RLN UPDATE – WESTERN
FACT SHEET

GRDC
GRAINS RESEARCH & DEVELOPMENT CORPORATION

WESTERN
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Strategies to reduce yield losses caused by root lesion nematodes (RLN)

KEY POINTS

- RLN are found in approximately 6.25 million hectares (or 80 per cent) of the WA winter broadacre cropping area. Populations potentially limit yield in at least half of these infested paddocks
- The main RLN species found in WA broadacre cropping are *Pratylenchus neglectus, P. quasitereoides* (formerly known as *P. teres*), *P. thornei* and *P. penetrans*
- The host range of RLN is broad and includes cereals, oilseeds, grain legumes and pastures, as well as many broadleaf and grass weeds
- A soil test prior to sowing can identify the number of RLN species present in a paddock and thereby inform crop and variety choice. In-crop soil testing can be used to identify the cause of crop symptoms
- Crop rotations using resistant crops/varieties or pasture species are recommended to reduce RLN population densities and minimise yield losses in subsequent crops
- Western region barley and wheat variety guides give *P. neglectus* and *P. quasitereoides* resistance ratings for commonly grown varieties

FIGURE 1: Patchy, chlorotic growth caused by RLN infestation in a cereal crop.

Introduction

Root lesion nematodes (RLN) are microscopic, worm-like organisms that feed on and damage plant roots, thus affecting crop yield. In the western region, RLN are often associated with patchy, unthrifty cereal crops. The key to managing them is to identify paddocks with yield-limiting numbers present, then incorporate resistant crops and varieties into rotations to reduce their number (see Box 1).

Symptoms

Like many soil-borne diseases, RLN can be difficult to identify visually in a crop so laboratory testing or a PREDICTA® B soil test may be required.

Figure 1 shows above-ground symptoms of RLN in cereals, which can include:

- patchy, uneven crops;
- early wilting, particularly if crops become water stressed;
- yellowing leaves;
- poor tillering and reduced biomass;
- stunting; and
- increased weed burden.

However, these symptoms are similar to other root diseases or nutrient constraints, so plant roots need to be examined for symptoms of nematode damage.

To inspect root systems for disease, plants should be carefully dug up using a spade, not pulled up, so that the root system is maintained, intact, as diseased roots can break and remain in the soil. Carefully wash the roots to remove soil then float them in a white tray of water to observe symptoms of root damage. To make it easier to identify damage, compare the roots of plants growing in a healthy-looking crop with those of an unhealthy crop.

In cereals, nematode-damaged primary and secondary roots will show a general browning and discolouration and there will be fewer, shorter lateral roots branching from the main roots (Figure 2). The root cortex (or outer root layer) may be damaged and may disintegrate when the roots are washed. Root symptoms may look similar to those caused by Rhizoctonia root rot, however, RLN do not cause spear tipping (Figure 3A).

Canola roots may also show symptoms similar to cereals (Figure 3B). Chickpea roots can show distinct dark brown-orange lesions at early stages of infection and the lateral roots can be severely stunted and reduced in number (Figure 3C).

Diagnosis in any crop is difficult as roots can be infested without showing symptoms, so infestation can only be confirmed with laboratory testing. Such testing also identifies the species of RLN, which is crucial as management differs between RLN species. Plant and soil samples can be sent to DPIRD Diseases Diagnostic Laboratory Services (DDLS) – Plant Pathology. The PREDICTA® B soil test (SARDI Diagnostic Services) also tests for nematode number and species and other soil-borne pathogens and is available through accredited agronomists (Box 2: Testing for RLN).

Distribution

All broadacre growing regions in WA are affected by RLN and at least 80 per cent of cropping paddocks are infested with one or more of species of *Pratylenchus*. *P. neglectus* is the dominant RLN species identified in 70 per cent of tested paddocks, followed by *P. quasitereoides* (29 per cent) and *P. thornei* (five per cent: see Table 1). The Sandplain, Central and Eastern zones have the highest incidence of *P. neglectus*, while the Sandplain and Central zones have the highest incidence of *P. quasitereoides*. *P. penetrans* is not often found in broadacre crops but can cause severe damage where present. More than one RLN species is often found in the roots of an individual crop, making management more challenging, but one species usually dominates.

FIGURE 2: Relatively healthy wheat plant on the left with numerous tillers and lateral roots compared with a heavily infested plant on the right. Root system on left where low infestation has more lateral roots and few lesions compared to the highly infested (104 RLN / g soil) roots on the right.

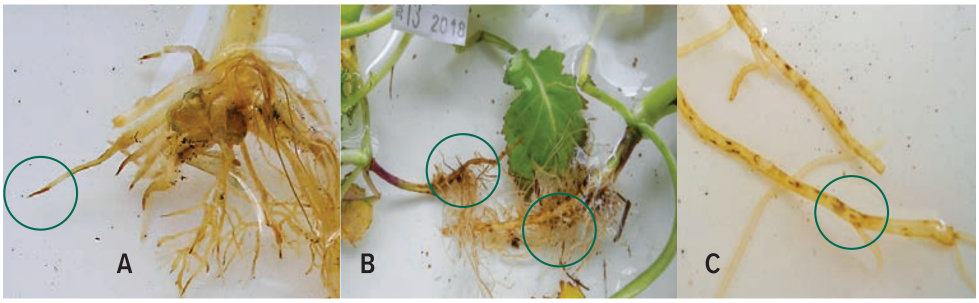

FIGURE 3: A. Root symptoms of Rhizoctonia root rot, which causes distinctive 'spear tipping' of roots whilst RLN causes general browning (Figure 2). B. Symptoms of *P. penetrans* in young canola plants. C. Chickpea roots showing distinctive orange-brown lesions due to infection with *P. neglectus*.

Economic importance

A recent study estimated average annual losses of $72 million in wheat alone due to RLN across WA, with losses of $160 million possible during seasons favourable for nematode damage. Wheat yield losses from RLN across the whole western region are generally 2.5 per cent, but losses in individual paddocks can be greater than 10 per cent where nematode numbers are high.

Yield loss

The extent of losses from RLN is related to their number in the paddock at planting (Table 2 and Figure 4). Therefore, the first step in managing RLN is to identify those paddocks with a yield-limiting number of nematodes by taking a soil test prior to planting (Box 2: Testing for RLN).

BOX 1: RESISTANCE AND SUSCEPTIBILITY DEFINITION

Resistant or non-host crops/varieties will reduce nematode numbers during the season. These crops are good options for growers wanting to reduce nematode numbers and yield loss in a subsequent crop.

Susceptible crops increase nematode numbers during the season. These increases in nematode numbers can result in higher yield losses in a subsequent crops.

Resistance ratings are published in annual wheat and barley variety guides (see 'Useful resources') or NVT Online (www.nvtonline.com).

Table 1: Incidence (% of paddock infected) of *P. neglectus* (Pn), *P. quasitereoides* (Pq) and *P. thornei* (Pt), and total incidence of *P. spp.* (any) in WA agro-ecological zones.

Zone/region	Incidence (%)			Mean density (RLN/g soil)		
	Pn	Pq	Pt	Pn	Pq	Pt
WA Sandplain	70	15	2	2.6	0.3	0.5
WA Central	76	52	6	6.6	3.1	0.7
WA Northern	51	4	5	5.0	0.1	0.2
WA Eastern	77	4	4	3.7	0.2	0.1
Western region	**71[w]**	**29[w]**	**5[w]**			

[w]: Weighted average, weighted by area sown in each zone

TABLE 2: Densities of root lesion nematodes (number / g soil) for each of four risk categories in the western GRDC region for seasons that range in their conduciveness for wheat yield loss in intolerant cultivars

	Wheat yield loss %				
	Nematodes/g of soil		Seasonal conditions and frequency[A]		
			Conducive	Intermediate	Non-conducive
	Pratylenchus neglectus	*Pratylenchus quasitereoides*	40%	30%	30%
BDL[B]	<0.1	<0.1	0	0	0
Low	0.1-5	0.1-9	0–5	0–2	0
Medium	6-25	10-35	5–20	2–10	0
High	>25	>35	20–40	10–20	0

[A] Conducive and non-conducive seasons are those where wheat yield loss does and does not occur respectively due to the nematodes. The historical frequency of these occurrences are provided. The conditions that favour yield loss are not understood

[B] BDL: below detection level

The relationship between pre-planting nematode number (based on a PREDICTA® B soil test result) and likely loss in wheat grain yield in a range of seasons is shown in Table 2. This table shows that the extent of wheat yield loss for a given number of nematodes varies based on (a) RLN species; (b) how conducive the season is to nematode damage; and (c) the frequency of the seasonal occurrences. For example, a test result of 15 *P. neglectus* per gram of soil will cause a yield loss in wheat of about 13 per cent in four out of 10 seasons and six per cent in three out of 10 years. However, if there are multiple soil pathogens in a paddock, yield loss may be greater.

Management

Observation and monitoring of above and below ground symptoms, followed by diagnosis of the cause(s) of any root disease, is the first step in implementing effective management. Although little can be done in-crop to minimise nematode damage, identifying the problem allows for planning of effective rotations in subsequent seasons.

The most important management tool is the use of rotations that effectively reduce RLN populations (see Figure 5). In heavily infested paddocks, resistant break crops should be grown for one or two years to decrease the population. Use a current crop variety guide (see 'Useful resources' page 6).

RLN have a wide host range which includes the most commonly grown broadacre crops (Figure 5). For example, field peas, lupins and faba beans are resistant to *P. neglectus* but susceptible to *P. penetrans*; barley is more susceptible to *P. quasitereoides* than to *P. neglectus*; and canola is susceptible to *P. neglectus, P. quasitereoides* and *P. penetrans.*

Several pasture species and varieties can be used in rotations to reduce RLN (Table 3), but weeds must be

BOX 2: TESTING FOR RLN

ON-FARM

If RLN infestation is suspected, growers are advised to check the crop roots. Carefully digging up and washing the soil from the roots of an infected plant can reveal evidence of infestation in the roots, which warrants laboratory analysis.

TESTING SERVICES

In-crop diagnosis is best achieved by sending samples of affected plants to your local plant pathology laboratory. Testing services are available at Disease Diagnostic Laboratory Services (DDLS) – Plant Pathology services at the DPIRD, South Perth (www.agric.wa.gov.au/bacteria/ddls-plant-pathology-services).
Growers are advised to contact their local DPIRD office or agronomist for advice on how to sample or watch the DPIRD YouTube clip (www.youtube.com/watch?v=_hqjXWEkByg).

A DNA-based soil-testing service, PREDICTA® B, is commercially available throughout Australia and growers can contact an accredited consultant or the plant pathology section of the local state department of agriculture for advice. In the PREDICTA® B test, a soil corer is used to sample randomly across a paddock to provide a yield risk rating for the whole paddock. The inclusion of plant material is crucial to get accurate results as the test provides risk ratings for multiple soil and stubble-borne diseases. For further information see the PREDICTA® B website (http://pir.sa.gov.au/research/services/molecular_diagnostics/predicta_b).

FURTHER INFORMATION

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managed because they can strongly influence nematode populations at the end of the pasture phase.

Pastures vary in their susceptibility to RLN, and under some pasture species, nematode levels may increase and become damaging to subsequent crops. Pastures should therefore be monitored for RLN, and their place in the rotation be considered for RLN management. In glasshouse trials, French and yellow serradella and sulla varieties were resistant to *P. neglectus*, whereas some clovers and medics were more susceptible (Table 3). Serradella has also significantly reduced *P. quasitereoides* in paddocks with high RLN densities.

Healthy soils and good nutrition can partly alleviate RLN damage by supporting good crop establishment and healthier plants that are better able to cope with infestation. Adequate nutrition helps crops to compensate for the loss of root function caused by RLN, although this does not necessarily lower nematode reproduction.

Applying lime to acidic paddocks (at least 2.5 tonnes per hectare) has been shown to reduce *P. quasitereoides* multiplication in wheat and barley.

Weeds can play an important role in the increase or persistence of nematodes in cropping soils. Control of summer and winter weeds and volunteers is therefore an important consideration for RLN management. Clover, wild oats, barley grass, brome grass and wild radish are susceptible to *P. neglectus*.

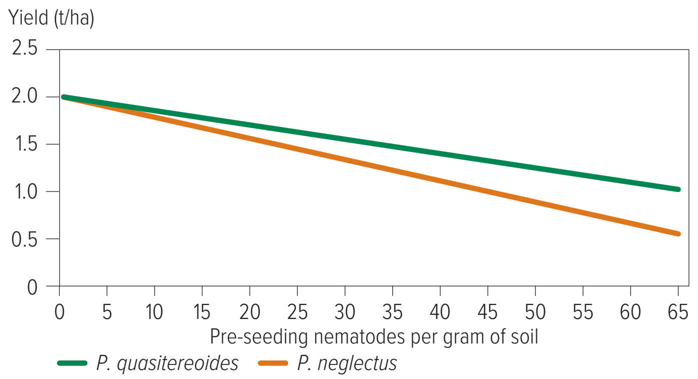

FIGURE 4: The effect of increasing numbers of RLN (*P. neglectus* and *P. quasitereoides*) on the grain yield of wheat in a season conducive to yield loss in the western region.

Table 3: *P. neglectus* resistance profiles for pasture species from DPIRD glasshouse experiments

Crop type	Variety	Resistance
Serradella	Cadiz	R
Serradella	Margurita	R
Serradella	Santorini	R
Biserrulla	Casbah	R
Lupin	Jenabillup	R
Eastern star clover	Sothis	MR
Subterranean clover	Dalkeith	MS
Arrow-leaf clover	Cefalu	S
Balansa clover	Frontier	S
Persian clover	Nitro Plus	SVS
Gland clover	Prima	SVS

R = resistant, MR = moderately resistant, MS = moderately susceptible, S = susceptible, SVS = susceptible to very susceptible.

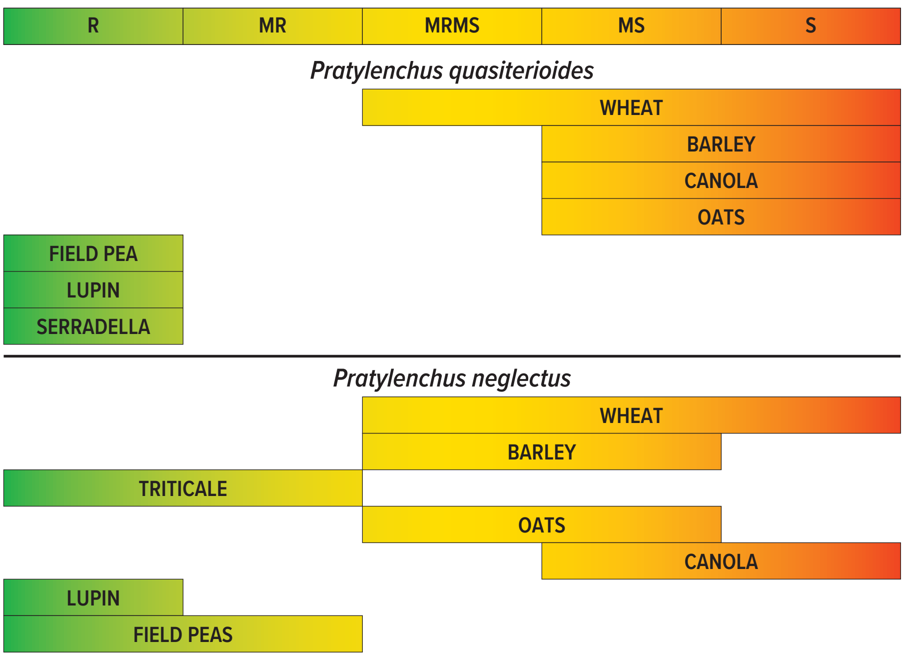

FIGURE 5: Comparison of the resistance of a range of cereals, oilseeds and pulses to RLN (*P. quasiterioides* and *P. neglectus*). In some crops, hosting ability varies between varieties and this is indicated where a range of risk ratings are shown. Therefore, it is important to check a current crop variety guide from your state department of agriculture or NVT Online for current information. New varieties may differ in their risk ratings from the overall rating for a crop species.

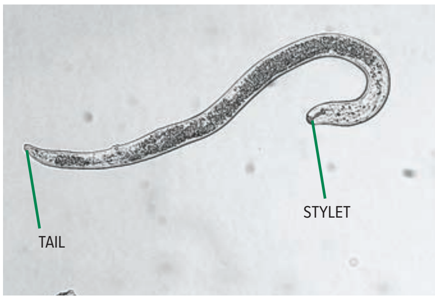

FIGURE 6: Mature RLN, less than 1mm long, as viewed under the microscope. Notice the syringe-like stylet at the head end, which is used to penetrate plant roots and extract nutrients.

Good farm hygiene will reduce the risk of introducing nematodes to uninfested soil as nematodes are unable to move great distances unaided.

Biology

RLN are microscopic, worm-like organisms less than one millimetre in length, which feed inside plant roots. They cannot be seen with the naked eye (Figure 6). They are migratory endoparasitic nematodes, meaning that they live in the roots but can migrate freely between roots and soil if the soil is moist. As plant roots and soil dry out in late spring, RLN enter a dehydrated state called anhydrobiosis and can survive high soil temperatures of up to 40°C and desiccation over summer. RLN can survive for years in this dehydrated state if the soil remains dry. The life cycle of RLN resumes after the rain in autumn wets the soil with juvenile and adult nematodes rehydrating to become active and invade plant roots, where they feed and multiply as they move through the root (Figure 7).

As the nematodes feed on root cells and reproduce in the roots, they damange cells causing brown lesions to form in the root cortex and lateral roots decline in number.

Eggs are laid within the root or soil, with the first larval stage and moult occurring within the egg. Second-stage larvae emerge from eggs and undergo three more moults before reaching adulthood. They develop from egg to adult in 40 to 45 days (approximately six weeks) depending on soil temperature and host (Figure 7).

There may be three or four RLN cycles within the plant each growing season, depending on soil temperature and moisture and length of the growing season. Multiplication is slow during winter when soil temperatures are cooler and, while it varies between species, optimum soil temperature is warm and soils are moist. Under these conditions, one life cycle is generally completed in six weeks.

When roots are damaged by RLN, the plants become less efficient at taking up water and nutrients, and less able to tolerate stresses such as drought or nutrient deficiencies or other soil-borne diseases. 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.

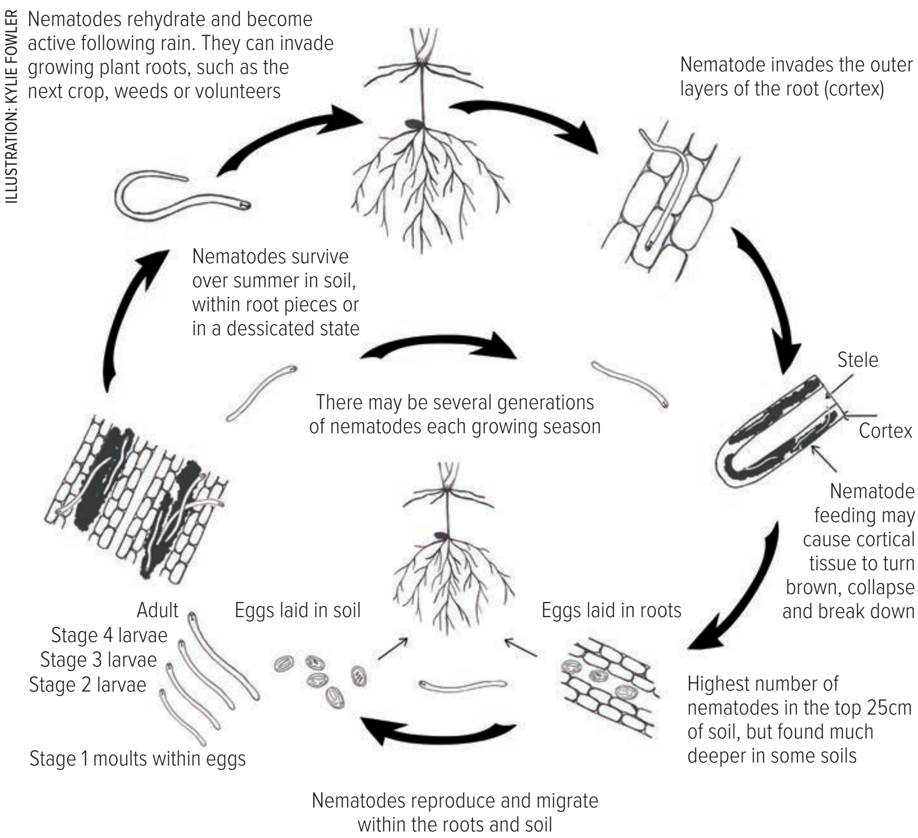

FIGURE 7: Disease cycle of Root Lesion Nematode, adapted from GN Agrios (1997) *Plant Pathology*, 5th edn (Academic Press: New York).

BOX 3: ROTATIONS FOR THE CONTROL OF RLN – AN EXAMPLE

A grower who has been growing a wheat canola rotation for the past eight years has noticed a gradual decline in yield in his wheat crops despite using soil nutrition testing to develop management plans. A subsequent PREDICTA® B test of the paddock revealed a high number of *P. quasitereoides* in the soil (38/g of soil). No other root diseases were detected at yield-limiting levels. At this level they could be losing up to 20 per cent yield in a conducive season due to *P. quasitereoides* and it may explain the gradual loss in yield as nematode numbers have increased over time.

To reduce future yield loss, the grower can choose to grow resistant crops. This includes crops such as lupins, field peas and some pastures.

By adding a lupin or field pea crop into the wheat canola rotation, nematode numbers may not reduce significantly overall as there are still two susceptible crops grown in close rotation. Alternatively, the grower could choose to put a serradella pasture in for two years to significantly reduce the nematode population.

FREQUENTLY ASKED QUESTIONS

Can I use a chemical to control RLN?

There are no economically viable chemical options available for the control of RLN in broadacre cropping.

Does timing of sowing help?

Trials in northern and southern Australia have shown that later-sown wheat crops can be more severely affected than those sown early in the cropping program, so where high nematode numbers are present these paddocks should be sown early.

What other plant-parasitic nematode species are found in the western region?

Cereal cyst nematode (CCN; *Heterodera avenae*) is a damaging pathogen of broadacre cereal crops that occurs in some parts of Western Australia. It affects wheat, barley, oats and triticale, and can cause yield losses of up to 80 per cent. The damage caused by the feeding nematode results in a proliferation of roots at the feeding site, forming a knot in the root and giving the plant symptoms characteristic of CCN. CCN has been successfully managed by growing resistant cereal varieties. See the CCN fact sheet for more information (https://grdc.com.au/TT-cereal-cyst-nematode).

Burrowing nematode (*Rhadopholus nativus*) is found throughout the broadacre growing region. It can reach high populations and cause yield loss in wheat and barley. It can also survive on rotation crops. Paddock and root symptoms are similar to those caused by RLN. This nematode species is not detected by PREDICTA® B but can be detected by testing services such as DDLS (Box 2: Testing for RLN). More information on burrowing nematode and its management is available on the DPIRD website (https://agric.wa.gov.au/n/2273).

USEFUL RESOURCES

In-season tests can be conducted on affected plants and the associated soil. Contact your state department of agriculture for testing laboratories in WA (08 9368 3721 or ddls@dpird.wa.gov.au). Sample forms and information can be found at www.agric.wa.gov.au/bacteria/ddls-plant-pathology-services

PREDICTA® B – soil analysis service delivered by accredited agronomists. PREDICTA® B can detect *P. neglectus, P. quasitereoides, P. thornei, P. penetrans* and cereal cyst nematode. Contact your local agronomist, or to locate your nearest supplier, email your contact details and location to russell.burns@sa.gov.au or nigel.percy@sa.gov.au

DPIRD Bulletins: www.agric.wa.gov.au

For variety ratings, see state department crop variety and disease guides published annually:

- state department cereal disease guides (https://extensionaus.com.au/field-crop-diseases/cereal-disease-guides)
- NVT crop variety guides (https://grdc.com.au/resources-and-publications/all-publications/crop-variety-guides)

MORE INFORMATION

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