult to distinguish in wheat.

Yellow spot and SNB symptoms appear as irregular or oval-shaped spots that are initially small and yellow and then enlarge to form brown dead centres with yellow edges.[33]

33 GRDC (2011) Fact Sheet, Yellow Spot, Western Region, GRDC, https://grdc.com.au/Resources/Factsheets/2011/08/Yellow-Spot-Fact-Sheet-Western-Region

Being stubble-borne, leaf spot diseases are a particular a problem in continuous wheat crops where stubble retention is practised.

These diseases have the capacity to reduce yield by up to 30 percent and compromise grain quality in medium-high rainfall areas and in above-average seasons in lower rainfall areas.[34]

Management practices for leaf spot diseases are outlined in Table 4.

Table 4: Characteristics and management of wheat leaf spot diseases.[35]

Septoria nodorum **blotch**	**Yellow spot**
Primary infection from wheat stubble.	Primary infection from wheat stubble.
Infection requires heavy and frequent rain with warm weather (20-25°C) that results in leaves remaining wet for more than six hours.	Infection requires at least six hours of leaf wetness with temperatures of 15-28°C and periods of dew.
Air-borne spores can spread kilometres.	Air-borne spores are heavier than *septoria nodorum* blotch and spread only metres.
Secondary infection results from splash dispersed spores spreading the disease through the crop. Disease can spread from leaves to heads in a wet spring, this is known as glume blotch.	Secondary infection (leaf to leaf) occurs via air-borne spores and is favoured by leaf wetness (dew, fog or rain), high relative humidity and temperatures above 10°C.
Integrated disease management options	
Crop rotation.	
Avoid very susceptible or susceptible wheat varieties.	
Ensure crop has adequate nutrition; particularly nitrogen and potassium.	
No seed treatments or in-furrow fungicides are registered for control of yellow spot.	
A fluquinconazole based seed dressing is now registered for suppression of *septoria nodorum* blotch.	
Apply foliar fungicides when evidence of disease moving up the canopy.	

5.4.2 Rusts

Figure 8: *Wheat seedling showing infection with leaf rust.*

(SOURCE: GRDC)

MORE INFORMATION

'Australian Cereal Rust Control Program': http://sydney.edu.au/agriculture/plant_breeding_institute/cereal_rust/index.shtml

34 GRDC (2011) Fact Sheet, Yellow Spot, Western Region, GRDC, https://grdc.com.au/Resources/Factsheets/2011/08/Yellow-Spot-Fact-Sheet-Western-Region

35 GRDC (2011) Fact Sheet, Yellow Spot, Western Region, GRDC, https://grdc.com.au/Resources/Factsheets/2011/08/Yellow-Spot-Fact-Sheet-Western-Region

Leaf, stripe and stem rusts are among the major constraints to durum wheat and bread wheat production in Australia.

These rusts are also distributed across the world and have diverse race structures that continuously evolve and form new strains.

The most significant shifts in rust response ratings in Australia have been due to a series of changes in the pathotypes of wheat leaf rust, including the movement of two pathotypes from the eastern grains belt to WA in 2013 and 2015.[36]

The characteristics of the various wheat rust diseases found in Australia are outlined in Table 5.

Table 5: Characteristics of stem, leaf and stripe rust diseases of wheat.[37]

Characteristics	Stem rust	Leaf rust	Stripe rust
Colour	Reddish brown	Orange brown	Yellow
Shape of pustules	Oval to elongated with tattered edges	Circular to oval	Small circular in yellow stripes running along leaf
Location on plant	Both sides of leaf, leaf sheaths, stems and external head	Mostly on upper surface of leaf	Mostly on upper surface of leaf in characteristic stripes along leaf veins. Also on leaf sheaths, awns and inside glumes
Optimal conditions	Warm, humid (18-30˚C)	Moist with temperature between 10-20˚C	Cool, moist conditions (8-15˚C)
Potential yield loss	Usually 10-50% (but can be up to 90%)	Up to 30%	60%

Managing rust involves avoiding (where possible) the use of very susceptible or susceptible wheat varieties. Growing varieties with some level of rust resistance is the key to controlling disease outbreaks.

Knowing both the seedling and adult rust resistance characteristics of wheat varieties underpins effective fungicide management.

It is more effective to use fungicides to protect a crop from rust infection, rather than to control an already occurring rust outbreak, and crop monitoring is key to ensuring timely fungicide applications.

The rust fungi continually mutate and some of these mutations are capable of overcoming wheat rust resistance. The more rust there is in the environment, the higher the possibility that mutations with new virulence will develop.

Removing the 'green bridge' of weeds and volunteer cereal (and other) crops between seasons is a major control tactic, as the rust fungus cannot survive without a living host.

This will reduce the amount of pathogen that survives over summer and the amount of rust present at the start of the next growing season.

The green bridge must be totally removed at least four weeks before sowing to minimise the risk of carrying rust into new season crops.[38]

If high levels of rust are present in a green bridge when crops are sown, research has found even crops with moderate levels of rust resistance can potentially be severely

36 University of Sydney (2016) University of Sydney Plant Breeding Institute 2016 Cereal Rust Report, Vol 14 Issue 4, http://sydney.edu.au/agriculture/documents/pbi/cereal_rust_report_2016_14_4.pdf

37 University of Sydney (2016) University of Sydney Plant Breeding Institute 2016 Cereal Rust Report, Vol 14 Issue 4, http://sydney.edu.au/agriculture/documents/pbi/cereal_rust_report_2016_14_4.pdf

38 GRDC (2010) Fact Sheet, Green Bridge, GRDC, www.grdc.com.au/GRDC-FS-GreenBridge

affected. The rust tends to infect crops during the very susceptible establishment phase before adult plant resistance traits have had a chance to develop.

Wheat leaf rust

A new wheat leaf rust strain, originating in eastern Australia, was detected in WA in 2013 and a second in October 2015. This has altered disease ratings for some prominent WA bread wheat varieties.

The introduction of these two wheat leaf rust pathotypes to WA had radically shifted the leaf rust response of many bread wheat varieties towards increased susceptibility.[39]

All durum wheat varieties tested by researchers ranged from highly resistant, resistant or moderately resistant to the two new strains, as shown in Table 6.

Table 6: Disease response of Australian durum varieties to three rust diseases.[40]

	Rust Response				
	Leaf Rust		Stem Rust	Stripe Rust	
	Eastern States	WA		WA	Yr17+27+
Carparoi⍉	RMR	R	R	MR	MR
DBA Aurora⍉	R	RMR	R#	RMR	RMR
EGA Bellaroi⍉	RMR	RMR	MR	MR	MR
Hyperno	R	RMR	RMR	MR	MR
Jandaroi⍉	RMR	MR	MR	MR	MR
Penne⍉	R	RMR	MR	MR	MR
Rotini⍉	R	RMR	RMR	MR	MR
Tjilkuri⍉	R	RMR	MR	MR	MR
WID802⍉	R	RMR	RMR	MR	MR
Yawa⍉	R	MR	RMR	MR	MR

# indicates the variety may be more susceptible to alternate pathotypes, e.g. when the reaction to a new or rare pathotype is unknown.

Seed dressings containing fluquinconazole or triticonazole and the in-furrow fungicide triadimefon are registered for suppression of wheat leaf rust.

These can be particularly important for early sown and long season crops and, in some cases, can replace the need for a foliar spray before flag leaf emergence.

Wheat plants treated with at-sowing fungicides may still display minor levels of infection, but infection will tend to be significantly lower than that in untreated crops.

Treating leaf rust early can also make the disease easier to manage in spring if follow-up spraying is required.

Wheat stripe rust

Flutriafol or triadimenol seed dressings suppress stripe rust in seedling crops. Longer-term control can be achieved with fluquinconazole-based seed dressings (depending on application rate) and flutriafol in-furrow fungicides.

Wheat stem rust

There are no seed dressing or in-furrow fungicides currently registered for control of wheat stem rust.

39 University of Sydney (2016) University of Sydney Plant Breeding Institute 2016 Cereal Rust Report, Vol 14 Issue 4, http://sydney.edu.au/agriculture/documents/pbi/cereal_rust_report_2016_14_4.pdf

40 University of Sydney (2016) University of Sydney Plant Breeding Institute 2016 Cereal Rust Report, Vol 14 Issue 4, http://sydney.edu.au/agriculture/documents/pbi/cereal_rust_report_2016_14_4.pdf

MORE INFORMATION

The University of Sydney Plant Breeding Institute '2016 Cereal Rust Report': http://sydney.edu.au/agriculture/documents/pbi/cereal_rust_report_2016_14_4.pdf

Rust resistance testing

If rust outbreaks are detected in wheat varieties with rust resistance, it is advised to send samples for testing to the Australian Cereal Rust Survey. The outbreak may indicate a new virulent rust strain has developed.[41]

Rust samples should be sent in paper envelopes (not plastic bags), marked with name and contact details, date, location and variety. Leaves and stems with active pustules are required.

Post as soon as possible to: Australian Cereal Rust Survey, Private Bag 4011, Narellan, NSW 2567.

Sampling instructions, posting details and further information about new pathotypes can be found on the Australian Cereal Rust Control Program website at http://sydney.edu.au/agriculture/plant_breeding_institute/cereal_rust/index.shtml

5.4.3 Nutrition interaction with leaf spot and rust diseases

Research has shown wheat crops deficient in N and/or potassium (K) can be more vulnerable to leaf spot infections.[42]

It has found N and fungicide use can have an additive effect in reducing leaf spot diseases until ear emergence, resulting in significant yield increases in susceptible varieties.

Nitrogen increases wheat vigour and tiller numbers to lift yield — and possibly enable more effective fungicide application — particularly on susceptible wheat varieties.

Addition of K does not necessarily control disease, but can help plants meet yield potential.[43]

5.4.4 Smut diseases in wheat

Figure 9: *Wheat flag leaf showing smut disease in the field.*

(SOURCE: GRDC)

Wheat smut diseases are caused by fungi that parasitise the host plant and produce masses of soot-like spores in the leaves, grains or ears and reduce grain yield and quality.[44]

Smut diseases, outlined in Table 7, have one of two distinct life cycles — internally seed-borne or externally seed-borne. It is important to know the type of smut and its life cycle to determine effective control options.

41 University of Sydney (2016) University of Sydney Plant Breeding Institute 2016 Cereal Rust Report, Vol 14 Issue 4, http://sydney.edu.au/agriculture/documents/pbi/cereal_rust_report_2016_14_4.pdf

42 DPIRD (2016) Managing Yellow Spot and Septoria Nodorum Blotch in Wheat, https://agric.wa.gov.au/n/2196

43 DPIRD (2016) Managing Yellow Spot and Septoria Nodorum Blotch in Wheat, https://agric.wa.gov.au/n/2196

44 DPIRD (2016) Smut and Bunt Diseases of Cereal — Biology, Identification and Management, https://agric.wa.gov.au/n/326

Table 7: Smut diseases that infect wheat.[45]

Disease	Location	Management	Notes
Covered smut (common bunt)	Seed and soil-borne	Seed dressing Some variety resistance is available Use only clean seed and thoroughly clean contaminated machinery Rotate contaminated paddocks out of wheat and into barley, oats and broadleaf crops for at least one year Destroy any wheat regrowth in the break crop year	Extremely difficult to detect infield; low levels can remain undetected in harvested grain. Seed can be tested at DPIRD DDLS https://www.agric.wa.gov.au/n/1766 Zero tolerance for common bunt in wheat delivered to CBH Group Barley, oats and broad leaf crops are not affected by common smut To diagnose covered smut in the field use GRDC-DPIRD MyCrop: https://agric.wa.gov.au/n/2129
Flag smut	Seed and soil-borne	Correct seed dressing – especially for susceptible varieties Resistant varieties	Barley, oats and broad leaf crops are not affected by flag smut To diagnose covered smut in the field use GRDC-DPIRD MyCrop: https://agric.wa.gov.au/n/2136
Loose smut	Internally seed-borne. Carried as a small colony of fungus inside the seed embryo rather than as spores on the seed coat	No resistant varieties yet Seed dressings reduce incidence – correct application of seed dressings is critical to ensuring adequate control In-furrow and foliar fungicide applications are not effective	Infected seed shows no symptoms and appears normal Machinery and soil do not transmit loose smut Prevalent in areas receiving more than 450 mm average annual rainfall Frequent rain showers and high humidity at flowering favour infection To diagnose covered smut in the field use GRDC-DPIRD MyCrop: https://agric.wa.gov.au/n/2140

Smut diseases commonly occur at low levels but, without fungicide seed dressings, can increase rapidly to cause significant yield loss. There are no registered in-furrow fungicides for smut diseases.

Smuts can be controlled by specific seed dressings applied at the correct label rate. It is critical that every seed is covered with seed dressing for effective control.

45 DPIRD (2016) Smut and Bunt Diseases of Cereal — Biology, Identification and Management, https://agric.wa.gov.au/n/326

MORE INFORMATION

DPIRD 'Diagnosing Fusarium Head Blight in Cereals': https://www.agric.wa.gov.au/mycrop/diagnosing-fusarium-head-blight-cereals

5.5 Fusarium head blight

Figure 10: *Wheat with varying levels of fusarium infection, resulting in poor germination, contrasts with disease-free seed (lower right).*

(SOURCE GRDC)

Fusarium head blight (FHB) is a rare fungal disease that occurs mainly in high rainfall areas. It can significantly reduce grain yield and quality and produces toxins affecting marketability.[46]

Durum wheat varieties are particularly susceptible to FHB and crops show scattered, bleached spikelets or heads several weeks after flowering, with pink or orange spores at the edge of glumes.

Seedlings can be blighted in young crops sown with infected seed.

FHB can commonly be mistaken for frost damage, copper (Cu) and molybdenum (Mo) deficiency, spring drought, crown rot or take-all.

But the disease can be distinguished by the common symptoms outlined above, combined with shrivelled grain that can be discoloured as white or pink.

Head infection is favoured by moisture or high humidity around flowering time.

There is no treatment available and preventative measures are key to control.

It is recommended to avoid sowing multiple winter cereal crops in sequences, which can promote the disease once it is established, and to not sow winter cereals into summer crop paddocks until all summer residues have broken down. It is also advisable to avoid sowing winter cereals adjacent to those paddocks.

46 GRDC-DPIRD (2015) MyCrop: Diagnosing Fusarium Head Blight in Cereals, https://agric.wa.gov.au/n/2138

MORE INFORMATION

GRDC 'Tips and Tactics – Root Lesion Nematodes – Western Region': https://grdc.com.au/Resources/Factsheets/2015/03/Root-Lesion-Nematodes

5.6 Root lesion nematodes

Figure 11: *The effect of root lesion nematodes (right) stunting root growth in wheat grown at Dumbleyung, WA.*

(SOURCE: GRDC)

Figure 12: *Root lesion nematodes are microscopic, worm-like organisms.*

(SOURCE: GRDC)

Root lesion nematodes, or RLN (caused by *Pratylenchus* species), are significant pests that feed on the roots of crop plants and cause yield loss.

These microscopic, worm-like organisms are less than 1 mm in length and cannot be seen with the naked eye.

RLN levels are increasing across the WA grainbelt according to research and survey work.[47]

RLN species were found in 90 percent of 130 paddocks surveyed in 2013 and levels in almost half of the surveyed paddocks were high enough to cause 15-50 percent yield loss.[48]

It is estimated RLN are now found on 5.74 million hectares (or more than 65 percent) of WA's cropping areas. Populations potentially limit yields in at least 40 percent of these infested paddocks.[49]

The main species of RLN found in broadacre cropping systems in WA are *P. neglectus*, *P. quasitereoides* (formerly known as *P. teres*), *P. thornei* and *P. penetrans*.

The host range of RLN is broad and includes cereals, oilseeds, grain legumes and pastures, as well as many broadleaf and grass weeds.

Knowing which species of nematode is present in paddocks is key to management, which is underpinned by the choice of crop rotations used.

5.6.1 Symptoms of RLN

Above-ground symptoms of RLN are often indistinct and difficult to identify.

Initial signs can be poor wheat crop establishment, stunting of plants, poor tillering and plants possibly wilting despite moist soil.

Nematodes are usually distributed unevenly across a paddock, resulting in irregular crop growth. Symptoms can be confused with nutrient deficiency and exacerbated by a lack of nutrients.[50]

When roots are damaged by RLN, the plant becomes less efficient at taking up water and nutrients and less able to tolerate stresses, such as drought or nutrient deficiencies.

Depending on the extent of damage and the growing conditions, affected plants may partly recover if the rate of new root growth exceeds the rate at which nematodes damage the roots.

Underground symptoms of nematode damage include a general browning or discolouration of primary and secondary cereal roots and there may be fewer, shorter lateral roots branching from the main roots. The root cortex (or outer root layer) can be damaged and may disintegrate.

Diagnosis of RLN and the specific species is difficult and can be confirmed only with laboratory testing, as all RLN species cause identical symptoms.

The PREDICTA® B soil test is a useful tool for identifying several nematode species and is available through accredited advisers and agronomists. Sampling guidelines are outlined below.

47 Collins, S (2013) WA Root Lesion Nematode Causes Yield Losses, GRDC-DAFWA 2013 Agribusiness Crop Updates, DAFWA, https://agric.wa.gov.au/n/724

48 Collins, S (2013) WA Root Lesion Nematode Causes Yield Losses, GRDC-DAFWA 2013 Agribusiness Crop Updates, DAFWA, https://agric.wa.gov.au/n/724

49 GRDC (2015) Tips and Tactics, Root Lesion Nematodes, Western Region, GRDC, www.grdc.com.au/TT-RootLesionNematodes

50 GRDC (2015) Tips and Tactics, Root Lesion Nematodes, Western Region, GRDC, www.grdc.com.au/TT-RootLesionNematodes

Plant samples

- Collect plants from several locations towards the margins of poor crop growth
- Use a trowel or shovel to keep the root system intact
- Keep the soil ball intact to protect the roots in transit.

Soil samples

- Use a soil corer or trowel to sample to 0-10 cm
- Take samples in crop rows and close to root systems
- Collect from 6-12 locations towards the margins of poor crop growth
- Put soil samples in a bucket and mix gently but thoroughly
- Remove a 500 g sample and seal in a plastic bag
- Collect a second sample from healthy areas in the crop
- Label all bags
- Include notes on relevant paddock symptoms.

NOTE: SARDI PREDICTA® B is available through accredited advisers.

5.6.2 Impact of the RLN lifecycle

RLN are migratory plant parasites that move freely between roots and soil if the soil is moist.

In WA, the lifecycle of RLN begins after opening rains in autumn. Juvenile and adult nematodes rehydrate, become active and invade plant roots, where they feed and multiply as they move through the root.

RLN lay individual eggs in the plant root, from which juvenile nematodes hatch and grow to adults — which in turn lay more eggs.

The nematodes develop from an egg to adult in 40-45 days (typically about six weeks), depending on soil temperature and host, and there may be three to five lifecycles in the plant host each season.

As plants and soil dry out in late spring, RLN enter a dehydrated state called anhydrobiosis and can survive high soil temperatures and desiccation over summer.

As the nematodes feed and multiply, lesions and/or sections of brown discoloration are formed on the plant root.

5.6.3 Paddock management for RLN

Implementing an effective management strategy for RLN relies on observation and monitoring the above and below-ground symptoms of nematode damage and diagnosis of the cause(s).[51]

If RLN infestation is suspected, it is advised to firstly check crop roots by carefully digging them up, washing off the soil and — if there is evidence of infestation — sending them for laboratory analysis.

Testing services are available at DPIRD DDLS-Plant Pathology and the SARDI DNA-based soil testing service PREDICTA® B for detection of the RLNs *P. neglectus*, *P. thornei* and *P. quasitereoide*.

Although little can be done in a current cropping season to ameliorate nematode symptoms, diagnostic test information is crucial in planning effective rotations of crop species and varieties in following seasons.

Well-managed rotations incorporating resistant or non-host break crops are vital.

The GRDC-DPIRD Crop Variety Guides are useful resources for choosing crop types and varieties with high resistance ratings, which can result in fewer nematodes remaining in the soil to infect subsequent crops.

51 GRDC (2015) Tips and Tactics, Root Lesion Nematodes, Western Region, GRDC, www.grdc.com.au/TT-RootLesionNematodes

Reducing RLN can lead to higher yields in following cereal crops.

Healthy soils and good crop nutrition can partly alleviate RLN damage through good crop establishment and healthier plants may recover more readily from infestation under more suitable growing conditions.

It is advised to observe crop roots to monitor development of symptoms.

Weeds can host parasitic nematodes within and between cropping sequences, so choice of pasture species and control of host weed species and crop volunteers is important.

Nematicides are not recommended for control of RLN on broadacre crops due to cost and potential mammalian toxicity — and because rotation crop options are available to help in nematode management.

There is limited information available about the effect of time of sowing on yield loss in intolerant crops in the presence of RLN.[52]

Adequate nutrition (especially N, P and Zn) can help cereal crops to compensate for the loss of root function caused by RLN, although this does not necessarily lead to lower nematode reproduction.

In field trials in areas infested with *P. neglectus*, yield losses for intolerant wheat varieties ranged from 12-33 percent when minimal levels of P were applied, but losses were reduced to only 5 percent with a high rate of P (50 kg/ha).[53]

Weeds can play an important role in increased incidence or persistence of nematodes in cropping soils. Poor control of susceptible weeds can compromise the use of crop rotations for RLN management.

Wild oats (*Avena fatua*), barley grass (*Hordeum vulgare*), brome grass (*Bromus*) and wild radish (*Raphanus raphanistrum*) are susceptible to *P. neglectus*.

There are several pasture species and varieties suitable to include in rotations to reduce RLN when these are targeted to the RLN species in the paddock, but weed control is vital as this can strongly influence nematode populations at the end of the pasture phase.

Nematodes cannot move across long distances unaided but can be spread by surface water, in soil adhering to vehicles and farm machinery and in summer dust (when in a dehydrated state). In uninfested areas, it is advised to use good hygiene to reduce these risks.[54]

52 GRDC (2015) Tips and Tactics, Root Lesion Nematodes, Western Region, GRDC, www.grdc.com.au/TT-RootLesionNematodes

53 GRDC (2015) Tips and Tactics, Root Lesion Nematodes, Western Region, GRDC, www.grdc.com.au/TT-RootLesionNematodes

54 GRDC (2015) Tips and Tactics, Root Lesion Nematodes, Western Region, GRDC, www.grdc.com.au/TT-RootLesionNematodes