WESTERN
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GRDC GROWNOTES™

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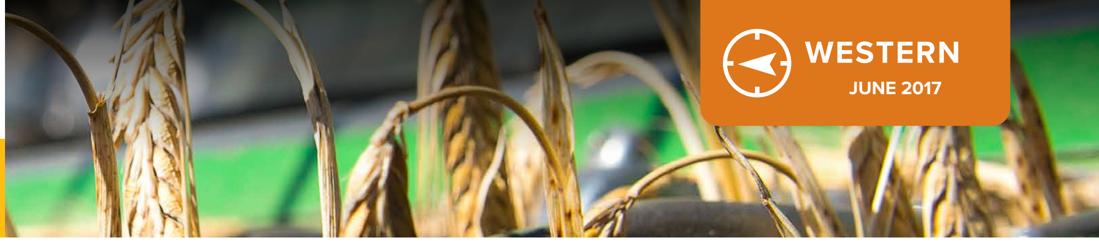
GRAINS RESEARCH & DEVELOPMENT CORPORATION

BARLEY

SECTION 8

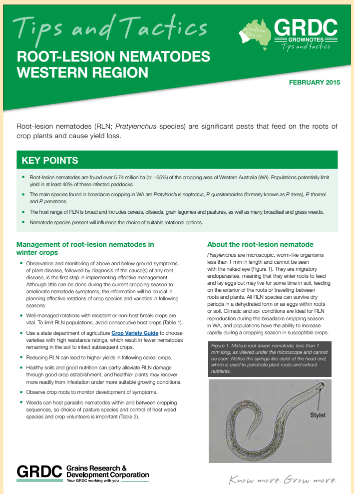
NEMATODE MANAGEMENT

SYMPTOMS AND DETECTION | VARIETAL RESISTANCE OR TOLERANCE | MANAGEMENT OF NEMATODES | TESTING FOR ROOT-LESION NEMATODES



MORE INFORMATION

GRDC (2015) Tip and tactics: Root-Lesion Nematodes. Fact sheet.


Tips and Tactics
GRDC GROWNOTES
ROOT-LESION NEMATODES
WESTERN REGION
FEBRUARY 2015
Root-lesion nematodes (RLN; *Pratylenchus* species) are significant pests that feed on the roots of crop plants and cause yield loss.
KEY POINTS
Management of root-lesion nematodes in winter crops
About the root-lesion nematode
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Know more. Grow more.

Nematode management

Root-lesion nemtodes (RLN; *Pratylenchus* spp.) are microscopic, worm-like animals that extract nutrients from plants, causing yield loss. [1]

Root-lesion nematodes are found over 5.74 million hectares (or ~65%) of the cropping area of WA and populations potentially limit yield in at least 40% of these infested paddocks.

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

The main species found in broadacre cropping in WA are *Pratylenchus neglectus*, *P. quasitereoides* (originally described as *P. teres*), *P. thornei* and *P. penetrans*.

Which nematode species are present will affect the suitability of the rotational options.

Barley in the Western Region is considered susceptible to *P. neglectus,* susceptible to *P. quasitereoides* and moderately susceptible to *P. penetrans.* [2]

Table 1: *Resistance of major crop broadacre species to Pratylenchus neglectus, P. quasitereoides and P. penetrans*

Susceptible	Moderately susceptible	Resistant
P. neglectus		
Wheat	Canola	Field peas
Barley	Oats	Lupins
Chickpeas	Durum wheat	Faba beans
		Lentils
		Triticale
		Rye
		Safflower
		Narbon beans
P. quasitereoides **(formerly** ***P. teres*****)**		
Wheat	Canola	Field peas
Barley		Lupins
Oats		
P. penetrans		
Field peas	Barley	
Lupins	Canola	
Chickpeas		
Oats		
Durum wheat		
Wheat		
Triticale		
Faba beans		
Wild oats		
Wild radish		

Souce: Soil Quality Background

1 KJ Owen, J Sheedy, N Seymour (2013) Root lesion nematode in Queensland. Soil Quality Pty Ltd. Fact sheet, http://www.soilquality.org.au/factsheets/root-lesion-nematode-in-queensland

2 GRDC (2015) Tips and Tactics: Root-Lesion Nematodes, Western Region, Fact sheet, http://www.grdc.com.au/TT-RootLesionNematodes

Root-lesion nematodes use a syringe-like 'stylet' to extract nutrients from the roots of plants (Photo 1). Plant roots are damaged as RLN feed and reproduce inside the plant roots. *Pratylenchus thornei* and *P. neglectus* are the most common RLN species in Australia. These nematodes can be found deep in the soil profile (to 90 cm depth) and in a broad range of soil types, from heavy clays to sandy soils. [3]

New CSIRO research funded by the GRDC is examining how nematodes inflict damage by penetrating the outer layer of wheat roots and restricting their ability to transport water.

Photo 1: *Microscope image of a root-lesion nematode. Notice the syringe-like 'stylet' at the head end, which is used for extracting nutrients from the plant root. This nematode is less than 1 mm long.*

Source: Sean Kelly, DAFWA)

MORE INFORMATION

DAFWA (2014) How to diagnose Root Lesion Nematode. Video.

DAFWA (2014) Crop damaging nematodes found in new area. Media release.

S Collins et al. (2014) Root lesion nematode has a picnic in 2013. GRDC Update Papers.

S Collins et al. (2013) *Pratylenchus teres* WA's home grown Root Lesion Nematode. GRDC Update Papers.

GRDC (2010) Plant Parasitic Nematodes (Southern & Western Region). Fact sheet.

8.1 Symptoms and detection

Root-lesion nematodes are microscopic organisms that occur in soil and plants. The most reliable way to confirm the presence of RLN is to have soil tested in a laboratory.

Signs of nematode infection in roots include dark lesions or poor root structure (Photo 2). The damaged roots are inefficient at taking up water and nutrients—particularly nitrogen, phosphorus and zinc—causing symptoms of nutrient deficiency and wilting in the plant shoots. Intolerant wheat varieties may appear stunted, with yellowing of lower leaves and poor tillering. However, these symptoms may not be present in other susceptible crops such as barley and chickpea. [4]

What is seen in the paddock?

Above-ground symptoms are often indistinct and difficult to identify. The first signs are poor establishment, stunting, poor tillering of cereals, and plants possibly wilting despite moist soil. Nematodes are usually distributed unevenly across a paddock, resulting in irregular crop growth. Sometimes symptoms are confused with nutrient deficiency and they can be exacerbated by a lack of nutrients.

3 KJ Owen, J Sheedy, N Seymour (2013) Root lesion nematode in Queensland. Soil Quality Pty Ltd. Fact sheet, http://www.soilquality.org.au/factsheets/root-lesion-nematode-in-queensland

4 KJ Owen, J Sheedy, N Seymour (2013) Root lesion nematode in Queensland. Soil Quality Pty Ltd. Fact sheet, http://www.soilquality.org.au/factsheets/root-lesion-nematode-in-queensland

Photo 2: *Barley roots with symptoms of Pratylenchus damage including stunting, lack of lateral roots, and browning lesions.*

Source: GRDC

When roots are damaged by RLN (Photo 2), plants are less able to tolerate stresses such as drought or nutrient deficiencies. Depending on the extent of damage and the growing conditions, affected plants may partly recover if the rate of new root growth exceeds the rate at which nematodes damage the roots.

Gaining the full picture requires an examination of what is going on under the ground. Primary and secondary roots of cereals will show a general browning and discoloration and there will be fewer, shorter laterals branching from the main roots.

The root cortex (or outer root layer) may be damaged and it may disintegrate.

Diagnosis is difficult and can be confirmed only with laboratory testing. This is essential if identification is sought to species level as all RLN species cause identical symptoms. The PreDicta B™ soil test (SARDI Diagnostic Services) is a useful tool for several nematode species and is available through accredited agronomists. [5]

RLN and acidic soil

Western Australia's acidic soils could be exacerbating the impact of RLN and limiting crop yields and growers' profitability.

Initial research by DAFWA supported by the GRDC, has found significantly higher RLN populations in barley, lupin and wheat crops grown in low pH soils.

The nematology research group at DAFWA conducted a series of glasshouse trials to test the impact of soil acidity on the multiplication of the main RLN species that impact WA wheat, barley and lupin crops.

The plants were grown in acidic soils (pH 5.1) taken from the same paddock and compared with plants grown in soil that had been treated with lime (pH 6.7).

5 GRDC (2015) Tips and Tactics: Root-Lesion Nematodes, Western Region, Fact sheet, http://www.grdc.com.au/TT-RootLesionNematodes

Significantly higher final populations of *P. quasitereoides* were recorded for seven of the nine wheat, barley and lupin varieties grown in low pH soil compared with the same varieties grown in the same soil limed to moderate pH.

The same result was recorded in barley for *P. neglectus*.

Diagnostic and management information is available by downloading the free MyCrop app for wheat, barley, canola and lupins. [6]

The life cycle of RLN

Root-lesion nematodes are migratory plant parasitic nematodes, and will migrate freely between roots and soil if the soil is moist. In WA, 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 1). Individual eggs are laid within the root, from which juvenile nematodes hatch and grow to adults, which in turn lay more eggs. They develop from egg to adult in 40–45 days (~6 weeks) depending on soil temperature and host. There may be 3–5 life cycles within the plant host each season.

As plants and soil dry out in late spring, RLN enter a dehydrated state called anhydrobiosis and can survive high soil temperatures and desiccation over summer. As the nematodes feed and multiply, lesions and/or sections of brown discoloration are formed on the plant root. Other symptoms include reduction in the number and size of lateral roots and root hairs. [7]

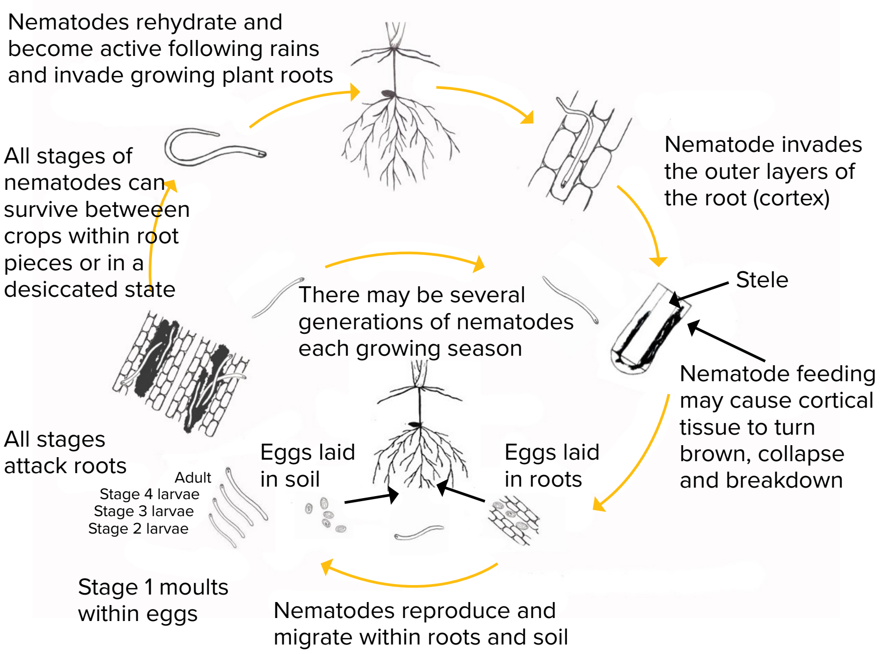

Figure 1: *Disease cycle of root-lesion nematode*

adapted from: GN Agrios (1997) Plant pathology, 5th edn (Academic Press: New York). (Illustration by Kylie Fowler)

6 DAFWA (2015) Soil acidity could increase risk of Root Lesion Nematodes. Media release. Department of Agriculture and Food, Western Australia, https://www.agric.wa.gov.au/news/media-releases/soil-acidity-could-increase-risk-root-lesion-nematodes

7 GRDC (2015) Tips and Tactics: Root-Lesion Nematodes, Western Region, Fact sheet, http://www.grdc.com.au/TT-RootLesionNematodes

P. quasitereoides

P. quasitereoides (originally described as *P. teres*) is unique to WA, and can reach high populations and cause more significant and widespread damage within a crop than *P. neglectus*. Growers need to manage *P. quasitereoides* within their cropping rotations through the use of species which are poor or non-hosts, or use resistant wheat and barley cultivars to limit the multiplication of this pest in the soil. Although *P. quasitereoides* is not as widespread, crops resistant to *P. neglectus* can be highly susceptible to this species, requiring a different suite of rotational crops and cultivars for effective management. It is necessary that in field diagnoses, the species of RLN is correctly identified to enable growers to choose appropriate crop cultivars and species to minimise current and future losses. [8]

Canola has been found to increase *P. quasitereoides* numbers especially if the canola is grown after a long cereal phase.

Economic importance

In WA, all growing regions are affected by RLN (Figure 2) and at least 65% of cropping paddocks are infested with one or more of the *Pratylenchus* species. Populations potentially limit yield in at least 40% of these infested paddocks.

Yield losses in broadacre cropping caused by *P. quasitereoides* or *P. penetrans* are a problem specific to WA. Research is under way to learn more about these species and the rotations that will limit their population below damaging levels in cropping soils. More than one RLN species can be found in the roots of an individual crop, although one species usually dominates.

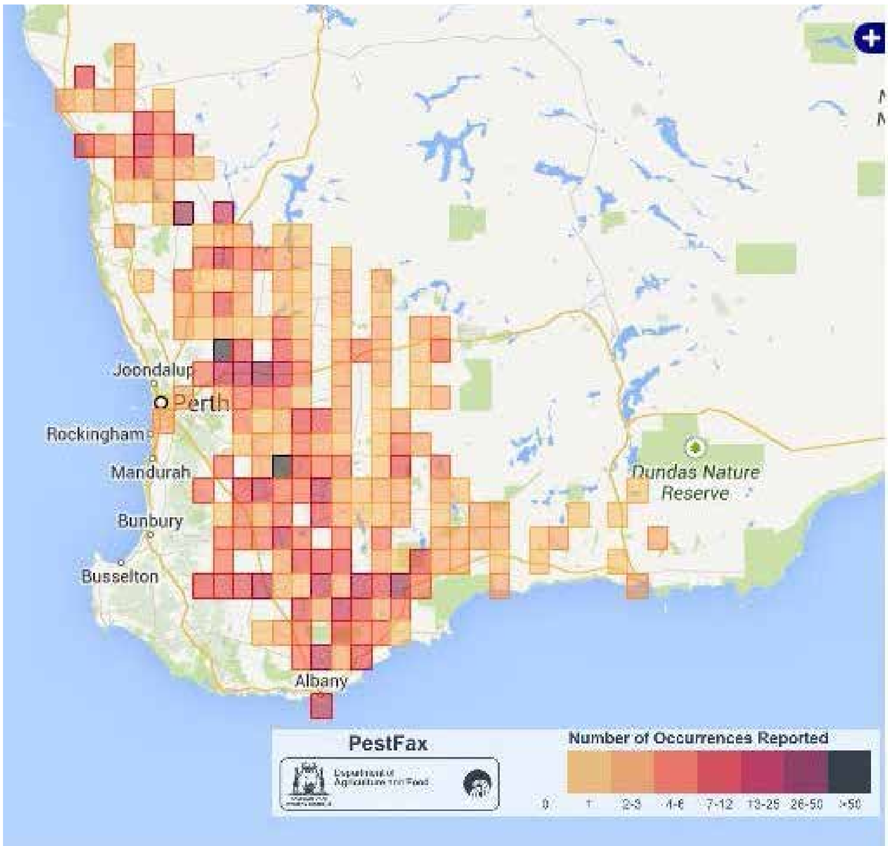

Figure 2: *Positive detection of root-lesion nematodes in Western Australia's broadacre cropping region between 1997 and 2013.*

Source: DAFWA

8 GRDC (2013) *Pratylenchus teres* WA's home grown Root Lesion Nematode. GRDC Update Papers, 12 March 2013, https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2013/03/Pratylenchus-teres-WAs-home-grown-Root-Lesion-Nematode

DAFWA has conducted research for nearly 20 years into the distribution, host range among crop species, variety resistance within crop species, and yield impacts of RLN on crops, including research trials, surveys and Agwest Plant Laboratory diagnostic samples.

During this time, 486 varieties across a wide range of crops have been assessed for resistance to the four main RLN species. [9]

Updated ratings

Recent studies sampling 765 paddocks in the 2014–15 seasons showed at least 50% of infested paddocks had RLN at potentially yield limiting levels. *P. neglectus* was the most frequent RLN, occurring in at least 63% of infested paddocks. P. *quasitereoides* was the next most common RLN at around 26% of infected paddocks surveyed. Cereal yield losses due to RLN are seasonally dependent and are in the order of 5–30%, but can be higher. RLN species *P. neglectus* and *P. quasitereoides* can cause losses of up to 18% in barley crops.

The actual yield loss due to RLN in different barley varieties is not yet quantified, but the impact of different varieties on nematode populations varies. The *P. neglectus* and *P. quasitereoides* nematode resistance scores have been updated since the last sowing guide to reflect WA only based observations. The ratings are based on glasshouse trials 2009–14 for both RLN species plus field trials in 2014–15 for *P. quasitereoides* (3 trials) and 2015 for *P. neglectus* (3 trials). [10]

MORE INFORMATION

DAFWA (2016) 2017 Barley variety sowing guide for Western Australia.

8.2 Varietal resistance or tolerance

Resistance and susceptibility of crops can differ for each RLN species. A resistant crop does not allow RLN to reproduce and increase in number (the opposite is susceptibility). [11] Tolerant varieties grow and yield well when RLN are present.

For example, field peas, lupins and faba beans are resistant to *P. neglectus* but susceptible to *P. penetrans*; barley may be more susceptible to *P. quasitereoides* than to *P. neglectus*; and canola is more susceptible to *P. neglectus* than to *P. thornei.*

Although there is no truly resistant variety of wheat, barley or oats, sufficient variation exists for susceptibility that variety selection in rotations can be a useful tool in managing the impact of RLN.

Pastures vary in their susceptibility to RLN, and under some pasture species, nematode levels could increase and become damaging to subsequent cereals. Pastures should therefore be monitored for RLN, and their place in the rotation should be considered for RLN management.

In glasshouse trials, French and yellow serradella, lotus and sulla varieties were resistant to *P. neglectus*, whereas clovers and medics were more susceptible (Table 2). Serradella has also been used successfully to reduce *P. quasitereoides* to manageable levels in a paddock with a history of high nematode densities.

Intensive cropping of susceptible crops, particularly wheat, will lead to an increase in nematode levels. Rotations are the key to limiting nematode multiplication and reducing future crop damage. [12]

9 GRDC (2015) Tips and Tactics: Root-Lesion Nematodes, Western Region, Fact sheet, http://www.grdc.com.au/TT-RootLesionNematodes

10 DAFWA (2016) 2017 Barley variety sowing guide for Western Australia. Department of Agriculture and Food, Western Australia, https://www.agric.wa.gov.au/sites/gateway/files/Barley%20variety%20sowing%20guide%20for%20Western%20Australia%202017%20web%20version.pdf

11 KJ Owen, J Sheedy, N Seymour (2013) Root lesion nematode in Queensland. Soil Quality Pty Ltd. Fact sheet, http://www.soilquality.org.au/factsheets/root-lesion-nematode-in-queensland

12 GRDC (2015) Tips and Tactics: Root-Lesion Nematodes, Western Region, Fact sheet, http://www.grdc.com.au/TT-RootLesionNematodes

Table 2: *Resistance of pasture species to Pratylenchus neglectus*

Cultivar	Species	Resistance rating
Tanjil lupin	*Lupinus angustifolius*	R
Charano yellow serradella	*Ornithopus compressus*	R
Flamenco sulla	*Hedysarum coronarium*	R
Yelbini yellow serradella	*Ornithopus compressus*	R
Margurita French serradella	*Ornithopus sativus*	R
Cadiz French serradella	*Ornithopus sativus*	MR
Santorini yellow serradella	*Ornithopus compressus*	MR
Erica French serradella	*Ornithopus sativus*	MR
Hykon rose clover	*Trifolium hirtum*	MS
Electra purple clover	*Trifolium purpureum*	MS
Sceptre lucerne	*Medicago sativa*	MS
Mauro biserrula	*Biserrula pelecinus*	S
Casbah biserrula	*Biserrula pelecinus*	S
Caprera crimson clover	*Trifolium incarnatum*	S
Cefalu arrowleaf clover	*Trifolium vesiculosum*	S
Sothis eastern star clover	*Trifolium dasyurum*	S
CFD27 bladder clover	*Trifolium spumosum*	S
2002ESP4 biserrula	*Biserrula pelecinus*	S
Coolamon subterranean clover	*Trifolium subterraneum*	S
Machete wheat	*Triticum aestivum*	S
Nitro Plus Persian clover	*Trifolium resupinatum*	S
Frontier balansa clover	*Trifolium michelianum*	S
Dalkeith subterranean clover	*Trifolium subterraneum*	S
Caliph barrel medic	*Medicago truncatula*	S
Urana subterranean clover	*Trifolium subterraneum*	S
Santiago burr medic	*Medicago polymorpha*	VS
Prima gland clover	*Trifolium glanduliferum*	VS

Note: Information for P. quasitereoides and P. penetrans is based on samples received by Agwest Plant Laboratories for diagnosis, combined with data from preliminary field and glasshouse trials.

Legend: R - Resistant, MR - moderately resistant, MS - moderately susceptible, S - susceptible, VS - very susceptible

Source: GRDC

8.3 Management of nematodes

The most important management tool is using rotations that effectively reduce RLN populations (Figure 3). In heavily infested paddocks, resistant break-crops should be grown for 1 or 2 years to decrease the population. Resistant varieties should be selected for the following years using the WA Crop Variety Guide.

Management of RLN in winter crops includes:

- Observation and monitoring of above- and below-ground symptoms of plant disease followed by diagnosis of the cause(s) of any root disease. Although little can be done during the current cropping season to ameliorate nematode

MORE INFORMATION

To hear Dr Sarah Collins, DAFWA discuss root lesion nematodes at the GRDC Agribusiness Crop Updates in 2014, visit https://www.youtube. com/ watch?v=XjtdPy7f0ks

symptoms, the information will be crucial in planning effective rotations of crop species and varieties in following seasons
- Well-managed rotations with resistant or non-host break-crops are vital. To limit RLN populations, avoid consecutive host crops (Table 1)
- Use the DAFWA Crop Variety Guide to choose varieties with high resistance ratings. These will result in fewer nematodes remaining in the soil to infect subsequent crops
- Healthy soils and good nutrition can partly alleviate RLN damage through good crop establishment, and healthier plants may recover more readily from infestation under more suitable growing conditions
- Observe crop roots to monitor development of symptoms
- Weeds can host parasitic nematodes within and between cropping sequences, so choice of pasture species and control of host weed species and crop volunteers is important (Table 1) [13]

Adequate nutrition (especially N, P and Zn) help crops to compensate for the loss of root function caused by RLN, although this does not necessarily lead to lower nematode reproduction. In field trials in areas infested with *P. neglectus*, yield losses for intolerant wheat ranged from 12% to 33% when minimal levels of P were applied, but losses were reduced to only 5% with a high rate of P (50 kg/ha).

Weeds can play an important role in the increase or persistence of nematodes in cropping soils. Thus, poor control of susceptible weeds compromises the use of crop rotations for RLN management.

Wild oats, barley grass, brome grass and wild radish are susceptible to *P. neglectus*.

Several pasture species and varieties are suitable in rotations to reduce RLN when targeted to the species present, but weeds must be managed because they can strongly influence nematode populations at the end of the pasture phase.

Manage volunteer susceptible crop plants, because they can harbour nematodes.

Nematodes cannot move great distances unaided. However, they can be spread through surface water and in soil adhering to vehicles and farm machinery. In uninfested areas, good hygiene should be practised. They can also be spread in dust when they are dehydrated over summer. [14]

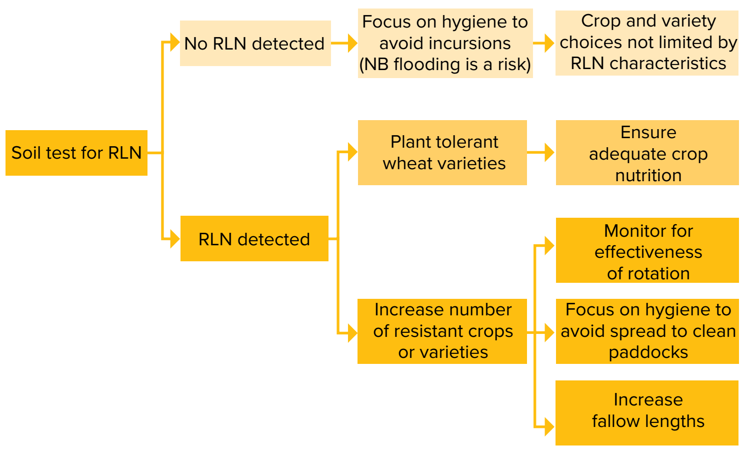

Figure 3: *Root-lesion nematode management flowchart.*

Source: GRDC

13 GRDC (2015) Tips and Tactics: Root-Lesion Nematodes, Western Region, Fact sheet, http://www.grdc.com.au/TT-RootLesionNematodes

14 GRDC (2015) Tips and Tactics: Root-Lesion Nematodes, Western Region, Fact sheet, http://www.grdc.com.au/TT-RootLesionNematodes

8.4 Testing for root-lesion nematodes

Two types of test are available for diagnosing nematode infestations:

- Growing season tests can be carried out on affected plants and associated soil. Live nematodes are extracted, counted and identified in the laboratory
- Soil and root testing can be used to define the problem and determine the species of nematode present within and outside of the growing season. Instructions for submitting representative plant and soil samples can be found online at DDLS–Plant pathology services [15]

Growers are advised to check the roots of the host crops if they suspect RLN infestations.

Suspect plants should be dug from the ground with a shovel, not pulled from the ground - this will leave most of the diseased roots behind. The roots must be carefully washed to remove the soil. They can then be inspected for disease by floating them in a white tray containing water, and looking for symptoms of nematode damage.

If evidence of infestation in the roots is observed, then a laboratory analysis or a PreDicta B™ test can be used to determine species and density.

The DNA-based soil testing service PreDicta B™, provided by SARDI Diagnostic Services, can detect *P. neglectus, P. thornei* and *P. quasitereoides*. [16]

However, this test does not identify *P. quasitereoides* (common in barley) and *P. penetrans*. Growers are advised to contact their local DAFWA office for advice.

Plant pathology services can assist with diagnosis. To obtain submission forms and full sampling instructions contact your local DAFWA office or find information online on the DAFWA website at DDLS–Plant pathology services or you can contact the labs by phone on +61 (0)8 9368 3721. [17]

15 DAFWA (2016) Diagnosing root lesion nematode in cereals. Department of Agriculture and Food, Western Australia, https://agric.wa.gov.au/n/2166

16 GRDC (2015) Tips and Tactics: Root-Lesion Nematodes, Western Region, Fact sheet, http://www.grdc.com.au/TT-RootLesionNematodes

17 DAFWA (2016) Diagnosing root lesion nematode in cereals. Department of Agriculture and Food, Western Australia, https://agric.wa.gov.au/n/2166