SOUTHERN
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GRDC GROWNOTES™

GRDC GRAINS RESEARCH & DEVELOPMENT CORPORATION

DURUM

SECTION 8

NEMATODE MANAGEMENT

ROOT-LESION NEMATODE (PRATYLENCHUS SPP.) | CEREAL CYST NEMATODE | NEMATODES AND CROWN ROT

Nematode management

Key messages:

- Nematodes (or roundworms) are one of the most abundant life forms on earth. In cropping situations they can range from being beneficial to detrimental to plant health.
- Well-managed rotations with resistant or non-host break crops are vital for minimising yield losses due to nematode infections. Avoid consecutive host crops to limit populations.
- Choose crop varieties with high resistance ratings, which result in fewer nematodes remaining in the soil to infect subsequent crops.
- Reducing root-lesion nematodes (RLN) and cereal cyst nematodes (CCN) can lead to higher yields in following cereal crops.
- Healthy soils and good nutrition can, to some extent, ameliorate RLN and CCN damage through good crop establishment, and healthier plants recover more readily from infestation.
- Observe crop roots to monitor development of symptoms.
- Weeds can host parasitic nematodes and control of host weed species and crop volunteers is important.
- Most durum varieties are moderately susceptible to the commonly found *P. neglectus* and are moderately resistant to *P. thornei* but vary more widely in resistance to CCN.

8.1 Root-lesion nematode (*Pratylenchus* spp.)

Key points:

- Root-lesion nematodes (RLN) are microscopic worm-like animals that extract nutrients from plants causing yield loss.
- Know your enemy—soil test to determine whether RLN are an issue and which species are present.
- Select wheat varieties with high tolerance ratings to minimise yield losses in RLN-infected paddocks, although there are only small differences in rankings between durum varieties.
- To manage RLN populations, it is important to increase the frequency of RLN-resistant crops in the rotation.
- Avoid crops or varieties that allow the build up of large populations of RLN in infected paddocks.
- Monitor the impact of your rotation.
- Sow early where possible to ‘get ahead’ and maximise yield.
- Manage fertility to maximise nutrition, particularly early in the growing season.
- Control volunteer hosts and weeds during late summer/early autumn and in break crops. [1]

RLN (*Pratylenchus* spp.) are microscopic plant parasites that are soil-borne, ~0.5 to 0.75 mm in length and will feed and reproduce inside roots of susceptible crops or plants potentially causing yield loss. The main RLN species in the southern region are *Pratylenchus neglectus* and *P. thornei* (Photo 1). The *Pratylenchus* species present in the soil will affect choice of management practices, in particular rotations. RLN have a wide host range and can multiply on cereals, oilseeds, pulses and pastures as well as on broadleaf and grass weeds. [2]

1 A Wherrett, V Vanstone Root-lesion nematode. Soil Quality Pty Ltd, http://soilquality.org.au/factsheets/root-lesion-nematode

2 GRDC (2015) Tips and tactics. Root-lesion nematodes. Grains Research and Development Corporation, February 2015, http://www.grdc.com.au/TT-RootLesionNematodes

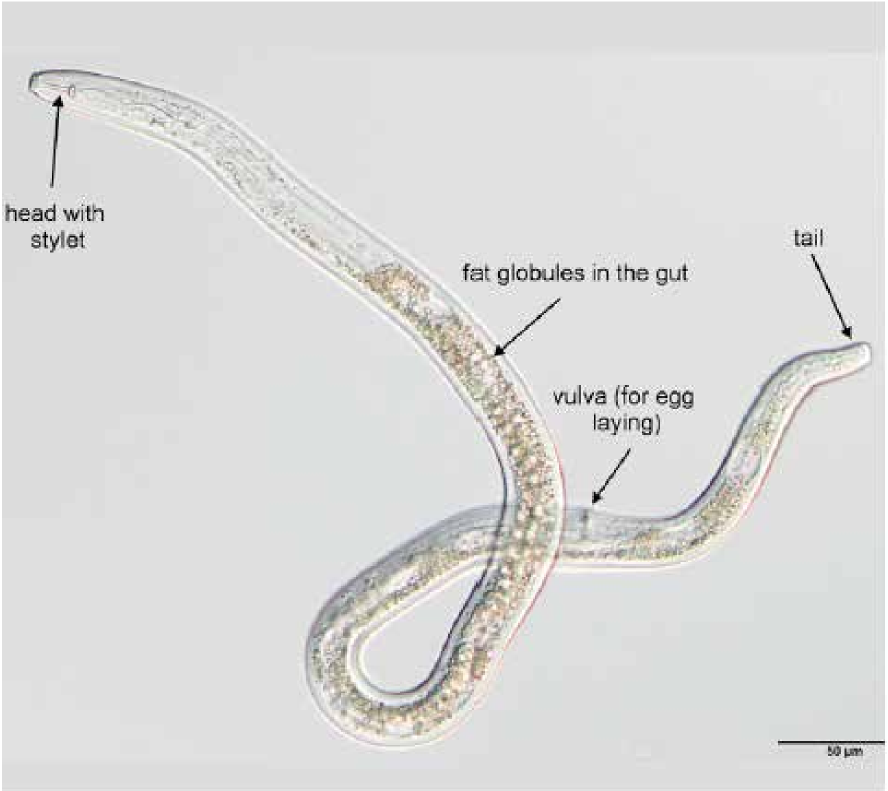

Photo 1: *A Pratylenchus thornei adult female viewed under the microscope. The nematode is approximately 0.65 mm long. The syringe-like 'stylet' at the head end is used for extracting nutrients from the plant root.*

Source: Grains Research and Development Corporation

The extent of RLN occurrence across Australia has recently been estimated (Figure 1).

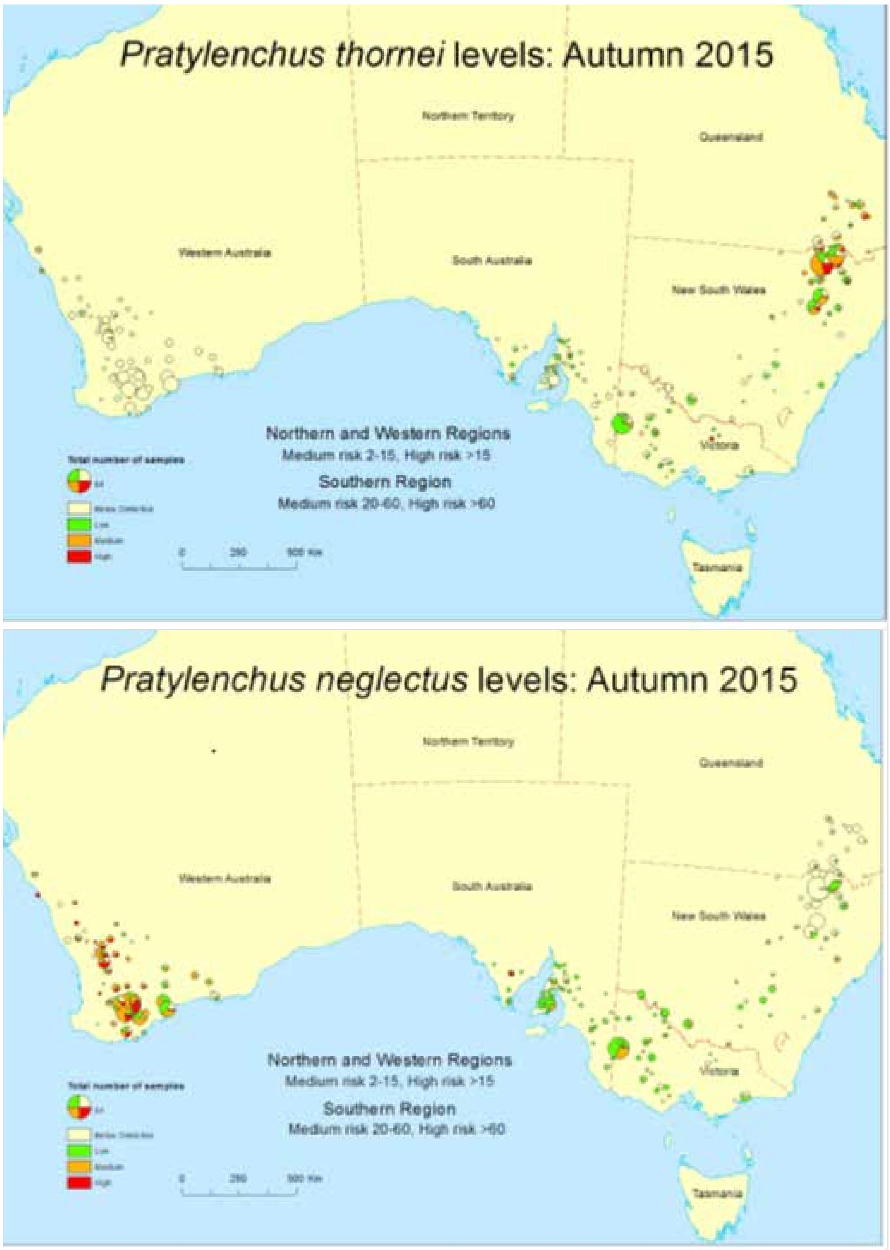

Figure 1: *The distribution and risk of causing yield loss of samples submitted to PreDictaB, SARDI in autumn 2015 for (top)* Pratylenchus thornei *and (bottom)* P. neglectus.

Maps are reproduced with permission from SARDI. Source: GRDC

RLN emerged as potential problems in cereals (and other crops) after management strategies were implemented to control CCN and take-all. Yield losses in the southern region are variable and currently under investigation, but present estimates for intolerant varieties indicate a 1% yield loss per two nematodes per gram soil. *Pratylenchus thornei* (Figure 1) occurs throughout the root zone and is often more damaging than *P. Neglectus*, which tends to be concentrated in the top 15 cm of the soil.

RLN move freely between roots and soil if the soil is moist. In the southern region, the life cycle of RLN begins after the opening rains in autumn. Juvenile and adult nematodes rehydrate, become active and invade plant roots, where they feed and multiply as they move through the root (Figure 2).

As the nematodes feed and multiply, lesions (sections of brown discoloration) are formed in the cortex of the plant root. Eggs are laid within the root or soil, and the first larval stage and moult occur within the egg. Second-stage larvae emerge from eggs and undergo three more moults before reaching adulthood. There may be 3–5 cycles within the plant each growing season, depending on temperature and moisture. The optimum temperature for nematode reproduction is 20°–25°C. The life cycle is generally completed in 40–45 days (~6 weeks) depending on temperature. [3]

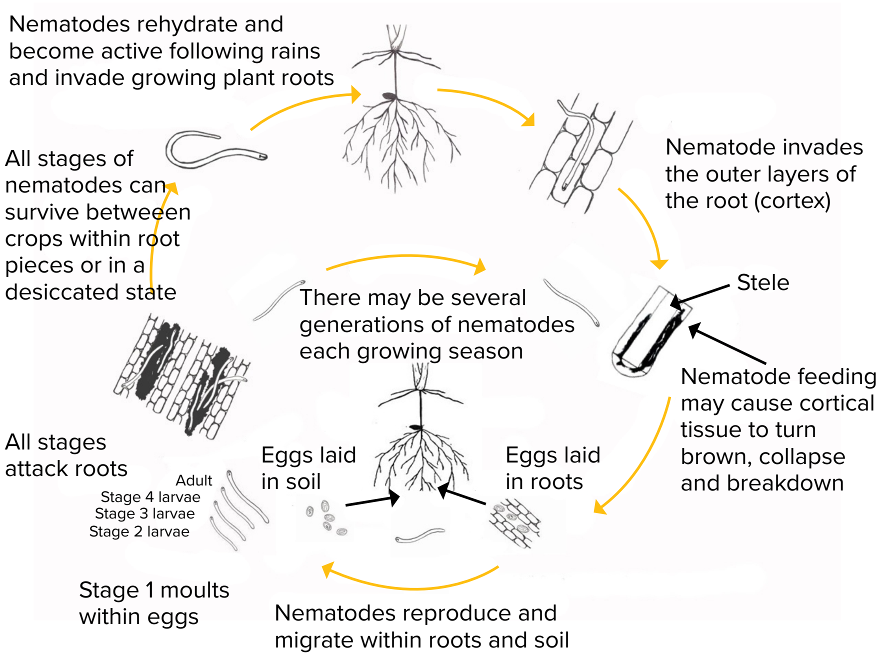

Figure 2: *Disease cycle and damage of root-lesion nematode. Adapted from GN Agrios (1997) Plant pathology, 5th edn (Academic Press: New York); illustration by Kylie Fowler.*

Source: Grains Research and Development Corporation

Yield losses caused by RLN are correlated with the population of these nematodes present in the soil at sowing, the tolerance of the wheat variety and the date of sowing. *P. neglectus* and *P. thornei* can cause yield losses of up to 40% in broadacre field crops in southern Australia if populations are high and intolerant varieties are sown late, but most yield losses are less than 15%. [4]

In field trials carried out by the Victorian and South Australian state departments from 2011 to 2013, *P. thornei* reduced grain yield in intolerant varieties by 2–12%, and *P. neglectus* reduced grain yield by 2–8% (Table 1). [5]

3 GRDC (2015) Tips and tactics. Root-lesion nematodes. Grains Research and Development Corporation, February 2015, http://www.grdc.com.au/TT-RootLesionNematodes

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

5 GRDC (2015) Tips and tactics. Root-lesion nematodes. Grains Research and Development Corporation, February 2015, http://www.grdc.com.au/TT-RootLesionNematodes

Table 1: *Grain yield loss (%) caused by root-lesion nematodes in Victoria and South Australia. Values are average percentage yield loss in the five most intolerant wheat varieties.*

	P. thornei		P. neglectus	
Year	South Australia	Victoria	South Australia	Victoria
2011	7.7	12.2	No trial	4.3
2012	9.0	5.3	8.0	6.6
2013	No trial	2.4	3.8	2.6

Source: Grains Research and Development Corporation

While having some susceptibility, durum varieties can generally be regarded as having among the best levels of resistance to both species of RLN relative to commonly grown wheat varieties in the Southern Region. Consult variety sowing guides for more information.

A survey of 385 paddocks in western Victoria during 2014 and 2015 found that RLN are widespread, being present in up to 98% of paddocks with yield losses possible in many paddocks (Table 2). Based on this data, annual losses due to root lesion nematodes was estimated at $2 million to $13 million, depending on the season. [6]

Table 2: *Percentage of paddocks (n = 385) surveyed in three regions in western Victorian during 2014 and 2015 within each root-lesion nematode risk category (below detection limit [BDL], low, medium and high) and the corresponding potential yield loss (%) caused by root-lesion nematodes.*

PreDicta B risk categories		Victorian region (%)			
Risk Category	Number of RLN per gram of soil	Mallee (n=173)	Wimmera (n=182)	Western District (n=30)	Potential yield loss (%)
Root lesion nematode: ***Pratylenchus neglectus***					
BDL	<0.1	2	5	37	<2
Low	0.1–20	77	75	60	0–10
Medium	20–60	18	20	3	0–20
High	>60	3	0	0	0–40
Root lesion nematode: ***Pratylenchus thornei***					
BDL	<0.1	72	47	73	<2
Low	0.1–20	27	46	27	0–10
Medium	20–60	0	6	0	0–20
High	>60	1	1	0	0–40

Source: Grains Research and Development Corporation

As the symptoms caused by RLN are not as distinct as for the other cereal root diseases it is advisable to have soil tested to determine the likely impact of this pest.

The impact of drought on nematode multiplication is not well understood, however stressed plants are more susceptible to attack. In contrast shorter growing season and reduced root growth can reduce nematode numbers. [7]

VIDEOS

WATCH: GCTV6: Root-lesion nematodes.

WATCH: Understanding root-lesion nematodes.

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

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

FAQ

8.1.1 Varietal resistance and tolerance

A tolerant crop yields well when large populations of RLN are present (in contrast to an intolerant crop). A resistant crop does not allow RLN to reproduce and increase in number (in contrast to a susceptible crop).

Durum varieties consistently show higher levels of resistance to the RLN *P. thornei* than bread wheat and barley varieties. The average *P. thornei* population remaining after a single durum crop is ~40-80% less than after EGA Gregory and 80–90% less than after a single season of Strzelecki. Indications are that DBA Lillaroi, DBA Aurora⦸ and Tjilkuri⦸ have similar levels of *P. thornei* resistance as Caparoi⦸ and EGA Bellaroi⦸. Jandaroi⦸ is generally the least *P. thornei*-resistant durum variety but is still similar to the most resistant commercial bread wheat options. [8] Figure 3 shows the relative build up on *P. thornei* population in three durum varieties and two bread wheat varieties, as measured in field trials conducted by Northern Grower Alliance and New South Wales (NSW) Department of Primary Industries from 2009 to 2014. Hyperno⦸, Caparoi⦸ and EGA Bellaroi⦸ resulted in significantly lower final populations of *P. thornei* than EGA Gregory. Strzelecki resulted in significantly larger populations of *P. thornei* than all other varieties graphed.

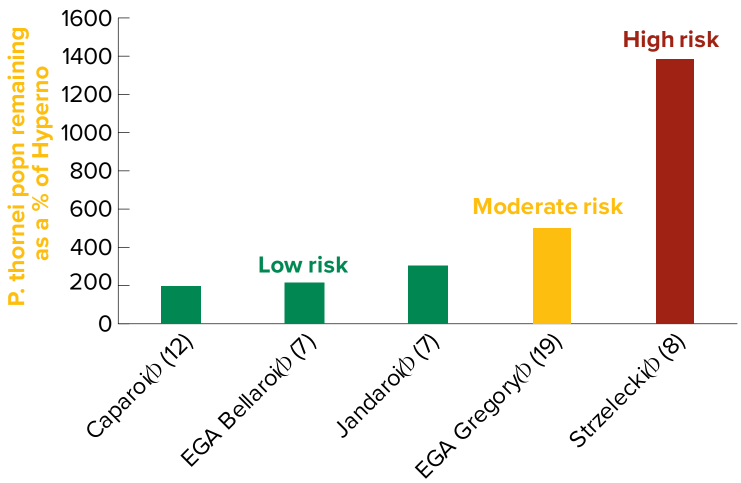

Figure 3: *Relative P. thornei build up following a single crop of durum and bread wheat varieties, expressed as a percentage of the moderately resistant durum variety Hyperno⦸. Number in brackets indicates the number of trials for each variety.*

Source: Grains Research and Development Corporation

Durum has a low to medium hosting ability for *P. thornei* and high for *P. neglectus*. [9]

Durum varieties differ in tolerance to *P. thornei*. Figures 4 and 5 show the yield impact of low versus high levels of *P. thornei* on different wheat varieties in trials undertaken in northern NSW and south-eastern Queensland. Significant levels of yield impact were seen in EGA Bellaroi⦸ in 2012 in northern NSW (-0.6t/ha; Figure 3) and DBA Lillaroi (-0.6t/ha), and in Tjilkuri⦸ (-0.4t/ha) in 2015 in south-eastern Queensland (Figure 4). Caparoi⦸ (and potentially Hyperno⦸ and DBA Aurora⦸) may be better options for durum production in paddocks with high levels of *P. thornei*. [10]

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8 B Burton, R Norton R Daniel (2014) Root lesion nematodes cereal variety and rotational crop impacts on yield and nematode numbers. GRDC update papers. Grains Research and Development Corporation, August 2014, https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2014/08/Root-lesion-nematodes-cereal-variety-and-rotational-crop-impacts-on-yield-and-nematode-numbers

9 GRDC (2015) Root lesion nematodes Southern Region Tips and Tactics Fact Sheet www.grdc.com.au/TT-RootLesionNematodes

10 B Burton, R Norton R Daniel (2014) Root lesion nematodes cereal variety and rotational crop impacts on yield and nematode numbers. GRDC update papers. Grains Research and Development Corporation, August 2014, https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2014/08/Root-lesion-nematodes-cereal-variety-and-rotational-crop-impacts-on-yield-and-nematode-numbers

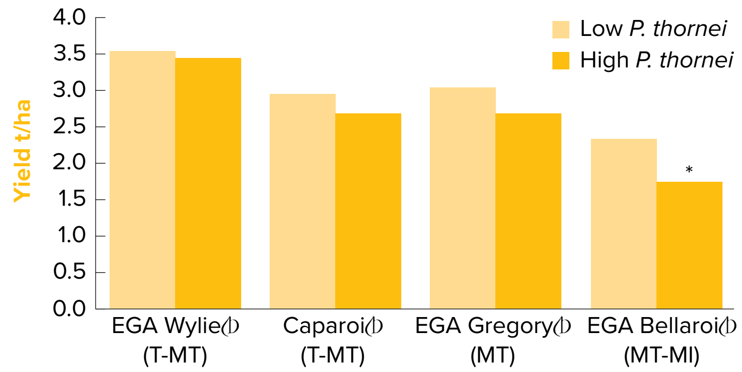

Figure 4: *Yield impact from P thornei near Yallaroi⦶, northern NSW, in 2012 with varieties ranked from left to right in decreasing P. thornei tolerance ranking. Letters in brackets are the tolerance rankings P. thornei (T: tolerant; MT: moderately tolerant; MI: moderately intolerant; 2016 Queensland Variety Guide). Light columns show variety yield with a starting population of 1.9 P. thornei/g soil (i.e. low P. thornei). Dark columns show yield when starting population was 19 P. thornei/g soil (i.e. high P.thornei). *= significant yield loss in variety under increased P. thornei population, e.g. EGA Bellaroi⦶.*

Source: Grains Research and Development Corporation

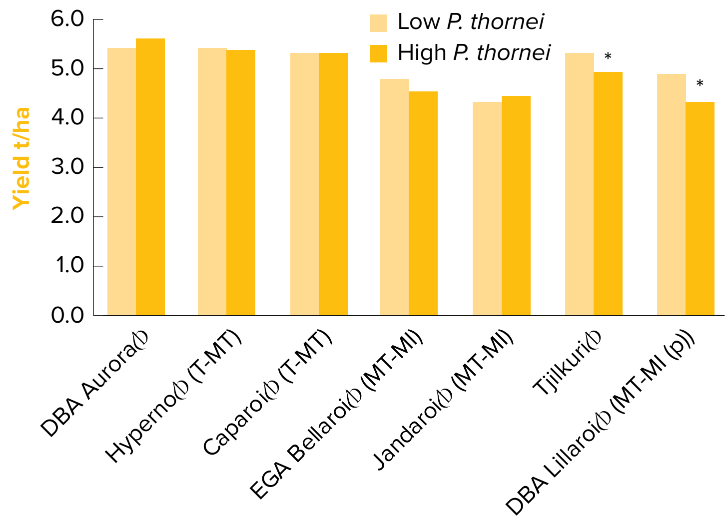

Figure 5: *impact from P. thornei near Macalister, south-eastern Queensland, in 2015 with varieties ranked from left to right in decreasing P. thornei tolerance ranking. Letters in brackets are the tolerance rankings P. thornei (T: tolerant; MT: moderately tolerant; MI: moderately intolerant; 2016 Queensland Variety Guide). NB: No available tolerance ranking for DBA Aurora⦶ and Tjilkuri⦶. Light columns show variety yield with a starting population of 2.7 P. thornei/g soil (i.e. low P. thornei). Dark columns show yield when starting population was 29 P. thornei/g soil (i.e. high P. thornei). *= significant yield loss in variety under increased P. thornei population, e.g. Tjilkuri⦶ and DBA Lillaroi.*

Source: Grains Research and Development Corporation

8.1.2 Damage caused by pest

Although symptoms of RLN damage in wheat can be dramatic, they can be easily confused with nutritional deficiencies and/or moisture stress.

Damage from RLN results in brown root lesions but these are difficult to see and can also be caused by other organisms. Root systems are often compromised with reductions in root branching and quantities of root hairs together with a reduced ability to penetrate deeply into the soil profile. RLN create an inefficient root system that impairs the ability of the plant to access nutrition and water.

Visual damage above-ground from RLN in wheat is non-specific. Lower leaf yellowing is often observed together with reduced tillering and a reduction in the amount of crop biomass. Symptoms are more likely to be observed later in the season, particularly when the crop is reliant on sub soil moisture. Clear symptoms are generally not seen in other crops.

In the early stages of RLN infection, localised patches of poor performing wheat may be observed (Photo 2). Soil testing of these patches may help to determine or eliminate RLN as a possible issue. In paddocks where previous wheat production has been more uniform, a random soil coring approach may be more suitable. Another useful indicator of RLN presence is low yield performance of RLN-intolerant wheat varieties. [11]

Photo 2: *Above-ground symptoms of root-lesion nematode are often indistinct and difficult to identify. Affected plants (centre-left) generally show poor vigour and are often stunted, and cereals tiller poorly.*

Source: Grains Research and Development Corporation

Below-ground symptoms

Because above-ground symptoms of RLN damage are almost indistinguishable from other root diseases or nutrient constraints, it is necessary to examine plant roots for symptoms.

To inspect the root systems for diseases, they should be dug from the ground using a shovel, not pulled from the ground. Pulling from the ground leaves most of the diseased roots behind. The roots must be carefully washed to remove the soil. Roots can then be inspected for disease by floating them in a white tray of water, and looking for symptoms of nematode damage.

In cereals, primary and secondary roots will show a general browning and discoloration. There will be fewer, shorter laterals branching from the main roots and a lack of root hairs (Photo 3). The root cortex (or outer root layer) will be damaged and it may disintegrate. [12]

11 B Burton, R Norton R Daniel (2014) Root lesion nematodes cereal variety and rotational crop impacts on yield and nematode numbers. GRDC update papers. Grains Research and Development Corporation, August 2014, https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2014/08/Root-lesion-nematodes-cereal-variety-and-rotational-crop-impacts-on-yield-and-nematode-numbers

12 GRDC (2015) Tips and tactics. Root-lesion nematodes. Grains Research and Development Corporation, February 2015, http://www.grdc.com.au/TT-RootLesionNematodes

Photo 3: *Symptoms of root-lesion nematode on wheat roots include darkening of the cortex and lack of root hairs.*

Source: Grains Research and Development Corporation

8.1.3 Thresholds for control

In the southern region, yield losses are variable, however, present estimates for intolerant varieties indicate a 1% yield loss per two nematodes per gram soil. The damage threshold has been estimated at 2,000 nematodes/kg soil (or 2/g soil). Control is warranted for paddocks with populations over this density threshold. [13]

Table 3 shows the estimated yield loss from *Pratylenchus* spp. in each risk categories.

Table 3: *Pratylenchus spp. yield loss categories using PreDicta B soil tests.*

Risk category	P. neglectus/g soil	P. thornei/g soil	Estimated % yield loss
Below detection limit	< 1	< 1	-
Low	1–20	1–20	0–10
Medium	20–60	20–60	5–20
High	>60	>60	10–40

Source: Primary Industries and Regions South Australia

8.1.4 Management of root-lesion nematodes

The yield loss caused by RLM is directly related to the number of nematodes present in a paddock. A pre-sowing root disease test is the best way to identify paddocks at risk of damage. Should damaging numbers be identified then appropriate

13 GRDC (2015) Tips and tactics: Root lesion nematodes southern region, www.grdc.com.au/TT-RootLesionNematodes

control strategies, including rotation to resistant crops, can be implemented to minimise loss. [14]

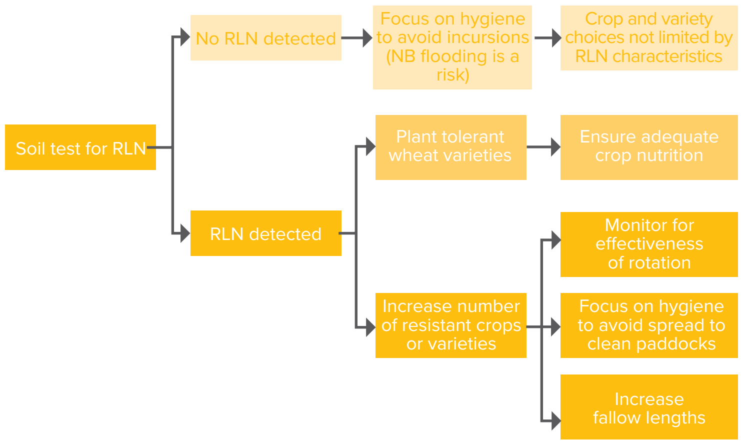

Figure 6: *Root-lesion nematode management flow-chart.*

Source: Grains Research and Development Corporation

Soil testing

The critical first step in the management of RLN is to test your soil and determine whether or not you even have the issue (Figure 6). Testing of soil samples is most commonly conducted via DNA analysis (commercially available as the PreDicta B test from the South Australian Research and Development Institute) with sampling to depths of 0–15 or 0–30 cm. Vertical distribution of *P. thornei* in soil is variable. Some paddocks have 'relatively' uniform populations down to 30 or 60 cm, some will have highest *P. thornei* counts in the 0–15 cm layer whilst other paddocks will have *P. thornei* populations increasing at deeper depths e.g. 30–60 cm. Although detailed knowledge of the distribution may be of some value, the majority of on-farm management decisions will be based on presence or absence of *P. thornei* with sampling at 0–15 or 0–30 cm depth providing that information. [15]

Management:

- Manage RLN by maintaining nematode numbers below threshold levels by growing resistant crops and varieties.
- In heavily infested paddocks, resistant crops or varieties should be grown for one or two years to decrease RLN populations.
- Hosting ability may vary between crop varieties. It is therefore important to check a current crop variety guide from your state department of agriculture or the National Variety Trials website for resistance and tolerance ratings.
- Protect paddocks that are free of nematodes by controlling soil and water run-off and cleaning machinery; plant nematode-free paddocks first.
- Weeds can play an important role in the increase and/or persistence of nematodes in crops and pastures. Therefore, poor control of susceptible weeds will compromise the use of resistant crop rotations for RLN management. [16]

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

15 B Burton, R Norton R Daniel (2014) Root lesion nematodes cereal variety and rotational crop impacts on yield and nematode numbers. GRDC update papers. Grains Research and Development Corporation, August 2014, https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2014/08/Root-lesion-nematodes-cereal-variety-and-rotational-crop-impacts-on-yield-and-nematode-numbers

16 GRDC (2015) Tips and tactics. Root-lesion nematodes. Grains Research and Development Corporation, February 2015, http://www.grdc.com.au/TT-RootLesionNematodes

VIDEOS

WATCH: Root lesion nematodes—What can I do?

WATCH: Crop variety effect on nematode.

MORE INFORMATION

GRDC Tips and tactics: Root-lesion nematode – Southern region

Strategies:

1. **Nematicides**: there are no registered nematicides for RLN in broadacre cropping in Australia. Screening of potential candidates continues to be conducted but RLN are a very difficult target with populations frequently deep in the soil profile.
2. **Nutrition**: damage from RLN reduces the ability of cereal roots to access nutrients and soil moisture and can induce nutrient deficiencies. Under-fertilising is likely to exacerbate RLN yield impacts however over-fertilising is still unlikely to compensate for a poor variety choice.
3. **Variety choice and crop rotation:** *These are currently our most effective management tools for RLN*. However, the focus is on two different characteristics:
4. *tolerance*—the ability of the variety to yield under RLN pressure; and
5. *resistance*—the impact of the variety on the build-up of RLN populations.
6. NB varieties and crops often have varied tolerance and resistance levels to *Pt* and *Pn*.
7. **Fallow:** RLN populations will generally decrease during a 'clean' fallow but the process is slow and expensive in lost 'potential' income. Additionally, long fallows may decrease mycorrhizal levels and create more cropping issues than they solve. [17]

Cultural control

Crop rotation with resistant crops such as grain sorghum, millet, sunflower and canary will reduce the numbers of nematodes in the soil to a level where susceptible wheat varieties can be grown, but will not eliminate them completely. [18]

8.2 Cereal cyst nematode

Cereal cyst nematode (CCN; *Heterodera avenae*) is a pest of graminaceous crops worldwide. This nematode is a significant issue for growers across eastern Australia and becomes more problematic in areas where intensive cereal cropping occurs. CCN will only infect, feed and develop on cereals and other grasses (particularly wild oat). Non-cereal crops will not host the nematode, so are useful in rotations to limit damage caused to cereals. [19]

Though durum is not the most susceptible cereal crop to CCN buildup, its use in a crop sequence will not provide a complete break. [20] The Southern Region durum varieties most commonly grown range from MS to MS/S in reaction to CCN and while not as susceptible as some hard wheat varieties, must be carefully considered in high risk situations.

In a survey of 385 paddocks in western Victoria during 2014 and 2015, CCN was identified in 4% and 12% of paddocks in the Wimmera and Mallee, respectively, showing the effect of good control through the cultivation of resistant cereal varieties and crop rotation (Table 4). However, if CCN levels increase large yield losses are possible. [21]

17 B Burton, R Norton R Daniel (2014) Root lesion nematodes cereal variety and rotational crop impacts on yield and nematode numbers. GRDC update papers. Grains Research and Development Corporation, August 2014, https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2014/08/Root-lesion-nematodes-cereal-variety-and-rotational-crop-impacts-on-yield-and-nematode-numbers

18 DAF QLD (2015) Wheat—diseases, physiological disorders and frost, https://www.daf.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/wheat/diseases

19 A Wherrett, V Vanstone. Cereal cyst nematode. Soil Quality Pty Ltd, http://soilquality.org.au/factsheets/cereal-cyst-nematode

20 Tony Craddock. (2016). Personal Communication.

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

Table 4: *Percentage of paddocks (n = 385) surveyed in three regions in western Victorian during 2014 and 2015 within each nematode risk category (below detection limit [BDL], low, medium and high) and the corresponding potential yield loss (%) due to cereal cyst nematode.*

PreDicta B risk categories		**Victorian region (%)**			
Risk category	Number of CCN per gram of soil	Mallee (n=173)	Wimmera (n=182)	Western District (n=30)	**Potential yield loss (%)**
Cereal cyst nematode (*Heterodera avenae*)					
BDL	<0.05	96	88	100	<5
Low	0.05–5	4	9	0	5–25
Medium	5–10	0	2	0	10–50
High	>10	0	1	0	15–70

Source: Grains Research and Development Corporation

Figure 7 illustrates the CCN lifecycle. CCN juveniles hatch from eggs contained in the cysts remaining from previous seasons; hatching occurs in response to lower temperatures and autumn rains. Hatching is delayed by late breaks or dry autumns and this increases the risk of crop damage. Once hatched the young nematodes seek out the roots of host plants. While the male nematodes remain free-living in the soil, the females penetrate roots and begin feeding. Following mating, the females produce eggs within their body. As the season progresses the females remain feeding at the same infection site and begin to swell into the characteristic white spheres. This process takes six to nine weeks, and the CCN females remain like this until the host plant begins to senesce. The females die and their cuticle hardens and turns brown to form a cyst. Cysts are particularly hardy, and remain in the soil over summer until temperatures fall and the autumn rains begin which stimulates hatching of the next generation. CCN have only one life cycle per year. However, each cyst contains several hundred eggs, so populations can increase rapidly on susceptible cereals. [22]

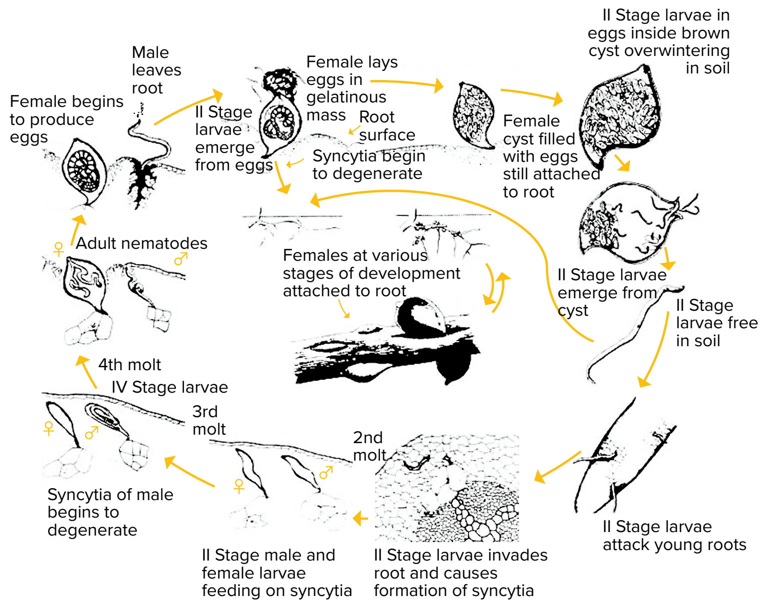

Figure 7: *Cereal cyst nematode life cycle and damage to plants. GN Agrios (1997) Plant pathology, 4th edition (Academic Press: New York).*

Source: Grains Research and Development Corporation

22 A Wherrett, V Vanstone. Cereal cyst nematode. Soil Quality Pty Ltd, http://soilquality.org.au/factsheets/cereal-cyst-nematode

Each year approximately 80% of nematodes hatch from cysts after the autumn break, while the remaining 20% stay dormant until the following season. This is why it will take at least two years with break crops to control CCN. However, under dry (drought) conditions up to 50% of nematodes remain dormant, and an extra year of break crop is advisable. [23]

8.2.1 Varietal resistance or tolerance

Continually check regional disease guides for updates on this data as ratings change annually as more data is collected. All durum varieties are moderately susceptible to CCN (Table 5).

Table 5: *Resistance of major durum varieties to common cereal diseases in South Australia for 2017.*

Durum wheat variety	Cereal cyst nematode resistance	Root lesion nematodes			
		P. neglectus	*P. thornei*		
Aurora⫽	MSS	MS	RMR		
Caparoi⫽	MS	MSS	MR		
Hyperno⫽	MS	MS	RMR		
Saintly⫽	MS	MS	MR		
Tjilkuri⫽	MS	MS	MR		
WID802⫽	MS	MS	MS		
Abbreviations					
R	Resistant	MR	Moderately resistant	MS	Moderately susceptible
S	Susceptible	VS	Very susceptible	MI	Moderately intolerant
I	Intolerant	-	Uncertain		

Source: Primary Industries and Regions South Australia

8.2.2 Damage caused by pest

The symptoms of CCN infection can be readily recognised. Above-ground, patches of unthrifty yellowed and stunted plants can be observed (Photo 4), which often gives the crop a 'patchy' appearance. Planting a susceptible crop in successive years will result in these patches becoming larger with time. [24]

23 G Hollaway (1996) Cereal root diseases. Agriculture Victoria, January 1996, http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/plant-diseases/grains-pulses-and-cereals/cereal-root-diseases

24 A Wherrett, V Vanstone (2017) Cereal cyst nematode. Soil Quality Pty Ltd, http://soilquality.org.au/factsheets/cereal-cyst-nematode

Photo 4: *Cereal cyst nematide will cause distinct patches of yellowed and stunted plants. Note the likeness of symptoms to poor nutrition or water stress.*

Source: Soil Quality Pty Ltd

Closer examination of the roots will reveal symptoms that are typical of CCN, with wheat roots 'knotted' (Photo 5). Development of root systems is retarded and shallow. Symptoms can be confirmed at flowering time in spring, when characteristic white cysts (1–2 mm in diameter) can be seen with the naked eye if roots are carefully dug and washed free of soil (Figure 6). These are the swollen bodies of the female CCN, each containing several hundred eggs. [25]

Photo 5: *Cereal cyst nematodes produce 'knotting' of wheat and barley roots.*

Source: Soil Quality Pty Ltd

25 G Hollaway (1996) Cereal root diseases. Agriculture Victoria, January 1996, http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/plant-diseases/grains-pulses-and-cereals/cereal-root-diseases

Photo 6: *Cereal cyst nematode-infected root system with characteristic white cysts.*

Source: Agriculture Victoria

8.2.3 Thresholds for control

Just two CCN eggs per of gram soil can cause significant economic loss to intolerant cereal crops. Levels of one to five eggs per gram of soil can reduce yield of wheat and oat by up to 20%. [26]

8.2.4 Management of cereal cyst nematode

As with other nematodes, there is no effective or economically feasible means of controlling CCN through chemical application. Chemical nematicides are expensive to use, toxic to humans and the success of applications are often highly variable. CCN is best controlled through effective rotation management. [27]

Only 70–80% of eggs hatch each season, regardless of the crop host. As a result, it can take several years for high CCN levels to be reduced by rotation with resistant or non-host crops. Plan ahead and make sure there is at least a two-year disease break following susceptible cereals. Timing of host removal is critical when establishing a disease break. In calculating the critical date to chemical fallow or remove host species from break crops consideration should be given to the time taken for host plants to die after herbicide application. Nematodes will continue to feed until the plant is dead.

Host plants, particularly susceptible self-sown cereals, must be controlled before the nematodes have completed the development of eggs. This is approximately 10 weeks after the autumn break (Figure 8). [28]

26 A Wherrett, V Vanstone. Cereal cyst nematode. Soil Quality Pty Ltd, http://soilquality.org.au/factsheets/cereal-cyst-nematode

27 A Wherrett, V Vanstone. Cereal cyst nematode. Soil Quality Pty Ltd, http://soilquality.org.au/factsheets/cereal-cyst-nematode

28 G Hollaway (1996) Cereal root diseases. Agriculture Victoria, January 1996, http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/plant-diseases/grains-pulses-and-cereals/cereal-root-diseases

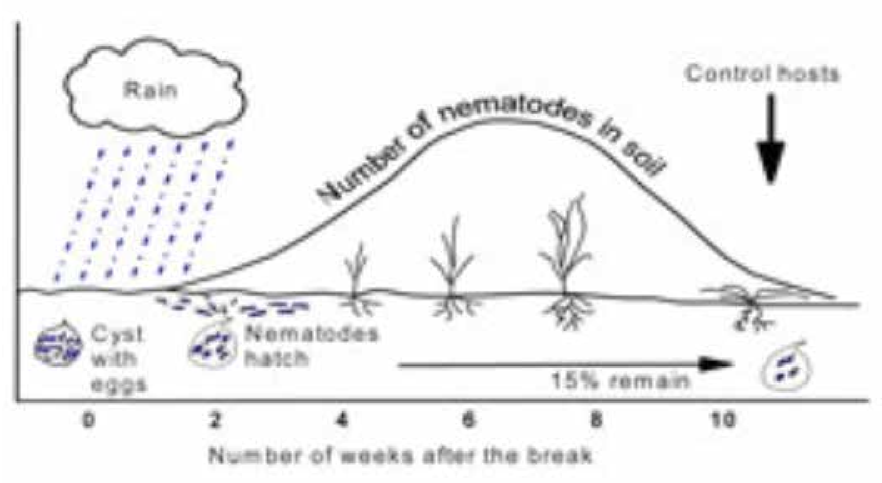

Figure 8: *Timing of the cereal cyst nematode life cycle in terms of the autumn break.*

Source: Agriculture Victoria

The use of resistant cereals and non-host crops, or fallow in rotations as part of a two-year break, is an effective method to control CCN.

Disease breaks for cereal cyst nematode:

- Grass-free pulse and oilseed crops or legume pasture.
- Resistant cereals – all durum varieties are moderately susceptible to CCN (see the Cereal Diseases Guide for a list of CCN-resistant cereal varieties).
- Chemical fallow prepared early in the season before nematodes have produced viable eggs. [29]

8.3 Nematodes and crown rot

While all winter cereals host the crown rot fungus, yield loss due to infection varies with cereal type. The approximate order of increasing yield loss is cereal rye, oats, barley, bread wheat, triticale and durum wheat. [30]

Many trials concentrate on crown rot, and it is becoming more important to build a picture of the interaction of crown rot with other factors, especially in combination with *Pt* levels. As well as reducing yield, *Pt* reduces grain quality and Nitrogen Use Efficiency, and increases the severity of crown rot infections. [31]

There have been numerous field trials since 2007 evaluating the impact of crown rot on a range of winter-cereal crop types and varieties. This work has greatly improved the understanding of crown rot impact and variety tolerance, but also indicates that we may be suffering significant yield losses from another “disease” that often goes unnoticed.

Although the trials were not designed to focus on nematodes, a convincing trend was apparent after 2008 that indicated *P. thornei* was having a frequent and large impact on wheat variety yield. [32]

Where Pt combines with high levels of crown rot (a common scenario), yield losses can be exacerbated if varieties are susceptible to Pt. Instead of a 10% yield loss from

29 G Hollaway (1996) Cereal root diseases. Agriculture Victoria, January 1996, http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/plant-diseases/grains-pulses-and-cereals/cereal-root-diseases

30 GRDC (2016) Tips and Tactics: Crown rot in winter cereals—Southern region.

31 Dixon T. (2013). Balancing Crown rot and Nematodes in wheat. Ground Cover Issue 104: May – June 2013. https://grdc.com.au/Media-Centre/Ground-Cover/Ground-Cover-Issue-104-May-June-2013/Balancing-crown-rot-and-nematodes-in-wheat

32 R Daniel (2013) Managing root-lesion nematodes: how important are crop and variety choice? Northern Grower Alliance/GRDC Update Paper, 16/07/2013.

Pt in a susceptible variety, it could be 30–50% if crown rot is combined with a Pt-intolerant variety (Photo 7).

The research has also shown that not only does Pt cause high yield loss in susceptible varieties, but Pt numbers can increase much faster than in an area in which tolerant varieties are growing. These increased Pt numbers can lead to even greater damage in future crops. [33]

Photo 7: *Grass plant showing both parasitic nematode damage to roots and crown rot in above ground tissues.*

Source: NCSU)

MORE INFORMATION

The additive yield impact of root lesion nematode and crown rot

VIDEOS

WATCH: GCTV9: Crown rot and root-lesion nematode.

There is increasing evidence for the enhancing effect of nematodes on levels of crown rot, which durum is very susceptible to. An extensive NSW farm survey conducted by Industry and Investment NSW exploring the effect of crown rot on wheat varieties including durum also highlighted the extensive level of nematodes, especially *P. thornei*, throughout the cropping belt. The researchers concluded that where *P. thornei* combines with high levels of crown rot (a common scenario), yield losses can be exacerbated if varieties are susceptible to *P. thornei*. Instead of a 10% yield loss from *P. thornei* in a susceptible variety it could be 30–50% if crown rot is combined with a *P. thornei*-intolerant variety. These trials were designed to evaluate the impact of crown rot on variety yield and quality. However, results strongly suggest that *P. thornei* is also having a significant impact on yield performance. The results do not compare the actual levels of yield loss due to the two diseases but indicate there is a greater range in variety *P. thornei* tolerance than currently exists for crown rot tolerance. Put simply, variety choice appears a more valuable tool when under *P. thornei* pressure than as a tool for crown rot management. [34]

8.3.1 Management

Variety choice is the key management option when it comes to managing Pt risk. However, when it comes to crown rot management, although varieties have some impact, rotation and stubble management are by far our most important management tools. RLN, especially Pt, need to be taken far more seriously and better factored into crop rotation considerations as well as variety choice. [35]

33 B Freebairn (2011) Nematodes and crown rot: a costly union. Ground Cover Issue 91, March-April 2011. https://grdc.com.au/Media-Centre/Ground-Cover/Ground-Cover-Issue-91-March-April-2011/Nematodes-and-crown-rot-a-costly-union

34 GRDC (2010) The additive yield impact of root-lesion nematode and crown rot? GRDC update papers. Grains Research and Development Corporation, September 2010, https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2010/09/THE-ADDITIVE-YIELD-IMPACT-OF-ROOT-LESION-NEMATODE-AND-CROWN-ROT

35 B Freebairn (2011) Nematodes and crown rot: a costly union. Ground Cover Issue 91, March-April 2011, https://grdc.com.au/Media-Centre/Ground-Cover/Ground-Cover-Issue-91-March-April-2011/Nematodes-and-crown-rot-a-costly-union

Soil testing

PreDictaB

Cereal root diseases cost grain growers in excess of $200 million a year in lost production. Much of this can be prevented.

PreDicta B (B = broadacre) is a DNA-based soil testing service that identifies which soil-borne pathogens pose a significant risk to broadacre crops prior to seeding (Photo 8).

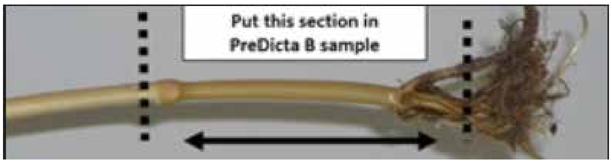

Photo 8: *Correct sampling strategy.*

Source: GRDC

PreDicta B includes tests for:

- Take-all (*Gaeumannomyces graminis var tritici (Ggt)* and *G. graminis var avenae (Gga)*).
- Rhizoctonia barepatch (*Rhizoctonia solani AG8*).
- Crown rot (*Fusarium pseudograminearum and F. culmorum*).
- Blackspot of peas (*Mycosphaerella pinodes, Phoma medicaginis var pinodella* and *Phoma koolunga*).

Access PreDicta B testing service

You can access PreDicta B diagnostic testing services through a SARDI accredited agronomist. They will interpret the results and give you advice on management options to reduce your risk of yield loss.

SARDI processes PreDicta B samples weekly between February and mid-May (prior to crops being sown) every year.

These timeframes help SARDI assist you with your cropping program.

PreDicta B is not intended for in-crop diagnosis. See SARDI's crop diagnostic webpage for other services.

Varietal choice

Crop rotation and variety choice are the important factors in protection against both diseases. Choosing a variety solely on crown rot resistance is not critical, especially if appropriate management techniques have been carried out, but choice of variety is crucial when it comes to *Pt* tolerance.

Further research into varietal tolerance to crown rot and nematodes has revealed that choosing a variety is difficult. Determining the relative tolerance of varieties to crown rot is complex as it can be significantly influenced by background inoculum levels, RLN populations, differential variety tolerance to *Pn* versus *Pt* and varietal interaction with the expression of crown rot. Other soil-borne pathogens such as *Bipolaris sorokiniana*, which causes common root rot, also need to be accounted for in the interaction between crown rot and varieties. Starting soil water, in-crop rainfall, relative biomass production, sowing date and resulting variety phenology in respect to moisture and/or temperature stress during grain-fill can all differentially influence the expression of crown rot in different varieties. [36]

36 T Dixon (2013) Balancing Crown rot and Nematodes in wheat. Ground Cover Issue 104: May—June 2013. https://grdc.com.au/Media-Centre/Ground-Cover/Ground-Cover-Issue-104-May-June-2013/Balancing-crown-rot-and-nematodes-in-wheat