VERSION 4.0

GROWER MANUAL

A practical guide to identifying and managing cereal root diseases in South Australia

SAGIT

SARDI
SOUTH AUSTRALIAN RESEARCH AND DEVELOPMENT INSTITUTE

Government of South Australia
Primary Industries and Regions SA

The guide is part of the SARDI Cereal Root Health Workshop series, supported by the South Australian Grains Industry Trust, and has been developed following feedback from growers and agronomists who wanted a guide to assist in identification and management options to minimise the risk from soil-borne diseases in the southern grain growing regions of Australia.

Acknowledgements

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Disclaimer

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Soil diseases in Australia - the impacts

Rhizoctonia uneven growth ID tip: look for uneven growth in barley and wheat developing in mid winter. Confirm by washing roots and examine for spear tips.
IMAGE: ALAN MCKAY, SARDI

Soil disease in Australia – the impacts

Cereal root diseases in Australia can have a serious impacts on grain yield.

Diseases such as cereal cyst nematode (CCN), take-all, rhizoctonia root rot, crown rot, root lesion nematode (RLN), stem nematode and blackspot of peas can cause:

- Significant yield losses by limiting water and nutrient uptake
- Increased weed seed set (reduced competition)
- Increased crop damage from some herbicides
- Reduce cropping options

Paddocks affected may have the following features:

- Bare patches, uneven growth, whiteheads in previous crop
- Unexplained poor yield
- Symptoms of nutrient deficiency in leaves
- Unexpected wilting/water deficiency

Cereal root diseases cost grain growers in excess of $200 million annually in lost production. Much of this loss can be prevented. However, most decisions to achieve this need to be made and implemented before crops are sown.

Disease development

There are four main factors that determine the development of each soil-borne disease, these include;

PATHOGEN LEVEL | **ENVIRONMENT** | **CROP & VARIETY** | **MONITORING AND MANAGEMENT**

The grower has some control over the pathogen levels prior to sowing (PREDICTA B), plan to change or select an appropriate crop or variety, monitor their crops throughout the season looking for characteristic root or paddock, symptoms, plan which crop/variety are grown and use best practice management such as weed management, nutrition, agronomy and soil. They are unable to change the environment, which can unfortunately contribute to unexpected responses despite the management approach.

Do not rely on crop symptoms alone to diagnose cause of disease.

The best practice approach to minimise the yield and productivity risks is to Know Before you Sow and:




IDENTIFY	PLAN	MONITOR	MANAGE
Over summer conduct PREDICTA B soil testing to determine disease levels. Test well before sowing to allow you time to respond.	Make decisions about which crop / variety to grow, considering resistance and tolerance ratings. Know the environmental conditions which may impact disease prevalence.	In crop assessment. Monitor your crop from late tillering to anthesis, looking for characteristic disease symptoms. Assessment should include a root wash.	Reconsider late applications of nitrogen, or cutting for hay depending on disease levels. Plan for next season.

How to sample and wash roots assess disease

If crops are performing poorly or you notice patchy areas, it may be a root disease. Growers and advisers are encouraged to check root health by doing a root wash. The following process is suggested.

MATERIALS

- Spade or shovel
- Buckets / large bags
- Roll of kitchen paper towels
- White tray (eg ice cream container /plastic plate / ½ drum or similar)
- Water

SAMPLING INSTRUCTIONS

- Select paddock / areas you which are poorly performing.
- Dig up repesentative plants by placing the spade about 10 cm from the plants and push down vertically to around 15 cm. Then lift plants carefully, trying to minimise root damage (Fig. 1 and 2).
- Carefully place the plants in a bucket or bag.
- Repeat procedure to collect sample from a neighboring 'good' area. Label plants to avoid confusion.

Collecting samples

Fig 1. Dig 2 plants, push down vertically to around 15 cm.

Fig 2. Lift plants carefully, to minimise root damage.

Fig 3. Soak plants in bag or bucket.

WASHING ROOTS

- Add water to the bucket / plastic bag to cover the roots and soak until soil is soft (Fig. 3).
- Gently agitate plants to remove soil, try to avoid clods breaking off roots.
- Rewash plant in a bucket of clean water, to remove remaining dirt and plant residues (Fig. 4 and 5).
- Alternatively, you can wash roots on a sieve over the bucket using a hose with spray nozzle.
- Remove plants from water and pat dry with paper towel.

ASSESSING YOUR SAMPLE

- To assess roots, float in water in a WHITE sample tray (eg ice cream container /plastic plate / ½ drum or similar) (Fig. 6).
- Refer to the manual and assess characteristic symptoms.
- For support, you can photograph the roots suspended in water (include crown and seminal roots in the image) and send to the SARDI team (contact details below) (Fig 7.).
- For greatest accuracy, it is recommended that you also conduct a DNA test.

POSTAGE OF WASHED SAMPLES

- If you would like to send your samples to SARDI for assessment, follow the below process:
- Remove the top growth 5 cm above the crown.
- Dry and wrap the roots with paper towel.
- Place wrapped roots into the plastic sample bags with the matching sample number.
- Fold and place into a sample bag and dispatch ASAP.

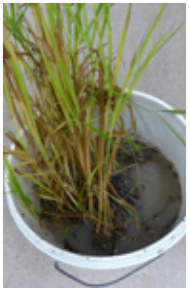


Fig 4. Rewash plant in a bucket of clean water.

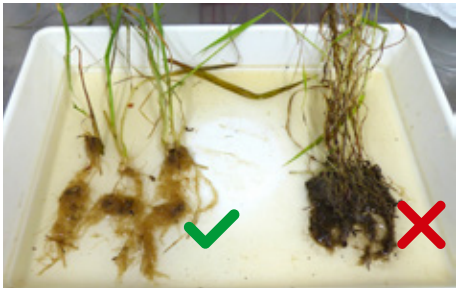


Fig 5. Remove all dirt and plant residues.

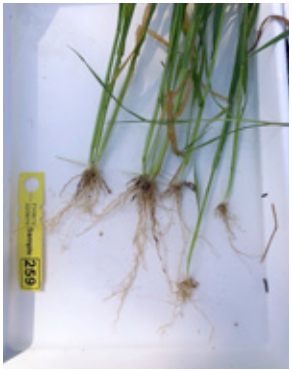


Fig 6. Float washed roots in a white tray with water.

Fig 7.Include crown and seminal roots and the sample number in image.

PREDICTA B

PREDICTA B is a DNA-based soil testing service, which measures pathogen levels in the soil, allowing growers to identify soil-borne disease risks prior to sowing to make better informed variety, rotation and paddock management decisions.

Benefits of the test include:

- Pathogens are identified that pose a disease risk before crops are sown
- Identify need for long-term disease management
- Samples are processed weekly from February to June
- Results (PDF) are emailed to the accredited agronomist to ensure producers receive the most relevant advice

PREDICTA B has tests for most of the soil-borne pathogens that cause following diseases of cereals and pulse crops and are reported with disease risk categories:

- Crown rot (cereals)
- Rhizoctonia root rot
- Take-all (including the oat strain)
- *Pratylenchus thornei*
- *Pratylenchus neglectus*
- Cereal cyst nematode (CCN)
- Stem nematode
- Blackspot (field peas)

Results for new tests are also reported with population density categories, including:

- Bipolaris (common root rot)
- Pythium clade f
- Eyespot
- *Pratylenchus quasitereoides*
- *Pratylenchus penetrans*
- Yellow spot
- Ascochyta blight in chickpeas
- Phytophthora root rot
- Fusarium stalk rot
- Charcoal rot
- White grain disorder
- Long fallow disorder

Soil-borne pathogens

It is important to understand the range of diseases that can impact crop health and further understand the terminology used to describe them. One common misconception is what constitutes a pathogen versus what constitutes a disease.

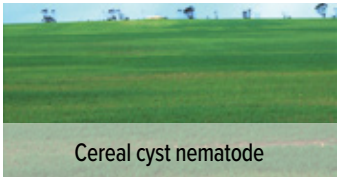
The following definitions are useful:

- Pathogen – a plant parasitic fungus or nematode.
- Disease – symptoms caused by the pathogen infecting the plant (note: the environment can also be important in determining the impact of a disease on the crop).

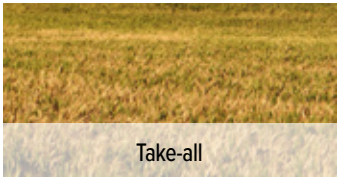
DID YOU KNOW?

PREDICTA B quantifies the pathogen not the disease.

PATHOGEN > 
Heterodera avenae

DISEASE > 
Cereal cyst nematode

PATHOGEN > 
Gaeumannomyces graminis var tritici (Ggt)

DISEASE > 
Take-all

PATHOGEN > 

Rhizoctonia solani AG8

DISEASE > 
Rhizoctonia root rot

PATHOGEN	 *Fusarium pseudograminearum*	DISEASE	 Crown rot
PATHOGEN	 *Pratylenchus* spp.	DISEASE	 Root lesion nematode
PATHOGEN	 *Ditylenchus dipsaci*	DISEASE	 Stem nematode

Rhizoctonia root rot

Reviewers: Alan McKay (SARDI), Gupta Vadakattu (CSIRO), Jack Desbiolles (UniSA) and Daniel Huberli (DPIRD)

Previous reviewers: David Roget, Albert Rovira and Stephen Neate (USQ)

The soil fungus *Rhizoctonia solani* causes crop damage by pruning newly emerged roots. Yield losses can be as high as 50 per cent in badly diseased crops.
IMAGE: ALAN MCKAY AND SJAAN DAVEY (SARDI).

Rhizoctonia spear tips on crown roots in wheat.
IMAGE: SJAAN DAVEY, SARDI

Spear tips on lupin roots caused by Rhizoctonia.
IMAGE: ALAN MCKAY, SARDI

About

Rhizoctonia root rot is an important diseases of cereals especially in the southern and western regions, the main hosts are cereals and grasses. The disease is caused by *Rhizoctonia solani* AG8.

WHERE DAMAGE IS MOST LIKELY

- In low soil fertility (especially P, N and Zn) eg. Sandy and alkaline calcareous soils of southern and western Australia.
- In low rainfall zones.
- In intensive cereal rotations or cereals grown after grassy pastures.
- Following a dry spring/summer.
- When weed growth is not controlled before sowing.
- There is no soil tillage below seed.
- When root growth below 5cm is restricted.
- Low moisture and low soil temperatures.

WHEN ARE YIELD LOSSES GREATEST?

- In above average rainfall seasons, symptoms worse than in below average rainfall years.
- Cold soils during seedling establishment, long winter.
- In sandy and alkaline calcareous soils, especially those prone to non-wetting.
- Inadequate crop nutrition, especially N, P and Zn.
- When there is green weed growth, especially grasses, ahead of seeding in areas with rhizoctonia history.
- When crops are sown with minimum soil disturbance and no disturbance below the seed.
- Late seeding, cold soil slow early growth, heat stress during grain fill.
- When there are herbicide residues that slow crop growth eg. sulfonylurea herbicides.

DID YOU KNOW?

- Rhizoctonia root rot can reduce yield of cereals by more than 50%; barley is the most susceptible.
- Affected crops cannot access water and soil nutrients efficiently and often appear N or P deficient.
- Affected crops are less competitive with weeds and so weed set is increased.
- Rhizoctonia root rot is more damaging in soils with low microbial activity. Yield losses can increase when other root diseases are present at medium to high levels.

Symptoms

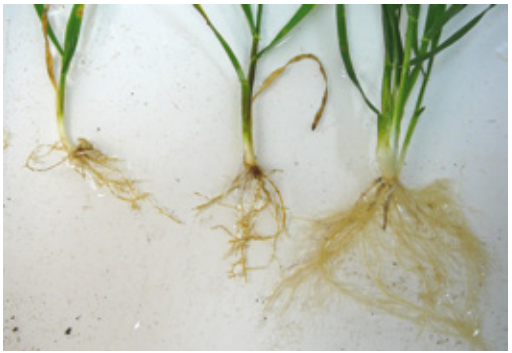
The symptoms of a *Rhizoctonia solani* AG8 infection include bare patches 3-5 weeks after sowing or development of uneven growth in mid-winter. Loss of roots can cause signs of N and P deficiency and reduced water uptake. Losses can exceed 50%, and recent research indicates the impact is greater in the better seasons, even though symptoms may appear worse in drought years.

IN PADDOCK

- Distinct bare patches occur when seminal roots are removed within 3 to 5 weeks of sowing; yield losses can exceed 50%.
  (Image: Jack Desbiolles, UniSA)

- Stunted plants in bare patches often show nutrient deficiency.
- Leaves often appear yellow, but sometimes red – similar to N and P deficient symptoms
  (Image: Alan McKay, SARDI)

- Development of uneven growth during mid-winter occurs when Rhizoctonia removes the crown roots; yield losses can exceed 30%.
  (Image: Alan McKay, SARDI)



PLANT ROOTS

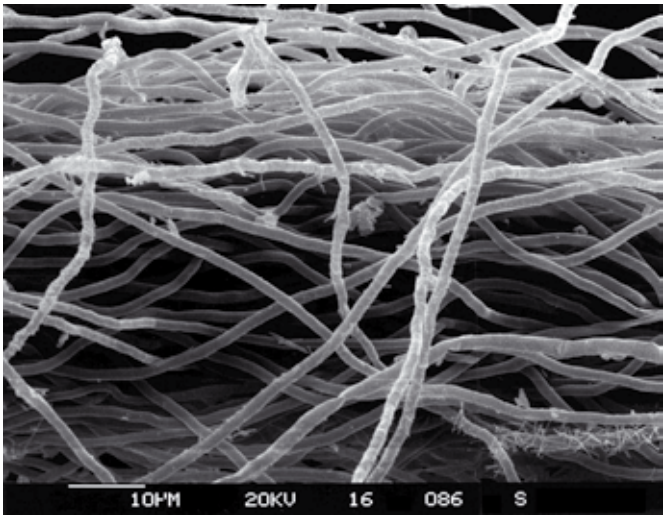
- *Rhizoctonia* affected wheat roots (left, middle) compared to a healthy plant (right). (Image: Alan McKay, SARDI)
- Affected plants show characteristic 'spear tipping' on seminal and crown roots.
- For a given level of root damage, the effect on plant growth is much greater in sandy soils than in heavier soils as plants require greater root volume to source water and nutrients.
- Seminal roots escaped serious infection, but crown roots have been removed. (Image: Sjaan Davey, SARDI)

Biology

***Rhizoctonia* is well adapted to low to medium rainfall regions and has a competitive advantage over other soil-borne organisms during drought.**

Rhizoctonia solani AG8 survives over summer on decaying crop residues.

- After the autumn rains it forms a hyphal network in the top 0 to 5 cm of soil. This hyphal network is sensitive to soil disturbance.
- The fungus grows throughout the growing season, especially in cereals, with the greatest increase occuring during spring, especially those affected by drought.
- It survives best when there is no summer rainfall.
- Well adapted to non-wetting soils.



Rhizoctonia forms a hyphal network in soil. **(Image: Gupta Vadakattu, CSIRO)**

Host range

Cereals and grasses are main hosts of *Rhizoctonia*. (Image: Gupta Vadakattu, CSIRO)

The main hosts of *Rhizoctonia solani* AG8 are winter cereals and grasses.

The fungus will infect roots of a broad range of plants, including oilseed, pulse and pasture legumes, but these are generally poor hosts. The reduced levels following these crops will benefit the next cereal crop, but by harvest *Rhizoctonia* levels will be high.

Rhizoctonia solani AG8 can survive at low levels in the absence of a live host, on plant debris.

TOLERANCE IN CEREALS

- Crops differ in ability to yield when affected by rhizoctonia root rot. Yields losses are greater in: barley > wheat > triticale> oats.
- There is growing evidence of varietal differences in ability to tolerate infection and in the amount of inoculum produced, this needs further investigation.
- There are other groups of *R. solani* that cause disease in pulses, oilseeds and pasture legumes.

Patches are not the only area within the crop where Rhizoctonia root rot causes yield loss.
IMAGE: GUPTA VADAKATTU, CSIRO

Impact of management and season

The ability of *Rhizoctonia* to survive and grow is influenced by soil type, fertility, moisture, temperature and biological activity. The disease is more severe when the crop is under stress e.g. in cold, dry and compacted soils or affected by herbicide residues. Under these conditions even low levels of inoculum can cause disease.

FACTORS THAT REDUCE INOCULUM	FACTORS THAT MINIMISE YIELD LOSS
• Wet summer, multiple rainfall events >20mm. • Above average spring rainfall. • Grass free oilseeds, pulses and pastures. • Summer weeds controlled. • Paddock maintained weed free before seeding. • Improve water holding capacity of non-wetting sands, increases soil biological activity and reduces the competitive advantage *Rhizoctonia* has in dry soils.	• Plant cereals after grass free canola, pulses or pastures. • No green weeds in few weeks before seeding. • Sow wheat instead of barley, if frost risk low. Sow early within the optimum time. • Encourage rapid early root growth below 10cm: - Use soil openers that disturb soil below seed. - N banded below seed. - Seedlings establish in warm moist soil. - Adequate moisture in soil profile. - No compaction layer. - No residual herbicides. • Dual application of fungicides at seeding above and below seed is most consistent for protecting crown roots. Other options include: - seed treatment + infurrow liquid stream. - seed treatment + coated fertiliser.

Management options

RHIZOCTONIA LEVEL	OPTIONS
• Below detection	• Control summer weeds.
• Low (capable of causing significant disease if conditions are conducive)	• Control summer weeds/green bridge. • Consider tolerant crops – oats > triticale > wheat > barley. • Sow at optimum time, if late break consider dry sowing. • Ensure adequate nutrition, especially N, P, Zn and other micro nutrients at seeding and tillering. • Consider registered seed treatments, these will not eliminate patching. • Use openers that disturb soil below the seed e.g. knife points/triple disc. • Minimise use of herbicides that slow root growth e.g. avoid sulfonylureas. • Risk increased if following grass/legume pastures.
• Medium	• As per low risk recommendations. • Consider grass free canola, mustard, pulse or pasture. • Consider in-furrow fungicides, dual banding above and below seed best in higher yield potential seasons. * Uneven growth reduced not eliminated.
• High	• Strongly consider grass free canola, mustard, pulse or pasture. • If sowing cereals as per medium risk recommendations. • Dual band fungicides in high yield potential seasons.

The reduced inoculum following grass free oilseed, pulse or pasture usually only benefits the establishment of the following cereal crop. Levels in the cereal crop will build to high levels during spring, placing the subsequent cereal at risk.

Do I need to soil test?

YES.

WHY?

- PREDICTA B will indicate if *Rhizoctonia solani* AG8 level is below detection, or represents a low, medium or high risk.
- While growers often know their worst Rhizoctonia paddocks based on a history of bare-patches. PREDICTA B can identify paddocks where the main symptoms are uneven growth that develops during mid-winter.
- Knowing which crops are at risk before sowing enables the most effective management strategies to be implemented.
- Rhizoctonia distribution can be very patchy and low Rhizoctonia levels detected by PREDICTA B can cause significant disease if conditions are conducive.

TIP:
Don't ignore low *Rhizoctonia* results in paddocks and regions where conditions suit development of disease, eg long cold winters.

FAQ's

Q: What farming systems approaches should I use to manage the disease?

A: Implement as many of the following as possible:

- Sow early/optimum seeding date while soil is warm.
- Pre-sowing tillage may reduce the disease by breaking up the fungal network.
- In no till system the effects of disease can be reduced by using narrow sowing points that cultivate below seeding depth to increase the rate of early root growth.
- Avoid single disc seeders in *Rhizoctonia* risk paddocks.
- In paddocks to be sown later, prevent weed growth after the break. This limits the build-up of *Rhizoctonia* and is especially important with direct drill systems.
- Sound nutrition to sustain/encourage early seedling vigour helps the plants cope with the disease.
- Nitrogen placed below the seed encourages rapid root growth below the *Rhizoctonia* layer, thus reducing damage to the seminal roots.
- Post emergent N applications will help plants recover, but root systems will still be damaged.

Q: Can I get rid of Rhizoctonia?

A: *Rhizoctonia* cannot be eliminated, only managed to minimise the damage it causes. Stubble retention systems can result in development of suppressive microbial populations, resulting in *Rhizoctonia* causing much less damage.

The fungus can still be present in suppressive soils. Disease suppression is dependent on greater return of residues (carbon) to the soil. Suppression is unlikely to improve in paddocks where water use efficiency is below 60%.

Q: Does burning stubbles affect Rhizoctonia?

A: No. In fact it is counter-productive in reducing organic matter inputs, which help with the development of disease suppressive soils.

Crown rot

Reviewers: Steven Simpfendorfer (NSW DPI), Margaret Evans (SARDI), Grant Hollaway (Agriculture Victoria) and Daniel Huberli (DPIRD)

Previous reviewers: Lester Burgess and Jerry Dennis, Cassandra Percy (USQ), Stephen Neate (USQ), Shahajahan Miyan (DPIRD) and Hugh Wallwork (SARDI)

Scattered whiteheads in wheat crop - how bad it can get.
IMAGE: MARG EVANS, SARDI

Comparison of stem colouration at tillering due to crown rot (left) and accumulation of anthocyanins (right). IMAGE: MARG EVANS, SARDI

Crown rot uninfected and honey coloured infected stubble.
IMAGE: STEVEN SIMPFENDORFER, NSW DPI

Crown rot tip: look for scattered white heads.
IMAGE: MARG EVANS, SARDI

About

Crown rot is a stubble-born disease of all winter cereals and grassy weeds. The disease, caused by *Fusarium pseudograminearum*, *F. culmorum* and/or *F. graminearum*, can reduce yields by up to 80 per cent in durum and 40 per cent in bread wheat. It can also decrease grain size and increase screenings.

WHERE DAMAGE IS MORE LIKELY

- *F. pseudograminearum* is the main cause of crown rot in Australia. *F. culmorum* can be important in the higher rainfall areas in South Australia, Victoria and southern Western Australia.
- Most damaging in the northern region, but can cause large losses in all regions.
- In intensive cereal rotations without break crops such as winter pulses, canola or summer crops.
- Where the plant available water content of the soil is low in spring and/or during high temperatures.
- Where there is a lot of infected residue.
- Where infected stubble has been mulched or cultivated close to sowing.

DID YOU KNOW?

- Losses in trials conducted in northern NSW averaged 80% in durum, 40% in bread wheat, 30% in barley and 23% in triticale across 11 sites in 2007.
- Losses in 12 trials conducted in SA averaged 34% in durum, 11% in bread wheat, 7% in barley and 20% in triticale from 1998 to 2008.
- The crop usually appears normal up to heading stage, when whiteheads appear.
- Yield losses are greater in drier springs. Losses are often negligible in seasons with a wet finish, but inoculum levels still increase.
- While all cereals can be affected, durum is very susceptible.

Symptoms

A tell-tale sign of crown rot is scattered whiteheads around flowering and a honey/dark brown coloured crown and lower stem with symptoms becoming more pronounced from mid to late grain fill through to harvest. To view the symptoms, the leaf sheaths should be pulled back. Whiteheads develop when water flow through to the stem is restricted by the fungus causing the head to hay-off prematurely. Symptoms can extend up the stem, and the fungus may form pink hyphae at the lower nodes.

Whiteheads are rarely observed in barley, but it is very susceptible to infection. Crown rot can kill barley plants in the vegetative growth stage if heat and moisture stress occurs.

Cereal oats and wild oats infected with *F. pseudograminearum* do not develop whiteheads and stem symptoms are difficult to detect. However, oats are still a host of the crown rot fungi.

PADDOCK

- Scattered whiteheads in durum and bread wheats, triticale and rye following moisture stress after head emergence.
- Whiteheads are rarely seen in barley (as it matures earlier) and are not evident in oats.
- In wetter springs whiteheads may not express, except around trees and compacted areas.
- Plants may be stunted and produce fewer tillers.
- Affected heads may contain no grain or shrivelled grain depending on stress timing.
- A pink hyphal growth may develop under the leaf sheath in wet conditions.

(Image: Marg Evans, SARDI)

PLANT

- Stem browning at head emergence.
- Must peel back leaf sheaths to view discolouration.
  (Image: Marg Evans, SARDI)

- Healthy stems on left and honey/dark brown stems on right.
- Symptoms most visible from early grain fill to just after harvest.
- These symptoms are rare in oats.
  (Image: Steven Simpfendorfer NSW DPI)

- Pink staining/hyphal growth at nodes, under leaf sheath or inside stems if adequate moisture.
  (Image: Hugh Wallwork, SARDI)

Note: There are other causes of whiteheads, such as frost, common root rot, heat, fusarium head blight, insect damage white grain disorder and take all. If in doubt, and to ensure you have the correct diagnosis, a soil or plant test is of importance.

IMAGE: STEVEN SIMPFENDORFER, NSW DPI

Winter cereals and many grass weeds host the crown rot fungi, which can grow and survive inside living and dead host material.

KEY FEATURES

- *Fusarium pseudograminearum* is the main cause of crown rot
- *F. culmorum* survives as thick walled, long lived resting spores (chlamydospores) in soil.
- Inoculum declines slowly over two to four seasons.
- Infection occurs by direct contact with infected plant residue.
- Infection requires moist conditions early in season.
- Warm weather favours fungal growth.
- The fungus grows quicker in water stressed plants.
- Infection restricts water flow up the stem, which results in whiteheads in seasons with a dry finish.

DID YOU KNOW?

Crown rot survives for up to four years in infected plant residues/stubbles. Infection occurs when plants come in close contact with infected residues. Crown rot levels generally increase in intensive cereal rotations.

Whiteheads showing up due to moisture stress around trees.
IMAGE: STEVEN SIMPFENDORFER, NSW DPI

Q: Which varieties are most tolerant to crown rot?

A: Tolerance to crown rot varies between cereals. Yield losses are greatest in durum wheat > triticale > bread wheat > barley.

Host range

The crown rot fungi can infect all winter cereals, but can be a particular problem in durum wheat.

HOSTS

- All winter cereals (durum, triticale, barley, wheat, oats and rye).
- Grassy weeds (including barley grass, brome grass, ryegrass, wild oats, silver grass).
- Durum wheat is particularly susceptible.

NON-HOSTS

- Pulses, oilseeds and cotton.
- Pasture legumes.
- Sorghum and maize – beware these as are hosts of *F. graminearum* which can cause fusarium head blight in winter cereals if wet weather occurs during flowering.

Impact of management and season

The ability of the crown rot fungi to grow and persist is influenced by crop and variety choice, moisture and temperature. The amount of inoculum produced is greater in bulky cereals; cereal type or variety has less affect. Yield loss and disease expression will be reduced if there is adequate moisture and mild temperatures during grain fill.

FACTORS THAT REDUCE INOCULUM	FACTORS THAT MINIMISE YIELD LOSS
Management	**Management**
• Increase frequency of grass free break crops in the rotation. • Breakdown cereal stubble; - Grow break crops with early canopy closure. - Burn cereal stubble, note crowns still infected. - Consider double breaks if levels are high. • Reduce frequency of durum wheat and triticale in the rotation; their stubble is more persistant.	Select paddocks: - With low crown rot inoculum. - With adequate stored soil moisture. - Without an underlying subsoil constraint or other root disease issue (e.g. RLN). • Select a cereal that will suffer less yield loss, eg barley < oats < bread wheat < triticale < durum wheat. • See local Cereal Variety Disease Guide for crown rot ratings. • Sow between rows of standing stubble of last cereal crop. • Plant at start of sowing window to minimise moisture stress at grain fill. • Match N fertiliser to season potential, too much N will produce bulky crop and induce late moisture stress.
Environment	**Environment**
• Conditions that favour stubble breakdown: - Significant summer rains. - Moist conditions below canopy of break crops and in fallows.	• Mild spring temperatures and adequate spring rainfall.

There are no in-crop fungicides to effectively control crown rot.

Management Options

FUSARIUM LEVEL	BREAD WHEAT/BARLEY	DURUM WHEAT
• Below detection	• No restrictions.	• No restrictions.
• Low	• Balance N to season potential. • Sow between rows of last cereal. • Consider non-host break crop. • Ensure adequate Zn nutrition. • Plant at the start of the sowing window for selected bread wheat or barley variety.	• Consider other cereals. • Balance N to season potential. • Sow between rows of last cereal. • Ensure adequate Zn. • Plant at start of the sowing window.
• Medium – high	• Plant non-host break crop if possible. • Select adapted varieties with best resistance ratings. • Consider barley in preference to wheat. • Sow between old rows if inoculum levels in this zone are low. • Apply N in crop to season potential. • Ensure adequate Zn nutrition. • Ensure good weed control. • Consider not planting a cereal if sowing is significantly delayed or switch to earlier maturing variety. • Consider crown rot registered seed treatment	• Do not sow durum wheat.

Do I need to soil test?

YES.

PREDICTA B testing is important to understand the Fusarium levels before seeding.

This will enable the implementation of a disease management strategy, which is especially important if growing durum. Testing will also enable growers to:

- Check impact of break crop.
- Check inter-row risk when inter-row sowing.
- Make better informed crop/variety choice.
- Check for other soil-borne pathogens that may increase crown rot risk, eg root lesion nematode.

Since whiteheads only appear in seasons with a dry finish, the absence of whiteheads does not indicate a freedom from crown rot. A more reliable diagnostic feature is to check for browning of the stem base. PREDICTA B can also assess the risk before sowing when the correct sampling protocol is followed, which includes adding stubble to the soil.

IMAGE: MARG EVANS, SARDI

FAQ's

Q: My durum crop is in head and has crown rot, should I cut it for hay?

A: Not necessarily. Check the level of crown rot first. Pull up 5–10 plants at each of 3–4 spots and check stem bases for browning. As a broad rule of thumb if less than 10–15% of plants are infected do not cut for hay. If >30–40% of plants are infected then cut for hay. The final decision should consider durum wheat prices, potential yields and value of the crop as hay. Also depends on soil moisture and weather conditions predicted during grain filling. If warm hot weather and low soil moisture then cut for hay.

Q: What about inter-row sowing?

A: Inter-row sowing can allow an extra cereal crop to be grown in infected paddocks. This will only work when inoculum levels are low between the rows (check by soil sampling) and where the old, infected stubble is standing and will not come into direct contact with the base of the new crop.

Q: I want to grow durum wheat, but what about crown rot?

A: Despite losses to crown rot, some growers report durum wheat produces better gross margins than bread wheat. Their strategy includes: choosing paddocks with low crown rot inoculum; having a break of 4–5 years between durum crops; not sowing durum late; choosing soil types that finish durum crops better; limiting early nitrogen application; and knowing after which break crops durum performs best on their farms.

Q: Which break crops are best for reducing crown rot?

A: Breaks from cereal are the best way to reduce crown rot inoculum. These breaks need to be free of grassy weeds to be effective. In the southern region, peas and fallow reduce inoculum most, followed by canola then vetch and medic (limited data for the last two). In the northern region sorghum, faba bean and canola are more effective breakcrop options than chickpeas.

Inoculum breakdown is accelerated where there are warm, damp conditions under the canopy. Where inoculum levels are very high and there is low rainfall, it may take 2–3 or even 4 years to achieve a low risk of yield loss for durum wheat.

Q: Will burning or cultivation get rid of crown rot?

A: Burning, cultivation, cutting for hay and baling for straw are not instant fixes for crown rot. They can be useful as part of a long term management strategy, but should be used with care as they can have detrimental effects on soil health and soil moisture levels. These management options will be more useful when followed by a break from cereals.

Pratylenchus
Root lesion nematode

Reviewers: Grant Hollaway (Agriculture Victoria), Joshua Fanning (Agriculture Victoria), Alan McKay (SARDI), Katherine Linsell (SARDI), John Thompson (USQ), Kirsty Owen (USQ), Carla Wilkinson and Sarah Collins (DPIRD)

Previous reviewers: Richard Daniel (NGA), Jeremy Whish (CSIRO), Vivien Vanstone (DPIRD), John Thompson (USQ), Nikki Seymour (USQ) and Sharyn Taylor

Root Lesion Nematode ID check: Damaged wheat roots will show a reduction in length and number of lateral roots, plus brown discoloured lesions.
IMAGE: FRANK HENRY, AGRICULTURE VICTORIA.

Root lesion nematode
(*Pratylenchus* species)

Root lesion nematodes (RLN) (*Pratylenchus* species) feed on the roots of crops. They are microscopic, worm-like organisms, less than 1mm in length, which use a syringe-like stylet to enter the roots and extract nutrients, causing significant damage as they feed. Each has a wide host range and can multiply on cereals, oilseeds, pulses and pastures as well as on broadleaf and grass weeds.

There are three main root lesion nematode (RLN) species affecting broadacre crops in Australia. The most important species in eastern Australia are *Pratylenchus thornei* and *P. neglectus*, and in the western region *P. neglectus* and *P. quasitereoides* (*formerly P. teres*).

WHERE DAMAGE IS MORE LIKELY

- When pre-sowing nematode densities are high
- In intensive cropping rotations with high frequency of susceptible crops and varieties
- Where intolerant cereal varieties are grown on stored soil moisture
- In paddocks with low fertility due to reduced ability of the root system to access the more limited soil nutrients
- When crops are sown late
- When crops are under stress due to other factors e.g. other diseases or nutrient deficiency

Did you know?

- In the northern region *Pratylenchus thornei* causes yield losses of 0 to 60% in 50% of current varieties (compared to the most tolerant variety EGA Wylie).
- Losses in the southern and western regions are still being determined; so far yield losses for the most intolerant varieties in the southern region range up to 15%.
- Yield losses are additive when other root or crown disease are also present.
- Damage to roots can increase symptoms of nutrient deficiency and restrict water uptake.
- Affected crops are less competitive with weeds increasing weed seed set.
- Choosing the right crop and variety to grow is the key to managing RLN.

Root lesion nematodes feeding in root cortex.
IMAGE: ABDOL TAHERI, UNIVERSITY OF ADELAIDE

Symptoms

Identifying damage caused by RLN is difficult to detect from aboveground symptoms alone. The first symptoms of RLN can be slow emergence and establishment, followed by stunting, poor tillering in cereals and plants wilting despite moist soil. Irregular crop growth will also be noted as nematodes are often distributed unevenly across a paddock.

Crop symptoms are the same for all *Pratylenchus* species, though some hosts are symptomless. Aboveground and root symptoms are usually visible around 6 to 8 weeks after sowing.

Scout wheat; 45 *P. neglectus*/g soil

5 *P. neglectus* /g soil

Crop symptoms

PADDOCK

- Delayed establishment, slow growth, fewer and shorter tillers and uneven canopy.
- Yellowing of lower leaves similar to N deficiency.
- Size of affected areas may increase during and between seasons.
- Wilting, particularly with a dry finish.

(Image: Alan McKay, SARDI)

PLANT ROOTS – CEREAL

- Reduction in length and number of lateral roots.
- Brown discoloured lesions on roots or entire root may be brown.
- No "spear tips" as with *Rhizoctonia*.

(image: Frank Henry, AgVic)

PLANT ROOTS – CHICKPEA

- Lateral roots reduced in length and number.
- Orange-brown coloured lesions on roots.
- Crop symptoms are the same for all *Pratylenchus* species, though some hosts are symptomless.
- Aboveground and root symptoms are usually visible around 6 to 8 weeks after sowing.
- Patches of ill thrift are often associated with early infestations.

(image: Vivien Vanstone, DPIRD)

SYMPTOM CHECK TIP

Since aboveground symptoms of RLN damage are similar to the symptoms observed in other root diseases, nutrient deficiencies or moisture stress it is recommended that plant roots are closely examined for symptoms. To do this plants must be dug from the ground using a shovel, not pulled, and washed carefully.

Note: soaking of the roots overnight is often required to completely remove soil without damaging the root system. Heavily damaged roots can be washed away in the paddock.

Biology

P. thornei

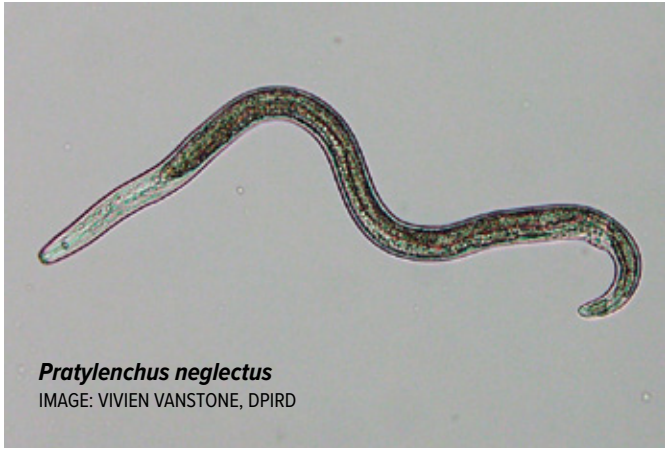
- *P. thornei* is widespread in the northern region particularly in the deep well-structured soils, where crops are grown on stored moisture.
- *P. thornei* can feed on roots throughout the soil profile, which reduces the ability of crops to utilise stored soil moisture.
- In the southern region *P. thornei* occur more often in the medium to high rainfall cropping districts in well structured clay soils. High populations have also been found in low rainfall districts in sandy soils.

P. neglectus

- *P. neglectus* occurs in most soils across Australia.
- *P. neglectus* occurs mostly in the top 10cm of soil.

P. quasitereoides* and *P. penetrans

- *P. quasitereoides* is important in the western regions of WA.
- *P. penetrans* is sporadic in WA but can be very damaging.
- RLN can produce multiple generations per growing season and can move between roots.
- In actively growing hosts a new generation can be produced in 40 to 45 days during the warmer months.
- Multiplication is reduced by drought.
- In dry soils RLN survives in a dehydrated state (anhydrobiosis) in old roots and soil, and become active when soil is moist.



Pratylenchus neglectus
IMAGE: VIVIEN VANSTONE, DPIRD

Host range

RLNs have a broad host range that includes cereal and broadleaf crops.

NON CEREAL PASTURE HOSTS

See latest Crop Disease Variety Guide and GRDC RLN Tips and Tactics for more regional details.

RESISTANCE CLASSIFICATION	*PRATYLENCHUS THORNEI*	*PRATYLENCHUS NEGLECTUS*	*PRATYLENCHUS QUASITEREOIDES*
Susceptible (good host)	Chickpea, faba bean, sub-clover, common vetch, sulla	Canola, chickpea, mustard, biserrulla, sub-clover	Canola, barley, wheat
Moderate (moderate host)	Pea, canola, lentil	Lentil, vetch, lotus, serradella, medic, lucerne	
Resistant (poor host)	Pea, lentil, medic, linseed, safflower, rye, oat, narrow-leafed lupin	Pea, narrow-leafed lupin, faba bean, safflower, rye, sulla, linseed	Narrow-leafed lupin, serradella, field pea

WEED HOSTS

Limited research in southern and western regions indicates some weeds can build-up or carry over *Pratylenchus*. Host range differs for each species.

NEMATODE BUILD-UP	*PRATYLENCHUS THORNEI*	*PRATYLENCHUS NEGLECTUS*
High	Barley grass	Wild oats, wild radish, barley grass
Medium	Brome grass, wild oats	Silver grass, brome grass, turnip

Impact of management and season

FACTORS THAT REDUCE INOCULUM	FACTORS THAT MINIMISE YIELD LOSS
Management	**Management**
• High frequency of resistant crops and varieties grown. • Host weeds controlled soon after early breaks and in resistant crops. • Low numbers can occur after a susceptible crop affected by severe spring drought.	• Hosts controlled soon after early breaks. • Low initial nematode densities. • Sow tolerant (and resistant) crops/varieties. • Sow early within optimum seeding window. • Provide adequate nutrition.
Environment	**Environment**
• Conditions that reduce RLN multiplication: - Droughts especially post tillering. - Wet soil with no hosts.	• Mild spring temperatures and adequate spring rainfall. • Note: losses are greater in northern region.

POINTS TO NOTE:

- Crops with good resistance to both *P. neglectus* and *P. thornei*:
  - peas and rye (check latest crop variety guides for new resistance classifications).

Management options

If medium or high nematode densities are detected, select crops and/or varieties to:

- Minimise grain yield losses (tolerant varieties).
- Reduce *Pratylenchus* populations in the soil for future years (resistant crops).
- Note: variety resistance and tolerance classifications can vary between *Pratylenchus* species (refer to....Cereal and Pulse Variety Disease Guides).

Southern Region *Pratylenchus* management options

RISK RATING	OPTIONS
Below detection	Focus on managing other crop constraints.
Low	Yield loss likely to be low. If growing a susceptible crop, monitor numbers next year; Scepter is more susceptible than Mace. Good weed control pre-sowing to prevent early multiplication.
Medium – High	Achieve good weed control before seeding and in-crop. Only sow resistant varieties. Two consecutive resistant crops are often needed to reduce high numbers to low levels. Sow early.

Note: choose appropriate crops and varieties for the *Pratylenchus* species present.

In Southern Region, controlling *Pratylenchus* should be a lower priority than CCN, take-all and *Rhizoctonia* barepatch.

If nematode populations are high, often two consecutive resistant crops will be needed to reduce numbers to low levels. If numbers are medium, one year of resistant crop/variety will usually reduce nematode numbers to low risk category.

If the most profitable crops are susceptible, avoid sowing late and plan to follow these with a resistant crops and varieties to reduce nematode numbers.

CROP TRAIT	EFFECT ON THIS YEARS CROP
Intolerant	Crop yields poorly when infested
Tolerant	Crop yields relatively well despite being infested
	EFFECT ON NEXT YEARS CROP
Susceptible	Nematode numbers increased
Resistant	Nematode numbers decreased

IMAGE: RICHARD DANIEL, NORTHERN GROWER ALLIANCE

Do I need to soil test?

YES.

WHY?

Knowing the levels of each RLN species present affects which crop and varieties to grow. PREDICTA B testing is important due to the following reasons:

- *Pratylenchus* symptoms are difficult to diagnose in the field.
- There are multiple species each with a different host range that often span cereals, pulses and oilseeds.
- Yield losses can occur with no above ground symptoms.
- A PREDICTA B test prior to sowing can identify the number of each RLN species present in the soil, and enable growers to make informed management decisions.

Here is an example of how PREDICTA B tests can assist farm management decisions.

Q: My soil test results indicate high levels of *P. neglectus* and *P. thornei*. What can I grow?

A: Check your local crop disease variety guide and choose resistant and tolerant varieties where possible. Work on rotation crops has been limited but is increasing. In the southern and western regions pea, lupin, lentil are more resistant, but there may be varietal differences so check current crop variety guides for the latest *Pratylenchus* classification ratings of individual varieties. It may take several seasons of resistant crops to reduce high populations to low levels.

FAQ's

Q: Can Pratylenchus predispose crops to infections from other disease?

A: Yes, if roots are damaged, the risk to infection by fungal disease may increase. In the northern region the effects of crown rot and *P. thornei* appear additive.

Q: Does summer weed growth increase *Pratylenchus* populations?

A: Most summer grass weeds in southern Australia are resistant, although susceptible self-sown cereals and wild oats can build up *Pratylenchus* populations during summer. The role of summer weeds in the northern region has not been examined.

Q: Do *Pratylenchus* numbers increase in dry years?

A: Sometimes, resistance is less effective in dry periods when plants are moisture stressed. However, reduced root growth and shorter growing seasons can reduce numbers. In general, during drought conditions nematode numbers do not change, regardless of crop resistance/susceptibility.

Q: Will summer rainfall change soil test results?

A: Summer rainfall generally has a limited effect on *Pratylenchus* numbers. They can survive a number of wetting and drying cycles. Prolonged wet periods in the absence of host plants may reduce numbers.

Q: To what extent are wheat varieties susceptible to *Pratylenchus*?

A: Wheat varieties range from very susceptible (VS) to moderately resistant (MR). There are programs to select more resistant varieties. Refer to current local crop disease variety guides for resistance classifications for current commercial varieties. The level of resistance in the best current varieties is not good enough to cause high initial *Pratylenchus* numbers to decline quickly.

In the southern region, new varieties are just starting to be assessed for tolerance to *Pratylenchus*; all are assessed for resistance. In the northern region, all wheat varieties in the National Variety Trials (NVT) are tested for tolerance and resistance. Tolerance is not linked to resistance and many tolerant varieties of wheat and other crops are susceptible. However, resistance can confer some degree of tolerance, because resistant varieties do not develop high nematode populations while they are growing.

Q: Is barley more resistant to *Pratylenchus* than wheat?

A: In the northern region, some barley varieties are as susceptible as wheat. Variety choice is important, particularly for barley. Barley appears to be tolerant and this will be examined in more detail in the NVT trials to be conducted over the next few years, by a new GRDC funded program. Consult current local disease variety guides.

In the southern region generally barley is more resistant than wheat. However, ratings vary from moderately resistant to moderately susceptible. It is advised to check the latest cereal disease guide for current ratings. In WA barley varieties examined to date are susceptible to *P. quasitereoides.* The GRDC funded field program on *P. neglectus* and *P. quasitereoides* is being scaled up in WA.

Q: Does canola control root lesion nematodes?

A: Canola may reduce *P. thornei* numbers, but not *P. neglectus.* or *P. quasitereoides. P. neglectus* and *P. quasitereoides* may reduce yield of susceptible canola varieties. Research has not demonstrated a biofumigation effect on *Pratylenchus.* Note: canola does not host mycorrhizae, this can cause poor crop growth in wheat following canola.

Q: How do medics and *Pratylenchus* interact?

A: SA field trials indicate medics are resistant to moderately resistant to *P. neglectus*, but medic seedlings are intolerant. They can suffer significant damage, but do not build up nematode numbers.

Q: Are lentils hosts?

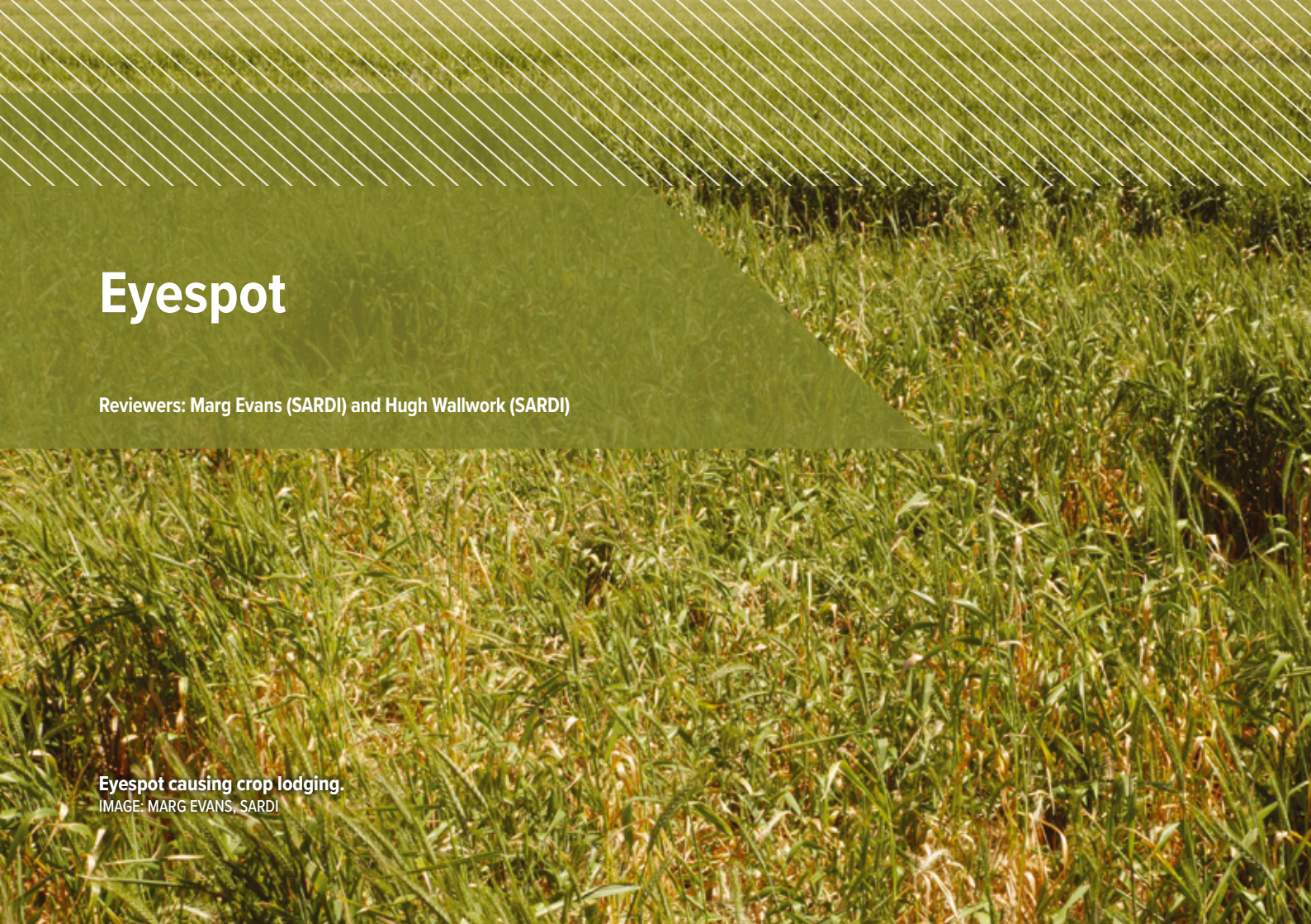
A: Lentils are rated resistant (R) to moderately resistant-moderately susceptible (MRMS). Work to assess resistance of rotational crops is ongoing. It is advised to check the latest pulse disease guide for up to date variety ratings.

Q: Can *Pratylenchus* numbers build up more in long season cereal varieties?

A: Yes, more reproduction cycles are possible on long season cereal varieties.

Eyespot

Reviewers: Marg Evans (SARDI) and Hugh Wallwork (SARDI)



Eyespot causing crop lodging.
IMAGE: MARG EVANS, SARDI

About

Eyespot, caused by the fungus *Oculimacula yallundae* (formerly *Tapesia yallundae*), damages plant stems resulting in direct yield loss through reduced grain numbers, small grain size and high screenings. Losses also occur through stem lesions leading to stem weakening and subsequent lodging.

Eyespot is a soil and stubble-borne disease with spores produced in autumn and winter. Spores can survive in plant stubbles for two years or longer if the stubbles have not broken down. The importance of this disease has increased with recent wetter seasons, stubble retention, more cereals in rotations, direct drilling and early sowing.

IMPACT

In paddocks with high inoculum levels in susceptible varieties, yield losses in the range 0 to 35% are likely, and if lodging occurs, yield losses can be much higher.

WHERE DAMAGE IS MORE LIKELY

- This disease is distributed in the medium to high rainfall areas of the southern region, including the Eyre Peninsula, Mid North and South East of South Australia, and the Western districts of Victoria.
- High intensity cereal systems.
- Stubble retention, reduced tillage.
- Early sown crops.
- Crops with good early bulk due to e.g. high sowing rates and high early fertilizer application.
- Wetter, low lying areas of paddocks.
- In more susceptible varieties with poor straw strength.

Eyespot affected crop post-harvest looks like it was rolled.
IMAGE: MARG EVANS, SARDI

Symptoms

Eyespot gets its name from the eye-shaped lesion that develop towards the base of the stem. These lesions weaken the stem, which is frequently kinked or broken at the mid-point of the lesion.

To see lesions clearly, strip back the leaf sheath to reveal the bare stem. There may also be a sooty mould around the area of stem damage. Young eyespot lesions are brown but turn a more bleached white on older stems. Older lesions can surround the entire stem and be up to 4 centimetres long. The lesion blocks the plant's vascular system, restricting plant growth and grain filling. Lesions also weaken the outer cell walls of the stem.

Strong winds can cause eyespot-infected crops to lodge in a single direction.
IMAGE: MARG EVANS, SARDI

Eyespot-lodged crops can look like animal damage.
IMAGE: MARG EVANS, SARDI

PADDOCK

- Lodging – green crops as well as mature crops can be affected. Typically the stems will fall in different directions, but if there is a strong wind then lodging from eyespot may be in a single direction and attributed to wind damage unless the stem bases are inspected for symptoms.
- Crops which have lodged due to eyespot often look as though stock, kangaroos or emus have been in the paddock. This is particularly the case where stems have lodged at or around head emergence as stems begin to grow upwards again.
- Low lying areas in paddocks or areas with heavy soil are most likely to be badly affected by this disease and are the areas which should be inspected if eyespot is suspected.
- After harvest, stubble may look as if it has been rolled as the weakened stems kink at the base and lie over.

Lesions with a golden-brown outer rim can form on stems.
IMAGE: MARG EVANS, SARDI

Stems can kink at the mid-point of eyespot lesions
IMAGE: MARG EVANS, SARDI

PLANT STEMS

- Although infection occurs early in the season, it is difficult to detect lesions on stems until head emergence/grain-fill.
- Eye shaped lesions on the bottom 10cm of the stem. There can be multiple lesions on a stem, with the presence of 1 to 3 lesions being quite common.
- Lesions are a deep golden-brown to dark brown to almost black on the outer rim; have a pale or bleached inner “iris”; and a dotted black “pupil” in the centre of the lesion (produced by hyphal growth).
- Lesions bleach or become lighter in colour as the stems age.
- Lesions can still be detected after harvest if the stubble is not too weather damaged.

Biology

- This (soil and stubble-borne) fungus grows on live hosts and can survive on infected plant residues for 3 years or more.
- Spores are distributed from infected residues by rain splash, causing stem infection.
- Air-borne spores can be distributed over large distances.
- Ideal conditions for infection occur when there is rain (3 mm or more per day) for several days during tillering and early stem elongation, combined with high humidity at the base of the crop and average daily temperatures of 4 to 10°C.

Host range

- Bread wheat, barley, triticale, durum wheat, oats and cereal rye.
- It is probable that a range of wild and cultivated grasses also act as hosts, but no information is available for Australian conditions.

IMAGE: MARG EVANS, SARDI

Impact of management and season

FACTORS THAT DECREASE INOCULUM	FACTORS THAT MINIMISE YIELD LOSS
Management	**Management**
• Break from cereal, free of grass weeds. A single year break will significantly reduce inoculum levels, but a two-year break may be required if initial inoculum levels were very high. • Use of more resistant varieties (currently being determined). • Burning stubble (consider agronomic, soil health and environmental issues before burning).	• Select paddocks with no or low inoculum levels for cereal crops. • Select a more resistant and tolerant cereal variety. • Do not delay sowing as an eyespot management strategy - the yield losses in delaying sowing will outweigh the potential yield gains from reduced eyespot incidence. • Reduce the humidity at the base of the crop (medium plant densities, good weed control, moderate nitrogen at sowing).
Environment	**Environment**
• Low rainfall during tillering and early stem elongation.	• Unknown

Management options

Disease risk categories have yet to be developed for this test, so management decisions should be based on current industry best practice.

AGRONOMIC PRACTICE	MANAGEMENT OPTIONS
PREDICTA B	• Rank paddocks based on population density results. • Select paddocks with lowest inoculum levels for sowing cereal crops.
Weed control	• Keep paddocks weed-free during break from cereal. • Control weeds to reduce humidity within the crop.
Rotation (crop type and variety)	• Select a more resistant cereal variety. See current Cereal Variety Disease Guide. • Avoid varieties with weak straw strength • Sow non-host crop
Machinery	• Sow at appropriate planting density to prevent high humidity within crop.
Nutrition	• Avoid excessive nitrogen (reducing canopy bulk reduces humidity).
Chemical	• Registered fungicides provide a powerful tool for reducing yield loss if timed and applied correctly. • Must be applied prior to canopy closure- around early stem elongation Zadocks Growth Stage 30/31 (first node).

The economic impact of each management option should be carefully considered before devising a management plan.

FAQ's

Pathogen:

Q1: How do I know whether there is eyespot in my paddock?

A: Look for lesions on the bases of stems during flowering and grain fill as visual symptoms are very difficult to identify early in the season.

Take soil samples and submit to PREDICTA B for analysis. Stubble pieces MUST be added to the sample.

Lesions look like eyes and have a rim which is a deep golden-brown to dark brown to almost black and a pale or bleached inner "iris" with a dotted black "pupil" in the centre of the lesion (produced by hyphal growth). Lodging is also a symptom associated with eyespot, but lodging does not always occur and yield losses will occur where lesions alone are present.

Lodging due to eyespot can often be mistaken for damage by kangaroos or by wind so lodged crops should be checked for stem lesions.

Q2: Which varieties are most resistant to eyespot?

A: Barley, durum wheat and long season bread wheat varieties are usually moderately susceptible or better, with only occasional varieties rating as susceptible. Most commercial sinter wheats are susceptible to eyespot, but some are only moderately susceptible. up-to-date information on variety resistance can be found in the latest South Australian "Cereal Variety Disease Guide .

Q3: Can I use fungicides to control eyespot?

A: Yes, but fungicide application must occur before canopy closure to be effective as it is critical that the fungicide reaches the lower stems. The recommended timing is at early stem elongation (GS30/31). Application at early tillering can give inconsistent results if eyespot re-infection occurs after fungicide effects have dissipated. DO NOT reduce the fungicide rate as this may result in the spray being intercepted by leaves, stubble, weeds etc. before reaching the stem bases. Use high water rates and travel at a lower than normal speed for best results.

Take-all (including the oat strain)

Reviewers: David Roget, Albert Rovira

Most common sign of take-all is patches of plants haying-off prematurely (haydie) and containing no grain.
IMAGE: MARG EVANS, SARDI

Take-all affected plant are easily pulled from the ground. When infection is severe "black socks" develop on lower stems.
IMAGE: MARG EVANS, SARDI.

Take-all affected plants often hay-off prematurely in patches.
IMAGE: BILL DAVOREN, CSIRO.

About

Take-all is a serious fungal root disease of wheat and sometimes other cereals. Losses from take-all infections in wheat can exceed 60% and losses in symptom-less crops can be up to 25%.

There are two main variants of the take-all fungus: *Gaeumannomyces graminis* var. *tritici* (*Ggt*) is the most common and it attacks all cereals except oats and cereal rye; exceptions are Bevy rye which is susceptible and in WA strains of *Ggt* can attack oats. *G. graminis* var. *avenae* (*Gga*) attacks oats plus all hosts of *Ggt*. Both occur throughout southern Australia but *Gga* is unlikely to be a significant problem unless there has been a history of oats in rotations.

DID YOU KNOW?

- Take-all causes the crop to hay-off prematurely.
- Take-all has the greatest impact in good seasons.
- Since the crop appears normal before heading, crop inputs such as post emergent nitrogen continue to be applied adding to economic losses.
- Risk increases when there are two consecutive seasons with above average rainfall.

WHERE DAMAGE IS MORE LIKELY

- The disease is most severe in above average rainfall seasons and high rainfall regions (i.e. southern and western cropping regions and areas closer to the coast).
- Take-all inoculum builds up over several seasons with good rainfall separated by dry summers. In districts that regularly receive significant summer rainfall, take-all often shows up following dry summer and autumn conditions
- Wet conditions in winter/spring favour a build-up of the fungus.
- The disease is most prevalent in southern and western regions in intensive cereal rotations with susceptible crops such as wheat or barley. Oats may be affected by the oat attacking strain, which also attacks wheat and barley.
- Grasses growing at least three weeks before sowing can increase *Ggt* and *Gga* levels further increasing the risk to early sown crops.
- Damage is more likely in higher pH soils (above pH5.5 in water or 4.6 in calcium chloride).

Symptoms

The symptoms of take-all infection may cause patches early in the season but in Australia the first indication of a problem is patches of crop haying-off following a heat event around anthesis and losses can be large.

PATCHES EARLY IN THE SEASON ARE RARE IN AUSTRALIA:

- A severe early infection of take-all will appear as patches of poor crop growth (up to several metres in diameter and with indistinct and irregular edges).
- Affected plants can be individuals scattered among healthy plants or entire populations of plants over a large area.
- Image shows patches of poor growth caused by severe early take-all infection.

(Image: Sean Bithell, NSW DPI)

CROP HAYING-OFF PREMATURELY:

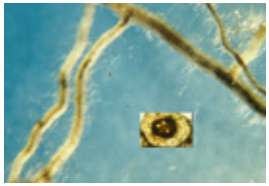
- Often the first obvious signs of a take-all infection are seen after flowering when small to large patches of the crop hays off prematurely, known as haydie.
- Heads in these patches contain no grain.

(Image: Marg Evans, SARDI)

HOW DO I CHECK FOR SYMPTONS?

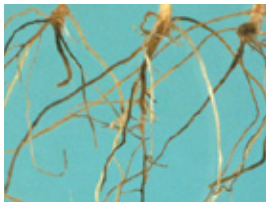
A: Dig up seedlings between early to mid-tillering, wash them in water and look for characteristic black lesions on roots. There may not be any foliar symptoms apparent at this time even though lesions appear on the roots.

Symptoms are harder to see later in the season on older roots that are dark brown in appearance. Roots infected with take-all will be black in the center. During a wet spring the fungus can grow through the crown and blacken the base of the stem ("black socks").



ROOT SYMPTOMS:

- Close examination of roots 6 to 8 weeks after sowing will reveal the characteristic blackening in the central region (the stele) of the root restricting movement of water and nutrients. (Image: David Roget, CSIRO)



- If conditions remain conducive the whole root turns black as the fungus spreads up the root. These plants are susceptible to moisture stress, especially later in the season. (Image: Russell Eastwood, Victorian Institute for Dryland Agriculture)

CROWN AND STEM SYMPTOMS:

- In wet springs the fungus can grow into the crown. These plants are easily removed from the ground.
- Plants from patches have black brittle roots, crowns. (Image: Rudolf De Boer, DPI VIC)

- In severe cases the fungus grows up the base of the stem bases, producing "black socks". (Image: Marg Evans, SARDI)

NOTE THAT:

- Crown rot, water stress and copper deficiency also produce whiteheads but do not cause blackening of roots.
- Crown rot often affects individual tillers on the plant and these whiteheads are scattered more evenly through the crop rather than in patches.

Biology

The take-all fungus grows on a living host, but can survive summer on dead roots and crowns. If no host is present then the disease declines very quickly, especially in moist soil.

- High available soil N over summer encourages inoculum survival. This can occur:
  - Following pastures with good N fixation
  - Following cereals with poor N utilisation
- Rarely a problem in soils pH <5.5 in water or pH <4.7 in $CaCl_2$ (calcium chloride).

Host range

Hosts

The *Ggt* strain of take-all generally infects:

- Barley, wheat, triticale, Bevy rye (oats in WA)
- Barley grass, brome grass and silver grass and some ryegrass populations especially in WA

***Gga* (the oat attacking strain) generally infects:**

- All of above plus oats. If present, oats should not be used as a break crop

Q: Are there any wheat, barley or triticale varieties that have tolerance or resistance to take-all?
A: Take-all losses in barley tend to be about half of wheat and triticale. Oats can be used as a break crop for the wheat strain of take-all. Cereal rye is resistant however, Bevy rye is susceptible.

Q: Does canola have a biofumigation effect?
A: Canola is a good break crop for take-all; however, it is no more effective against take-all than any other break crop.

Impact of management and season

Take-all is most likely to be an issue when a wheat crop follows a cereal crop or where grass weeds are not controlled in a break crop or pasture.

Increases in *Ggt* and *Gga* levels are greater in a wet spring followed by dry summer.

Risk increases when there are two consecutive seasons with above average rainfall.

FACTORS THAT REDUCE INOCULUM	FACTORS THAT MINIMISE YIELD LOSS
Management	**Management**
• Take-all is effectively controlled with one break crop, unless drought. Volunteer hosts over summer generally do not increase inoculum unless average daily temperatures <25°C. • Low soil mineral N over summer. • Grass free pastures, pulses, canola or oats. • Grass free pastures, pulses, canola or oats - remove grasses before August in >450mm rainfall regions and by late June in lower annual rainfall areas. • Delay sowing wheat to end of seeding program. • Check take-all risk in limed paddocks, increased pH increases risk. • Early breaks with >3 weeks grass control. An early season break where grasses are controlled will allow more time for breakdown of inoculum.	• Low initial *Ggt* and *Gga* levels. • Barley sown instead of wheat, can reduce yield loss by 50%. • Provide adequate nutrition. • Hosts controlled soon after early breaks. • Fungicide seed and fertiliser treatments can reduce yield loss if take-all risk is low to medium. • Sow crop at end of the seeding to allow more time for *Ggt* and *Gga* to decline (paddock host free).

Management options

There is no resistance to *Ggt* or *Gga* in wheat, barley or *Gga* in oats, therefore other management strategies are needed.

Take-all is effectively controlled with one year break crop, unless there is a drought.

Grasses need to be removed from break crops in time to allow breakdown of infected roots, e.g. by before August in areas with >450mm annual rainfall and late June in lower rainfall areas.

Sowing between the rows of the last cereal crop reduces risk of infection.

Chemical treatments applied to seed or fertiliser are available to reduce the impact of take-all if sowing into paddocks with low to medium risk of take-all. Registered products include fluquinconazole seed dressings and in-furrow fungicides containing flutriafol or triadimefon.

Barley is more tolerant of take-all and yield losses are usually 50% of those for wheat. Sowing low to medium risk paddocks last can reduce risk as it gives more time for inoculum break down provided the paddock is host free.

Ggt/Gga LEVEL	OPTIONS
Below detection	• No restriction on crop selection.
Low	• Consider fungicide treatment if sowing wheat, particularly when paddock has been limed. • Sow between the rows of previous cereal. • If sowing cereals, sow high risk paddocks last. • Supply adequate nutrition, particularly P and Mn. • Ammonium rather than nitrate based fertilisers. • Consider break crops – oilseeds, pulses, and oats in eastern Australia if no *Gga*.
Medium	• Sow oilseed or pulse crops if possible. • Sow between the rows of previous cereal. • If sowing cereals use fungicide treatment. • Adequate nutrition, particularly P and Mn, consider ammonium rather than nitrate N. • Sow low risk cereal crop paddocks first. • Consider barley or rye instead of wheat.
High	• Sow break crops.

OTHER MANAGEMENT CONSIDERATIONS INCLUDE:

- High available soil N over summer encourages inoculum survival. This can occur:
  - Following pastures with good N fixation
  - Following cereals with poor N utilisation
- Keep in mind potential changes to inoculum level since soil sampling. *Ggt* and *Gga* levels will increase within 3 weeks on grasses and volunteer cereals that germinate at the break of the season.
- Consider the long-term plans for the paddock if susceptible crops are to be sown.
- Beware of cereal paddocks that were recently limed, take-all is rarely a problem when pH <5.5 in water or pH <4.7 in $CaCl_2$.

Disease breaks for take-all

- **Pulse, oilseed crops and legume pastures.**
- **Oats (unless the oat attacking strain is present).**
- **Fallow.**

IMAGE: BILL DAVOREN, CSIRO

Do I need to soil test?

YES.

WHY?

- PREDICTA B has two tests for take-all pathogens, one for *Ggt* + *Gga* and the other for *Gga* only.
- Testing before sowing enables growers to make important management decisions.
- If medium to high levels of *Ggt* or *Gga* are detected alternative non-host crops can be grown. This will also reduce the take-all risk for future crops.
- If low to medium levels are detected a fungicide treatment can be used at seeding to reduce losses in cereals.

  Note: there are no post emergent fungicide treatments to control take-all so early treatment is essential.

FAQ's

Q: If I see 'whiteheads' in the crop, what yield loss can I expect?

A: Usually more than 25% yield loss. Similar whitehead symptoms can also be induced by frost, moisture stress and copper deficiency.

Q: What conditions favour take-all and crown rot?

A: Take-all is favoured by wet spring conditions whereas crown rot prefers dry spring conditions for growth and development. Both are favoured by wet winters.

Q: I had take-all results in the medium-high range, but we had significant summer rainfall. To what extent am I at risk from take-all this season?

A: Summer rainfall events of 25 mm reduce take-all inoculum by 30%. The effect of additional 25 mm rainfall events is cumulative. Several such rainfall events could reduce the risk category to low. This effect is more pronounced in stubble retention systems which encourage low available N over summer, this reduces the ability of take-all inoculum to survive. Host plants that germinate during summer will generally not increase disease levels, but can if soil temperatures are below 25°C. Consider retesting the soil before sowing.

Q: What is the relationship between grass density in pastures and break crops and take-all in the following crop?

A: Grass densities of 50 plants/m^2 or greater will increase take-all levels. Maximum build up of take-all will occur with densities of 200 plants/m^2 or greater. Aim for grass densities of 5 plants/m^2 or less.

Q: Is a fungicide available to treat take-all?

A: There are several fungicides registered for suppression of take-all, these include a seed treatment (fluquinconazole) and fertiliser treatment (flutriafol and triadimefon). No useful resistance has been identified.

Q: My cropping soils are acidic, will take-all be a problem?

A: Take-all is less damaging on acid soils and appears to have little effect at or below pH 4.7 (calcium chloride) or 5.5 (water). However, the fungus can persist in low pH soils and may become a problem if the paddock is limed.

Q: If I apply lime this or last year, what are the implications for take-all?

A: The main risk is with localised high pH where the lime was not well incorporated. This may cause take-all to increase.

Q: Is the value of oats as a break crop greater when it is grazed to reduce weeds?

A: Grass control by late June/July is the critical factor to control take-all in oats for either grazing or grain. If *Gga* is present, do not use oats as a break crop.

Q: Will stubble burning reduce take-all?

A: Generally stubble burning does not reduce take-all as most of the inoculum is underground.

Q: To control take-all, how good does my grass control need to be?

A: In <450 mm rainfall districts control all grasses by late June. In >450 mm rainfall districts control all grasses by late July.

Q: Does improved soil suppressive activity that develops under intensively cropped stubble retention systems help control take-all?

A: Yes, the higher soil microbial activity in more suppressive soils has been shown to reduce take-all. This suppressive activity is likely to reduce the impact of most fungal diseases but not nematode diseases.

Q: Does take-all build up in grasses that germinate over summer?

A: Not generally. The soil is usually too hot for infection to occur during summer. However, take-all build-up can occur in cool summers with average soil temperature <25°C.

Q: In high rainfall areas where I can get yields of up to 6t/ha in the presence of take-all, why worry?

A: The disease can still cause significant yield loss even in high yielding crops with soft finishing seasons.

Cereal cyst nematode (CCN)

Reviewers: Grant Hollaway (Agriculture Victoria), Alan McKay (SARDI), John Lewis (SARDI) and Joshua Fanning (EcoDev, Victoria)

Previous reviewers: Alan Dubé, Sharyn Taylor, Franky Charman-Green and Vivien Vanstone

CCN Tip: White females are visible on roots around anthesis.
IMAGE: JOHN FISHER, UNIVERSITY OF ADELAIDE

CCN ROOT ID TIP: Look for knots on wheat, barley and triticale roots. IMAGE: VIVIEN VANSTONE, DPIRD

CCN ROOT ID TIP: In CCN affected oats there will be no knots – look for stunting. IMAGE: HUGH WALLWORK, SARDI

About

Cereal Cyst Nematode (CCN), *Heterodera avenae* is a parasitic nematode that affects the roots of cereal crops, such as wheat, barley, oat and triticale. The pest is prevalent throughout Western Australia, South Australia, southern NSW and Victoria. It can cause yield losses of up to 80 per cent in intolerant varieties, so its control should be given a high priority.

WHERE DAMAGE IS MORE LIKELY

- In intensive cereal rotations with susceptible varieties (refer to current local cereal variety disease guide).
- Where cereal varieties are less tolerant to CCN.
- In low fertility paddocks due to a reduced root system to access soil nutrients.
- Where there has been poor weed control in break crops.
- CCN damage is more severe on light textured or low fertility soils where root development is more critical.

Did you know?

- Affected crops are less competitive with weeds due to restricted plant growth.
- CCN can increase yield losses further if other root diseases are present.
- CCN damage is related to the density of eggs or nematodes present in a field before planting.
- The density of nematodes is related to the frequency of susceptible crops in the rotation.

Symptoms

The symptoms of CCN infection can be easily recognised. Infected crops may show patches of yellow and stunted plants.

An assessment of the roots is essential to diagnose CCN using tell-tale signs of thickening, shortening and knotted appearance.

IMAGE: VIVIEN VANSTONE, DPIRD

IMAGE: VIVIEN VANSTONE, DPIRD

PADDOCK

- Areas of stunted growth (poor emergence and establishment)
- Plants with few tillers
- Yellow/pale green patches as with N deficiency
- Wilted plants (despite moist soils)
- Patches in crop with good nutrition

PLANT (6–8 WEEKS AFTER SOWING)

- Knots on wheat, barley and triticale (not oats)
- Roots will appear thickened, shortened and will have a knotted appearance
- Reduced rooting depth


IMAGE: HUGH WALLWORK, SARDI

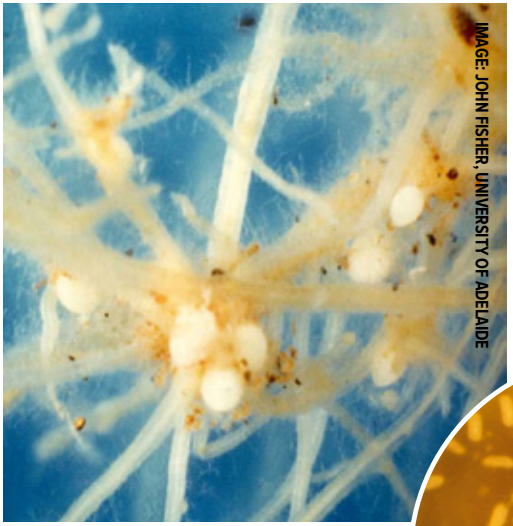


IMAGE: JOHN FISHER, UNIVERSITY OF ADELAIDE

OATS

- Roots stunted and swollen, stop growing
- No knotting
- Can be confused with herbicide damage

ANTHESIS

- White pinhead sized cysts (egg sacs) visible on roots (note you may need to wash soil off of roots to view these clearly)
- CCN cysts turn brown as female matures and contain 200 to 300 eggs

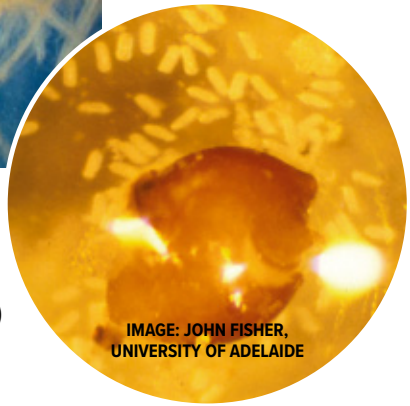
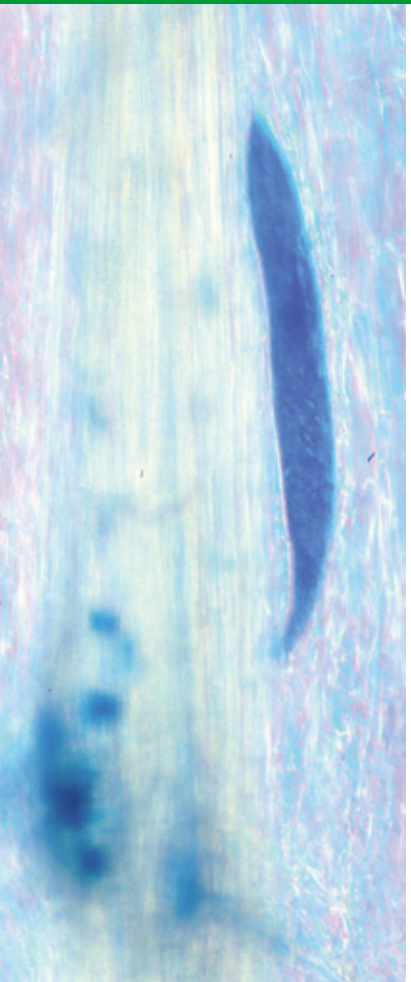


IMAGE: JOHN FISHER, UNIVERSITY OF ADELAIDE



CCN female feeding and developing in wheat root.
(Image: Franky Charman-Green)

Biology

- CCN is a sedentary plant-parasitic nematode, which means after invasion of the host it sets up a fixed feeding site within the plant root.
- CCN has one generation per season, which makes it easier to manage.
- CCN survive over summer as eggs in brown cysts, each cyst contains 200 to 300 eggs.
- Most cysts occur 5 to 10cm below soil surface.
- 60 to 80% of eggs hatch each year, so 20 to 40% remain. A two year break is required to control medium to high levels.
- In dry years fewer eggs hatch, so following consecutive dry years, a two year break may not be sufficient to control CCN.
- Eggs need a cold treatment <15°C and moisture to hatch for juveniles to hatch.
- Hatching occurs over 8 to 10 weeks.
- After mating, the females produce eggs within their body, swell and by anthesis the white females attached to the roots, are visible.
- The female nematode dies as the crop ripens and forms a brown cyst that hardens and remains in the soil until the next season to repeat the cycle.

White females visible on wheat roots around anthesis.
(Image: John Fisher, University of Adelaide)

Host range

CCN generally infects cereals including wheat, barley, oats (including wild oats) and triticale varieties. Other grasses are generally poor hosts.

UNDERSTANDING CROP RESISTANCE/TOLERANCE RESPONSES

To select the best crop and variety to grow from current local Cereal Variety Disease Guides, it is important to understand the difference between resistance and tolerance. Where there is a significant CCN population and cereal is to be sown, use varieties that are both resistant and tolerant to CCN. There are often no CCN tolerance classifications for new cereal varieties.

BARLEY: Barley varieties are tolerant, although they can still be susceptible. This means that while the tolerant barley crop will not be affected by the nematodes, the nematodes can still reproduce using the plant as a host if the variety is susceptible, leaving high populations in the soil to infect a subsequent crop.

WHEAT: Ranges from moderately tolerant to intolerant depending on the variety.

OATS: Ranges from moderately tolerant to very intolerant depending on the variety.

VARIETY TRAIT	EFFECT ON YIELD
Intolerant	Crop yields poorly when infested by CCN.
Tolerant	Crop yields relatively well despite. CCN infestation.
	EFFECT ON CCN LEVELS
Susceptible	CCN levels increase, posing risk to next crop.
Resistant	CCN level will decline.

TIP

Variety choice is the only defence against CCN: Choose varieties which are both resistant and tolerant to the nematode. Note: if CCN populations are very high, sow a oilseed or pulse crop.

Impact of management and season

The following on-farm management practices can help control CCN and prevent large yield losses. Two consecutive years of break with either non-host crops and/or CCN resistant cereals has proved successful for keeping CCN under control.

Did you know?

CCN used to cause large yield losses in the southern region.

FACTORS THAT REDUCE CCN LEVELS	FACTORS THAT MINIMISE YIELD LOSS
Management	**Management**
• High frequency of resistant cereal varieties and non host crop in rotation. • Break using pulses, oilseeds and CCN resistant varieties has kept CCN under control. • Two consecutive years of non-hosts or resistant crops usually controls CCN, drought can increase this period to 3 years. • Removing self sown cereals from pulse and oilseed crops within 8 weeks of seeding.	• Low initial nematode densities. Sow tolerant (and resistant) crops/varieties. • Sow early within optimum seeding window. • Provide adequate nutrition. • Sowing between the row of the last cereal.
• Conditions that reduce CCN multiplication: - Droughts especially post tillering.	• Above average rainfall, mild spring temperatures and adequate spring rainfall.

Use your regional cereal variety disease guide and select the most resistant adapted cereal variety and avoid sowing consecutive susceptible varieties.

Management options

Managing CCN is essential to avoid yield loss. As a general rule management should consider:

ROTATIONS:

Plan a two year break between each susceptible cereal; breaks can include CCN resistant cereal varieties and non-host crops e.g. canola, lupins, chickpeas and legume pastures. If not implementing a two year break, use PREDICTA B to monitor CCN.

VARIETIES:

Choose varieties with high resistance ratings. This will limit CCNs reproductive potential, meaning fewer nematodes to infect subsequent crops. Cereal variety options, including ratings for CCN resistance, is listed in current State Cereal Disease Variety Guide or NVT Online. Tolerance of varieties to CCN are no longer reported.

CHEMICALS:

There is no effective chemical control for CCN currently available.

WEED CONTROL:

Effective weed control is important as CCN affected crops compete poorly with weeds. Wild oats are also a good host for CCN.

SOIL FERTILITY:

Maintaining soil fertility can help minimise the effects of CCN, especially during crop establishment. Emerging crops will perform better if their root systems establish prior to nematode infection. However the larger root system may increase the nematode population.

GENERAL MANAGEMENT CHECKLIST FOR CCN

CCN LEVEL	OPTIONS
Below detection	• Focus on other crop constraints.
Low	• Prevent CCN build up, avoid susceptible cereals and control grass weeds.
Medium	• Sow canola, pulses, pasture legumes. • If sowing cereals: - Sow most resistant varieties - Sow early - Sow between the rows of the last cereal - Ensure adequate nutrition - Achieve good weed control • Avoid sulfonylurea herbicides.
High	• Sow canola, pulses or pasture legumes. • If sowing cereal use resistant barley. • Sow early, etc, as per medium rating above.

There is no effective chemical control for CCN currently available.

Do I need to soil test?

YES.

WHY TEST?

- To determine what crop varieties to grow (i.e. if medium or high levels are detected alternative crops or varieties should be sown to both minimise grain yield losses and reduce the CCN populations).
- To check if CCN levels are increasing in paddocks with high frequency of susceptible varieties.
- To determine if existing management is working (i.e. the strategic use of non-host and resistant varieties).
- There are no registered chemical treatments to control CCN.

IMAGE: KATHERINE LINSELL SARDI

Here are some examples of how you can use that information ...

Q: My CCN levels are low and I want to grow wheat. What variety should I choose?

A: You should grow the most profitable variety, preferably resistant to CCN, to keep levels low. However, you can grow a susceptible wheat if you do not plan to grow another susceptible cereal in the paddock in the following two years. A PREDICTA B root disease test can help you monitor CCN levels.

Q: My soil tests show medium CCN levels. Can I grow any resistant cereal?

A: Recent improvements in farming practices have increased early seedling vigour and root growth. This should increase crop tolerance to CCN. In medium to high rainfall districts where the season breaks early, nutrition is adequate and the crop can be sown close to the optimum date, adapted resistant wheat varieties could tolerate medium levels of CCN. Make sure the paddock was sampled properly and to at least 10 cm deep. In low rainfall districts with sandy soils, the safer option would be to sow a resistant barley variety.

Q: I have high CCN levels, how long should I wait until I sow a cereal crop?

A: If a cereal must be sown when CCN levels are high, triticale is a useful option. A resistant barley variety may also be an option if the crop can be established early. In the second year resistant and tolerant cereals can be grown, however, if the first year was a drought, the level of carryover may be higher than expected. Do not sow susceptible, intolerant varieties until CCN levels are reduced to below detection levels.

IMAGE: VIVEN VANSTONE, DPRID

FAQ's

Q: In our area the damage from CCN seems to be greater in black soil rather than red ground. Why?

A: CCN multiplies more easily in soils with good structure than the hard setting types. The black soils often have better structure than the red soils.

Q: When should grasses be controlled in legume crops to stop build up?

A: Remove self sown cereals and grasses before the females form in late August to September (sometimes earlier). Spray within 7 weeks of sowing or before end of July, which ever is sooner.

Q: Does the use of sulphonylureas affect the CCN problem?

A: Yes, anything that slows root growth will increase the damage caused by CCN.

Q: Does summer rainfall affect CCN populations?

A: CCN does not hatch during summer, so even summer rainfall, which stimulates germination of cereals, will not change CCN levels. Eggs need a period of cold, below 15°C, with moisture before they hatch.

Q: Why is there more CCN after a drought?

A: Normally 60–80% of eggs will hatch in the growing season. Fewer CCN eggs hatch in a drought year and so more carry over to the next season.

Common root rot

Reviewers: Stephen Neate (USQ), Cassandra Percy (USQ) and Steven Simpfendorfer (NSW DPI)

Left, healthy sub-crown internode. Right, dark brown lesions on sub-crown internode. IMAGE CASSY PERCY, USQ

Left, healthy sub-crown internode. Right, dark brown lesions on sub-crown internode. IMAGE CASSY PERCY, USQ

Dark brown discolouration on sub-crown internode and lower leaf sheath. IMAGE: CASSY PERCY, USQ

About

Common root rot, caused by the fungus *Bipolaris sorokiniana*, has the potential to cause chronic yield loss in wheat and barley crops. Due to the often indistinct nature of symptoms it can frequently go undiagnosed causing lower levels of yield loss in paddocks. *B. sorokiniana* has been recorded in most soil types worldwide and occurs in all wheat growing regions in Australia.

IMPACT

- Yield losses of 0 to 40% have been reported in bread wheat, average long term losses are estimated to be about 10% annually.
- Disease severity is often higher in barley, but yield loss is generally lower than in bread wheat.

WHERE DAMAGE IS LIKELY

- Where cereal crops are grown consecutively.
- Yield losses are greater under low soil moisture conditions during grain-filling but can also occur in wetter years.
- Yield losses may be relatively low but consistent across seasons.
- Common root rot exacerbates losses when plants are also infected by other root and crown pathogens such as crown rot.
- Deep planting.

HOW PREDICTA B RESULTS CAN BE USED

- To rank paddocks based on inoculum levels and therefore determine the potential risk of common root rot in the new season's crop.
- Monitor changes in inoculum load at different phases of the cropping sequence.
- To confirm diagnosis in-crop. Common root rot symptoms can be confused with crown rot and take-all.

Image shows: Common root rot, dark brown discoloration on sub-crown internodes and several crown roots.

IMAGE: PETER WHITTLE, FORMERLY SA DEPARTMENT OF AGRICULTURE.

Symptoms

Symptoms of common root rot include reduced crop tillering, ill-thrift, pale leaves, stunting and smaller heads. Symptoms can appear from tillering onwards but generally become most obvious after flowering. Dark brown to black discoloured lesions on sub-crown internodes will be evident, in addition to a general, pale to mid-brown discolouration of seminal roots and sometimes crown roots.

PADDOCK

- Crop may lack vigour.
- Can occur as single plants or in patches scattered throughout the paddock.

WHEAT AND BARLEY PLANT

- Reduced tillering.
- Sometimes pale colour.
- Stunting.
- Smaller heads.

Image shows: Top, uninfected plant. Bottom, common root rot infected with brown lesions on sub-crown internode. (Image: Cassy Percy USQ).

WHEAT AND BARLEY BELOW GROUND

- Browning of the coleoptiles, sub-crown internode, roots, lower leaf sheaths and internodes.
- Lesions on the sub-crown internode are diagnostic of the disease.
- Lesions may appear brown to black.

Image shows: Common root rot lesions developing on subcrown internode and spreading to seminal roots *Rhizoctonia* (spear tips) on crown roots. (Image: Cassy Percy USQ).

DISTINGUISHING COMMON ROOT ROT FROM TAKE-ALL AND CROWN ROT

Common root rot, take-all and crown rot can generally be distinguished by symptoms but visual similarity means they can be easily confused. Diagnosis in the field is further complicated by plants frequently being co-infected with two or more of these pathogens.

Diagnosis should be confirmed by sending infected plant material to your local plant pathologist.

The diagnostic symptoms of each disease are summarised below:

TAKE-ALL	COMMON ROOT ROT	CROWN ROT
• Causes blackening of central region (stele) in roots. • 'Black socks' develop on the crown. • Whiteheads (patches of affected areas within the crop). • Haying-off. • Black discolouration of tiller bases. • Blackening of sub-crown internode.	• Primarily infects the sub-crown internode causing dark brown to black lesions. • Brown discolouration of tiller bases. • Plants exhibit general ill-thrift. • Less obvious whiteheads than take-all.	• Brown discolouration of tiller bases. • 'Honey' brown coloured crown and lower stem. • Whiteheads scattered throughout paddock. • Pink staining under leaf sheath (moisture dependant).

Biology

- *B. sorokiniana* survives as thick walled conidia in the soil or as mycelium in plant debris in both summer and winter rainfall cropping areas.
- Most conidia are found in the top 15cm of soil.
- Plants can be infected at any stage of development.
- Earlier infections may result in more severe symptom development and damage.
- Temperatures greater than 20 to 30°C favour common root rot, but severe disease can develop at lower temperatures, particularly when associated with low soil moisture.
- *B. sorokiniana* has been demonstrated to survive in host debris for at least 2 years; however, it is a weak competitive coloniser and less capable of surviving outside the host tissue.

Brown lesions on sub-crown internode

IMAGE: FRANK HENRY, FARM SERVICE VICTORIA

IMAGE: CASSANDRA PERCY, USQ

Host range

- Wide host range including durum and bread wheat, barley, oats, triticale and rye.
- The disease is most severe in wheat and barley; however, oats, triticale and rye may also act as hosts but with less severe disease implications.
- Moderate resistance exists in commercial durum and bread wheat varieties. Barley genotypes vary greatly in susceptibility (see current local Cereal Variety Disease Guide).
- A wide range of non-cereal grasses may also act as hosts.

Impact of management and season

The severity of common root rot in wheat and barley is associated with the population of *B. sorokiniana* in the soil at the time of planting. In limited investigations, the highest populations have been reported after a susceptible barley crop.

FACTORS THAT REDUCE INOCULUM	FACTORS THAT MINIMISE YIELD LOSS
Management	**Management**
• Reduce frequency of cereals in the rotation by sowing non-host pulse, oilseed and pasture species. • Break crops or pastures must be grass-free. • Grow partially resistant varieties of wheat, barley or durum.	• Avoid sowing susceptible varieties into paddocks with high pre-sowing inoculum levels. • Disease severity is often higher in barley, but yield losses are lower than wheat. • Sow resistant varieties of durum, bread wheat and barley. • Ensure soils have adequate moisture and fertility (especially N and P). • If moisture permits, reduce sowing depth to limit the length of the sub-crown internode.
Environmental	**Environmental**
• Unknown.	• Disease severity generally greatest under warm (20 to 30˚C), dry soil conditions. • Can be serious in very wet seasons.

Management options

The severity of common root rot in wheat and barley is associated with the population of *B. sorokiniana* in the soil at the time of planting.

Disease risk categories have yet to be developed for this test, so management decisions should be based on current industry best practice.

AGRONOMIC PRACTISE	MANAGEMENT OPTIONS
PREDICTA B	• Rank paddocks based on inoculum levels. • Monitor changes in inoculum levels in different phases of cropping sequence. • Confirm last years in-crop diagnosis/identify likely cause for this years issue.
Weed control	• Control self-sown cereals and grasses in pulse and oilseed crops.
Rotation (crop type and variety)	• Disease most severe in wheat and barley. • Oats, triticale and rye may not develop severe disease but act as hosts. • Sow most resistant variety of wheat and barley. • Rotate with non-host crop (inoculum may take more than 1 year to reduce in level).
Stubble management	• Stubble removal does not effectively reduce inoculum as the fungi survives as thick walled spores in the soil.
Machinery	• Sowing cereals between the rows of previous susceptible crop may slightly reduce infection levels.
Nutrition	• Optimum soil fertility will minimise losses (especially N and P).
Chemical	• There are no chemical treatments registered for controlling common root rot.

The economic impact of each management option should be carefully considered before devising a management plan.

Pythium root rot

Reviewer: Paul Harvey (CSIRO)

Large patches of poor crop establishment in lentils caused by pythium root rot.
IMAGE: YPAG

Pythium infected wheat, seed-treated with metalaxyl-M (left) and untreated (right). IMAGE: SYNGENTA

Pythium infected canola, untreated (left) and seed-treated with metalaxyl-M (right). IMAGE: CSIRO.

About

All major grain crops, pulses and pastures grown across Australia can host and be infected by pathogen *Pythium*, which causes seedling damping off and root rot. Pulses and canola are highly susceptible to *pythium* root rot, with wheat and barley significantly less susceptible.

Pythium is ubiquitous in Australian cropping soils, but is more prevalent in regions with an annual rainfall above 350mm. Areas with higher levels of organic matter, acid-neutral soils and under reduced tillage systems are also more likely to encounter the pathogen.

WHERE DAMAGE IS MORE LIKELY

- In cold, wet seasons, particularly in acidic-neutral soils with high levels of organic matter.
- Poor weed control, including sowing before herbicide treated weeds have fully decomposed.
- Disease incidence is greater after long-term pastures (legume) and in less diverse rotations, such as repetitive wheat > canola and to a lesser extent, wheat-canola-legume sequences.
- More diverse rotations that include two non-consecutive cereals e.g. wheat > canola > barley > legume had lower disease incidence and greater grain yields overall, compared with the less diverse rotations.

Did you know?

- A national four year trial demonstrated that a 25% reduction of *Pythium* inoculum lead to an 11% increase in grain yield, averaged across several crops.
  - Decreased soil-borne *Pythium* inoculum (-25 %) and *Pythium* root infection (-23 %)
  - Increased emergence of wheat (+6 %), canola (+3 %), lupins (+13 %) and peas (+2 %)
  - Increased grain yield of wheat (+4 %), canola (+12 %), lupins (+26 %) and peas (+ 11 %)
- Roots damaged by *Pythium* are more vulnerable to infection of other pathogens such as *Rhizoctonia* and *Fusarium*.
- Loss of root hairs in legumes due to *Pythium* reduces nodulation and nitrogen fixation.
- Individual yield responses varied between seasons and rotation strategy.

IMAGE: CSIRO

Symptoms

A *Pythium* infection can be evident with seedling damping-off, failure to thrive and yield decline. Symptoms can often be confused with *Rhizoctonia* infection, therefore a PREDICTA B soil test is recommended along with a review of the following crop symptoms.

PADDOCK

- Slow emergence and poor vigour.
- Severe areas lead to crop patches.
- Often found in wetter areas of the paddock.

Patches in barley caused by pythium root rot. **(Image: Paul Harvey, CSIRO)**

PLANTS

- Seedlings appear spindly or stunted.
- Cereals: first leaf may appear short, twisted and cupped.
- Severely affected areas (patches) become more obvious later in the season (spring).

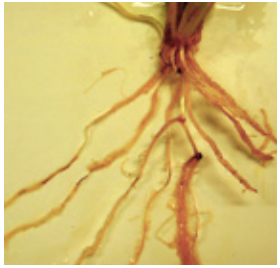
Pythium root rot in wheat, right plot untreated, left plot seed treated with metalaxyl-M. **(Image: Syngenta)**

Pythium root rot in canola, left plot untreated, right plot seed treated with metalaxyl-M. **(Image: Paul Harvey, CSIRO)**

Infected seedlings appear spindly and stunted, and in cereals the first true leaf is often short, twisted and cupped. In 60 recent cereal cropping trials across southern Australia (SA, Vic, NSW, WA) symptoms generally attributed as moderate-severe rhizoctonia root rot were observed at the majority of sites.

Pythium was the dominant pathogen, isolation frequencies (30 to 50%) were significantly higher than *Rhizoctonia* (16%).

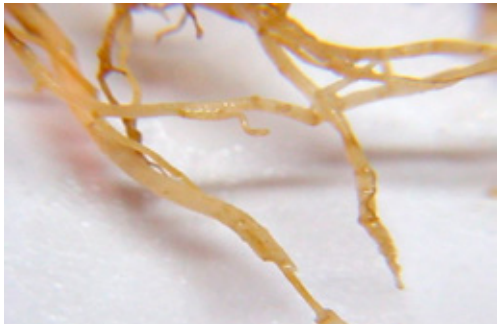
Root rot in wheat, left plot untreated, right plot treated with metalaxyl-M. **(Image: Paul Harvey, CSIRO)**



ROOTS

- Soft yellow-brown lesions.
- Reduced fine feeder and laterals.
- Outer layer rotted, central tissue exposed.
- Wire-like and 'spear points'.

Pythium root rot on wheat roots; soft yellow to light brown lesion, especially near the root tips. Loss of lateral roots and cortex rotting away exposing central vascular tissues.
(Image: Paul Harvey, CSIRO)



Pythium root rot symptoms on lupin roots.**(Image: Paul Harvey, CSIRO)**

Pythium root rot symptoms on lentil. **(Image: YPAg)**

Biology

***Pythium* is a pathogen which infects root hairs and root tips, it is also attracted to germinating seeds and actively growing tissue. *Pythium* reproduces rapidly (oospores) in infected tissue throughout the growing season causing root rot, and/or repeat infection.**

The pathogen can exist as saprophytes on fresh plant material and as a root parasite of potentially all major crop, pasture and weed species. It has the ability to survive in soils as thick-walled spores (oospores) and can remain dormant during dry periods and/or in the absence of a host plant. However, it will grow rapidly on fresh plant material added in soil, such as unweathered stubble and weeds killed by herbicides or tillage.

KEY FACTS:

- Chemical exudates released from germinating seeds and emerging roots trigger *Pythium* to grow and attract it to the host, infection occurring as early as 24 to 48 hours after sowing into moist soil.
- *Pythium* is more prevalent in cool, wet seasons.
- Populations are greater in heavy, acidic soils with high levels of organic matter.
- Survival stage can persist in soil for many years.
- Eradication is not possible, but inoculum levels and root infection can be suppressed.
- Pathogen can often occur without causing seedling damping-off symptoms.
- Cold, waterlogged soils are not a prerequisite for pythium disease development, with high incidences of pythium root rot recorded in established crops 8 to 10 weeks post-emergence in drier soils.
- In over 90 cereal, canola and pulse field trials in the last decade across southern and western Australia pythium root rot occurred as a complex of as many as 8 species. *Pythium irregulare* was found to be the most common, comprising 90% of all soil and root isolates.
- The mean soil-borne inoculum levels were 250 to 350 propagules (spores) per gram of soil in the top 10cm of soil.
- Cereal, canola and pulse root isolation frequencies were 35%, 57% and 66%, respectively.
- Sporulation results in repeated ‘waves’ of rapid infection throughout the growing season leading to root rot.
- Roots damaged by *Pythium* are more vulnerable to infection by other root pathogens and can lead to the development of root disease complexes (e.g. *Pythium-Rhizoctonia*, *Pythium-Fusarium*).

Host range

All major grain crops and pastures in Australia host *Pythium*, reducing productivity in isolation or in complexes with other common root diseases (e.g. *Pythium-Rhizoctonia, Pythium-Fusarium*). Cereals (wheat and barley) are less susceptible to *Pythium* than canola and pulses, but *Pythium* has been reported to contribute to yield decline in continuous cereal systems.

Significant increases in Pythium inoculum and root infection were observed with consecutive wheat and barley crops compared with these cereals grown in rotation with pulses.

POINTS TO NOTE:

- All major grain and pasture species are susceptible, resistant varieties are not available.
- Highly susceptible: grain legumes (lupins, peas, lentils), pasture legumes (medic, sub-clover) and canola.
- Less susceptible: wheat and barley.
- A broad range of weeds are hosts.

CROP SUSCEPTABILITY	EFFECT THIS SEASON
Highly susceptible	Plants damaged by *Pythium* and yield affected (decreased).
Less susceptible	Crop yields not severely affected despite plants being infected.
	EFFECT NEXT YEAR
Highly susceptible	Soil-borne *Pythium* inoculum increases.

Impact of management and season

FACTORS THAT DECREASE INOCULUM	FACTORS THAT MINIMISE YIELD LOSS
Management	**Management**
• Diverse rotations with two non-consecutive cereal phases. • Grow less susceptible crops such as cereals. • Improve soil drainage. • Good weed control and decomposition of residues prior to sowing. • Note: pulse, pasture legumes and canola support greater *Pythium* populations than cereals.	• Sow less susceptible crops, such as barley. • Use fresh seed from previous season. • Apply adequate fertiliser during seeding. • *Pythium* chemical treatments e.g. metalaxyl-M seed dressing and in-furrow treatments. • Clean seed beds (i.e. weeds decomposed prior to sowing).
Environment	**Environment**
• Below average rainfall. • Sandy, alkaline soils with low organic matter.	• Seasons with no waterlogging.

Management options

Pythium can be managed using an integrated approach, which includes crop rotations and disease suppressive treatments. Seed and crop nutrition can also play an important role.

Disease risk categories have yet to be developed for this test, so management decisions should be based on current industry best practice.

AGRONOMIC PRACTICE	MANAGEMENT OPTIONS
PREDICTA B	• Rank paddocks based on population density.
Weed control	• Ensure good weed control in paddock and delay sowing until weeds have decomposed.
Rotation (crop type and variety)	• Employ diverse rotation strategy, incorporating two non-consecutive cereal phases e.g. wheat > canola > barley > pulse. • Grow less susceptible crops i.e. barley. • If *Pythium* levels are high, avoid sowing canola, pulses or pastures legumes for 3 years. • Sow fresh seed.
Machinery	• Remove compaction layers.
Nutrition	• Ensure adequate nutrition. • Apply fertiliser in close proximity to germinating seed.
Chemical	• Consider metalaxyl based seed treatments, these only provide protection to seedlings and early crop growth.

The economic impact of each management option should be carefully considered before devising a management plan.

Do I need to soil test?

YES.

WHY?

- If medium or high *Pythium* levels are anticipated and/ or detected:
  - Treat seed with a Pythium-selective chemical
  - Plant less susceptible crops
- The PREDICTA B test under evaluation for *Pythium* clade f detected 3 of the 7 root pathogenic Pythium species isolated from cropping trials (2002-2010) including the dominant species *Pythium irregulare.*
- A non-quantitative ELISA test is available to detect the presence of Pythium in soils and roots.
- In crop symptoms of *Pythium* root rot can be mistaken for Rhizoctonia root rot .
- Seed treatments containing metalaxyl-M are registered for suppression of pythium seedling “damping off” and root rot in grain and horticultural crops. There are no post emergent treatments registered for suppression of pythium root rot.

Root rot in wheat, left plot untreated, right plot treated with metalaxyl-M.
(IMAGE: PAUL HARVEY, CSIRO)

Stem nematode

Reviewers: Jackie Nobbs (SARDI), Alan McKay (SARDI) and Sue Hoppo (SARDI)

Previous reviewers: Greg Walker and Sharyn Taylor

STEM NEMATODE ID TIP: LOOK FOR CROP PATCHINESS IN LUCERNE, OATS, PEAS AND CANOLA.
IMAGE: MICHAEL RETTKE, SARDI

Stem nematode affected oats. IMAGE: HUGH WALLWORK, SARDI

Stem nematode patches in lucerne. IMAGE: MICHAEL RETTKE, SARDI

About

Stem nematode (*Ditylenchus dipsaci*) is a destructive nematode capable of causing large losses in intolerant crops.

The nematode feeds on emerging plant shoots, crown and above ground biomass, causing distorted and stunted growth. Leaf surface area can also be impacted either side of the midrib.

The population can build up rapidly as the nematodes life cycle is completed in 20 days – this means it can reproduce four or five times in a season. The other factor contributing to its virulence is its hardy survival mechanism - the nematode has the ability to dehydrate and can survive in soil, plant crowns and hay for over 10 years.

With the nematode estimated to cause yield losses of up to 80 % control should be given a high priority.

WHERE DAMAGE IS MORE LIKELY

- Recorded in all eastern states.
- Where several host crops are grown consecutively.
- Where oat varieties are less tolerant to stem nematode (refer to local cereal disease variety guides).
- Yield losses are greater in cooler and wetter districts and in heavier soil types.
- Yield losses and weed seed set are also greater in areas of higher weed populations due to a poorer competitive ability of the affected crop.

Did you know?

- The oat race reduces growth and yield of oats by up to 80%.
- It damages seedlings of field peas and canola.
- The lucerne race reduces growth and life-span of lucerne and may also reproduce on faba beans.
- Affected crops are less competitive with weeds.
- Some markets have nil tolerance for stem nematode infestation in grain or seed.

Symptoms

Stem nematode infection will be evident through areas of poor crop emergence, establishment and growth. Plants will appear stunted and distorted with swollen stem bases and or rotting of the crown. Symptoms can vary between crop types so the following symptom guide should be considered.

PADDOCK

- Areas of poor emergence/stunted growth.
- Often in low lying and wetter areas of paddock.
- Image shows stem nematode patches in lucerne.

(Image: Michael Rettke, SARDI)

PLANT – PEA

- New tillers distorted.
- Leaves and tillers may show yellow to brown streaks before dying prematurely.
- Affected patches can become obvious in spring.
- Plant stunted and young leaves distorted.

(Image: Hugh Wallwork, SARDI)

(Image: Hugh Wallwork, SARDI)

Stunted and distorted tillers. (Image: SARDI)

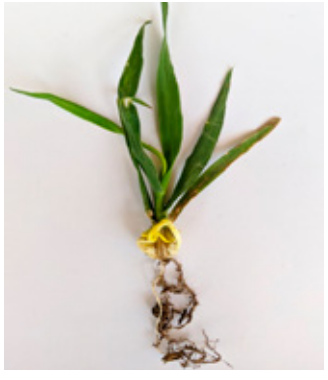
Stem nematode patches in oat crop. (Image: SARDI)

OAT PLANTS

- Short tillers swollen at base.
- New tillers twisted.
- Rotting of crown.

PLANT – CANOLA AND PULSES

- Seedlings severely stunted, leaves twisted.
- Resembles hormone herbicide damage.
- Patches in the crop early in the season.



Stunted and distorted tillers. (Image: SARDI)

Swollen stem base. (Image: SARDI)

Biology

Many host specific races of stem nematode occur worldwide; however the oat and lucerne races are present in Australia. The stem nematode moves in soil surface moisture to invade plants, so it prefers clay loam to clay soil types and is more likely to occur in low-lying, wetter areas of the paddock. Moist soils and temperatures of 15 to 21°C provide optimum conditions for nematode invasion and multiplication.

The life cycle of the stem nematode can be completed in 3 weeks, and in wet seasons can complete 4 to 5 generations; so low populations can build to high levels in one season.

As the plant dries, the 4th stage juveniles cluster together in the crown and stems and dehydrate to form “nematode wool”. These nematodes survive in crop residues and if dry can survive for up to 10 years. The nematode is dispersed in infested material by wind, water, hay, seed and infested soil on equipment, footwear and livestock.

In moist, host-free soils the nematode can probably survive only for 1 to 2 years, some reports indicate >8 years, but this may be due to volunteer hosts and susceptible weeds supporting low populations.

KEY FEATURES

- Multiply quickly, 4 to 5 generations per season.
- Prefers heavy soil types and cool wet seasons.
- Juveniles penetrate crowns and tiller base.
- Survive in stubble, seed and soil.
- Seed-borne in faba bean and lucerne.
- Dispersed by spread of infested material by wind, water, hay, seed etc.
- Can survive for many years if dry e.g. hay.
- Survival stage becomes active when wet.
- Eradication difficult.

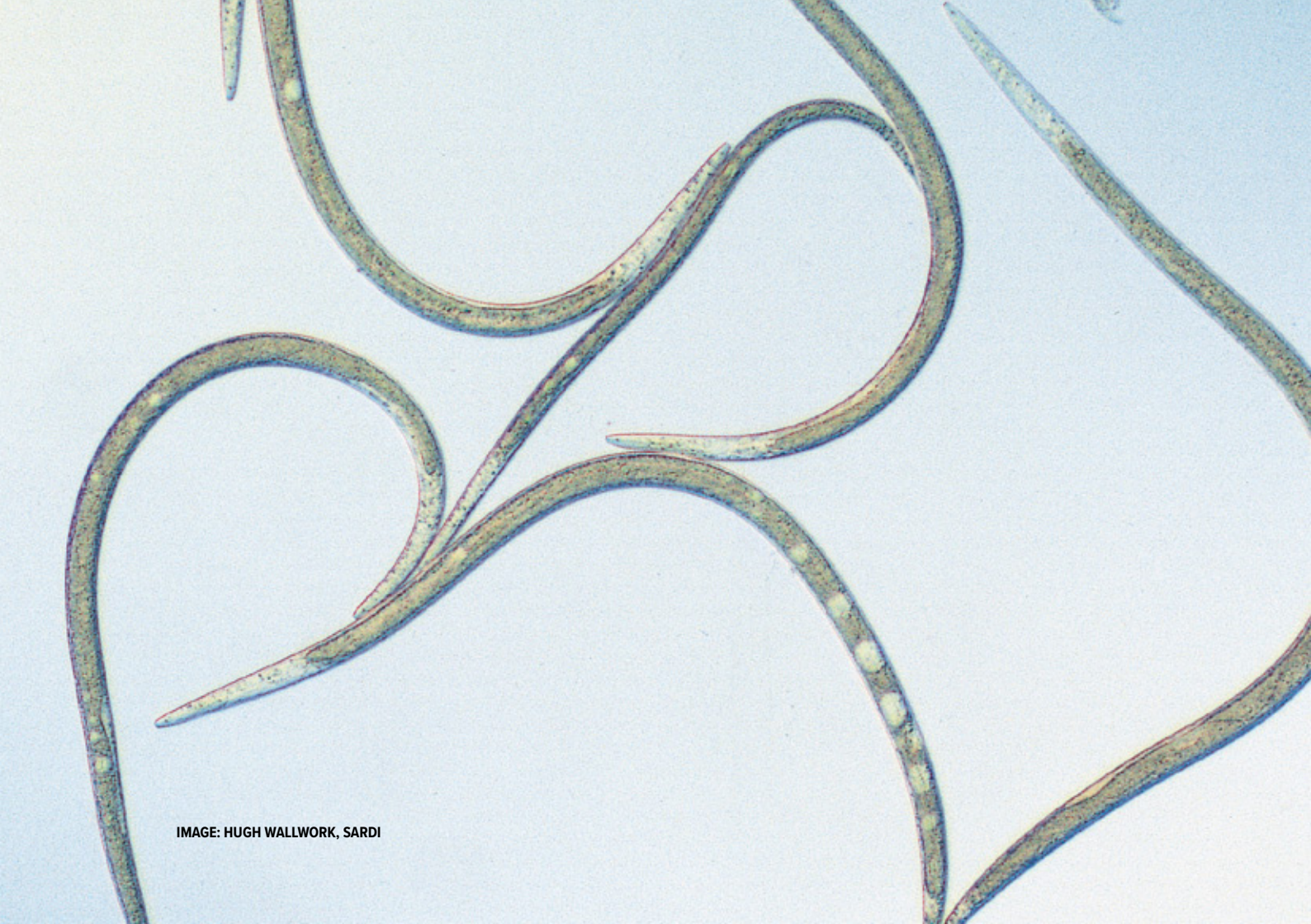


IMAGE: HUGH WALLWORK, SARDI

Host range

The oat race is the most important stem nematode race in the cropping region of Australia; good hosts include oats, wild oats, faba beans and onions. Low numbers may also survive on a range of weeds. While canola and pea seedlings can be severely affected, the nematode does not multiply and plants may recover as the season progresses.

Stem nematode poses a significant threat to other crops in Australia including some vegetables, particularly *Allium* crop species such as onions and garlic.

OAT RACE HOSTS

- Oats, wild oats, faba beans and onions/garlic are good hosts.
- Seedlings of canola, peas, chickpeas, lentils and medics are intolerant.
- Resistant and tolerant oat varieties available.
- Faba beans only show symptoms when initial stem nematode numbers are high.
- Can be seed-borne, especially in faba beans.
- Low numbers may survive on broad range of weeds.

LUCERNE RACE HOSTS

The lucerne race has been recorded in Australia. Some early Australian surveys detected it in 22 to 40% of lucerne crops, mostly flood irrigated.

- Lucerne, information on other hosts limited, possibly faba beans and potatoes.
- Resistant and tolerant lucerne varieties are available.
- Can be seed-borne in lucerne.
- Low numbers may survive on broad range of weeds.

RESISTANCE/TOLERANCE RESPONSES	
CROP TRAIT	**EFFECT ON YIELD**
Intolerant	Plants damaged by stem nematode and yield affected.
Tolerant	Yield loss likely to be low. Avoid susceptible crops/varieties. If growing intolerant varieties, sow early. Good weed control pre-sowing to prevent early multiplication.
	EFFECT ON STEM NEMATODE
Susceptible	Increase
Resistant	Reduce

Impact of management and season

Where there is a significant stem nematode population, tolerant non-host crops should be grown e.g. wheat, barley, triticale and rye. Ensure good weed control, including non-arable areas in and around the paddock.

FACTORS THAT DECREASE STEM NEMATODE NUMBERS	FACTORS THAT MINIMISE YIELD LOSS
Management	**Management**
• Growing resistant or non-host crops such as wheat, barley, triticale and rye. • Three year break from susceptible crops. • Ensure good weed control, including non-arable areas in and around the paddock.	• Grow resistant and tolerant varieties. • Population below detection. • Avoid growing susceptible crops, particularly in low-lying, wetter areas of the paddock.
Environment	**Environment**
• Dry seasons, however there will be a carry-over of nematodes from previous seasons.	• Dry winters that do not favour disease development. • Warm soil temperature at seeding. • Sandy, free draining soils.

Single rows of tolerant (row 2) and intolerant oat varieties (rows 3 and 4)
IMAGE: SUE HOPPO, SARDI

Management options

LEVEL OF STEM NEMATODE	OPTIONS
Below detection	• Focus on other cropping restraints.
Low	• Sow non-host crops or resistant and tolerant oat or lucerne varieties. • Do not grow successive susceptible crops in paddocks in which stem nematode has been detected. • Avoid growing faba beans in paddocks with a history of infestation. • Ensure hay contractors clean equipment before entering new paddocks; even resistant varieties can spread the nematode.
Medium – High	• Sow non-host cereals. • Ensure good weed control in paddock and adjoining non-arable areas that may be a reservoir to re-infest the paddock. • Do not sow canola, pulses or pasture legumes for 3 years, longer if break seasons include droughts.

Do I need to soil test?

YES.

WHY?

The PREDICTA B test detects all races of stem nematode recorded in Australia. If any level of stem nematode is detected, it is advised to grow resistant/tolerant varieties or non-host crops. This will ensure you:

- Minimise grain yield losses
- Reduce the stem nematode populations in the soil for future years

Note: There are no registered chemical treatments at seeding for reducing stem nematode. There are no post emergent treatments for controlling stem nematode.

IMAGE: MICHAEL RETTKE, SARDI

Further Information

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