The key to managing root-lesion nematode (RLN) is to incorporate resistant crops and varieties into rotations.

**KEY POINTS**

- Root-lesion nematodes are species of *Pratylenchus* nematodes that feed on the roots of crops and can cause yield loss.
- The main RLN species in the Southern Region are *Pratylenchus neglectus* and *P. thornei*.
- The *Pratylenchus* species present in the soil will affect choice of management practices, in particular rotations.
- A PreDicta B test (SARDI Diagnostic Services) prior to sowing can identify the number and species of nematodes present in the soil, and therefore inform management practices.
- RLN have a wide host range and can multiply on cereals, oilseeds, pulses and pastures as well as on broadleaf and grass weeds.
- Crop rotations using resistant crops are recommended to reduce RLN density to below threshold levels.
- Reducing RLN densities can lead to higher yields in subsequent cereal crops.

**Management of RLN**

- In the Southern Region, *Pratylenchus thornei* at 10 nematodes/g soil can cause grain yield losses of 10–15% in the intolerant wheat variety Derrimut, depending on seasonal conditions.
- Manage RLN by maintaining nematode numbers below threshold levels by growing resistant crops and varieties.
- A PreDicta B test will determine nematode numbers in a paddock prior to sowing. This test also identifies the species present, thereby assisting management decisions.
- In heavily infested paddocks, resistant crops or varieties should be grown for 1 or 2 years to decrease RLN populations (Table 1).
- 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 NVT Online for resistance and tolerance ratings.
- Resistant varieties will result in fewer nematodes remaining in the soil to infect subsequent crops.
- Tolerant varieties are able to perform well in the presence of the nematode, but they may not reduce nematode densities.
- Intensive cropping of susceptible crops—particularly wheat and chickpeas—can lead to an increase in nematode populations and greater yield loss in subsequent crops.
- Weeds can play an important role in the increase and/or persistence of nematodes in crops and pastures (Table 1). Therefore, poor control of susceptible weeds will compromise the use of resistant crop rotations for RLN management.
- Healthier plants recover more readily from infestation. Providing adequate nutrition (especially nitrogen, phosphorus and zinc) will allow plants to better tolerate plant parasitic nematodes, although this does not lead to lower nematode reproduction.
- Nematodes cannot move large distances unaided. However, they can be spread by surface water, and in soil adhering to vehicles and farm machinery. In un-infested areas, good hygiene should be adopted. They can also be spread in dust when they are in a dehydrated state over summer.
Resistance and tolerance

Crop varieties are rated for resistance and tolerance to RLN. The mechanisms of resistance and tolerance are different and need to be treated as such. Resistance is the ability to reduce nematode populations in the soil. Tolerance is the ability of a crop or variety to perform well in the presence of the nematode. Resistance and tolerance are not mutually inclusive; a tolerant crop can be susceptible and an intolerant crop can be resistant.

About the root-lesion nematode

*Pratylenchus* nematodes are microscopic, worm-like organisms, less than 1 mm in length. They feed on and in root tissues using a syringe-like stylet to enter the roots and extract nutrients.

Many species of RLN are found in Australia. In South Australia and Victoria, the main species are *P. neglectus* and *P. thornei*; however, *P. penetrans* and *P. crenatus* have also been reported, albeit at a very low frequency.

Species identification is important for effective RLN management. Some crops, varieties and plant types have different levels of resistance to different species of the *Pratylenchus* family. For example, canola is more susceptible to *P. neglectus* than *P. thornei*, whereas vetch is more susceptible to *P. thornei* than *P. neglectus* (Table 1). Likewise, some wheat varieties with resistance to one species can be resistant.

---

### Table 1: Comparison of the hosting ability of a range of cereal, pulse and weeds to root-lesion nematodes *Pratylenchus thornei* and *P. neglectus*

In some crops, hosting ability varies between varieties, and this is indicated where a range of risk ratings is shown. Therefore, it is important to check a current [Crop Variety Guide](#) from your state department of agriculture or [NVT Online](#) for resistance and tolerance ratings. Within some crops there is variation in the susceptibility and resistance of varieties, and this is indicated where a range of risk ratings is shown. New varieties or hybrids may differ in their risk ratings from the overall rating for a crop species. NT, Not tested; p, provisional rating.

<table>
<thead>
<tr>
<th>Plant</th>
<th><em>P. thornei</em></th>
<th><em>P. neglectus</em></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Crop</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Barley</td>
<td>Medium</td>
<td>Low to medium</td>
</tr>
<tr>
<td>Canola</td>
<td>Medium</td>
<td>High</td>
</tr>
<tr>
<td>Chickpeas</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Durum wheat</td>
<td>Low to medium</td>
<td>High</td>
</tr>
<tr>
<td>Faba beans</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Fenugreek</td>
<td>Low</td>
<td>NT</td>
</tr>
<tr>
<td>Field peas</td>
<td>Low</td>
<td>Medium</td>
</tr>
<tr>
<td>Lentil</td>
<td>Low to Medium</td>
<td>Medium</td>
</tr>
<tr>
<td>Lathyrus</td>
<td>Low to Medium</td>
<td>Low</td>
</tr>
<tr>
<td>Lentil</td>
<td>Low</td>
<td>Medium</td>
</tr>
<tr>
<td>Lupins</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Medic</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Narbon beans</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Oats</td>
<td>Low</td>
<td>Medium to high</td>
</tr>
<tr>
<td>Rye</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Safflower</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Triticale</td>
<td>Medium</td>
<td>Low</td>
</tr>
<tr>
<td>Vetch</td>
<td>High</td>
<td>Medium</td>
</tr>
<tr>
<td>Wheat</td>
<td>Low</td>
<td>Medium</td>
</tr>
<tr>
<td><strong>Weed</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Barley grass</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Brome grass</td>
<td>Medium</td>
<td>Medium</td>
</tr>
<tr>
<td>Silver grass</td>
<td>NT</td>
<td>Medium</td>
</tr>
<tr>
<td>Wild oats</td>
<td>Medium</td>
<td>High</td>
</tr>
<tr>
<td>Wild radish</td>
<td>NT</td>
<td>High</td>
</tr>
</tbody>
</table>

Low risk  Caution  High risk
more susceptible to the other. It is therefore important to consult a current Crop Variety Guide or NVT Online once the species of nematode present in a paddock has been determined.

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

Several studies have shown that the extent of yield loss attributed to *P. neglectus* or *P. thornei* is directly related to the population density at sowing. This density can be determined with a PreDicta B soil test prior to sowing.

Research is under way to learn more about RLN and the rotations that will decrease their populations in cropping soils.

**Life cycle**

Root-lesion nematodes are migratory plant parasites that 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 1).

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.

As plants and soil dry out in late spring, RLN enter a dehydrated survival state called anhydrobiosis. In this state, nematodes can survive high soil temperatures of up to 40°C and desiccation over summer. RLN can survive many years in this dehydrated state if the soil remains dry. Nematodes can also survive in root pieces.

More than one RLN species can be found in the roots of an individual crop, although one species usually dominates.

**Economic importance**

In the Southern Region, high densities of RLN generally cause yield losses of 10–20% in wheat crops. The extent of damage, and subsequent grain yield loss, depend on seasonal conditions, the tolerance of the crop and the numbers of nematodes present at sowing. 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 2). In general, the losses caused by RLN in southern Australia are less than those in northern Australia.

Aboveground symptoms

Damage caused by RLN is difficult to detect from aboveground symptoms, which are often indistinct and a poor diagnostic indicator. The first signs of RLN are poor emergence and establishment, which are followed by stunting, poor tillering in cereals and plants wilting despite moist soil (Figure 2). Nematodes are usually distributed unevenly across a paddock, resulting in irregular crop growth. Symptoms of RLN damage can be confused with, or exacerbated by, nutrient deficiencies.

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. 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.

Belowground symptoms

Because aboveground 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 (Figure 3). The root cortex (or outer root layer) will be damaged and it may disintegrate.

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 3).

Visual diagnosis is difficult and can be confirmed only with laboratory testing or by using a PreDicta B soil test.

Table 2: Grain yield loss (%) caused by root-lesion nematodes in Victoria and South Australia

<table>
<thead>
<tr>
<th></th>
<th>P. thornei</th>
<th></th>
<th>P. neglectus</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>South Australia</td>
<td>Victoria</td>
<td>South Australia</td>
</tr>
<tr>
<td>2011</td>
<td>7.7</td>
<td>12.2</td>
<td>No trial</td>
</tr>
<tr>
<td>2012</td>
<td>9.0</td>
<td>5.3</td>
<td>8.0</td>
</tr>
<tr>
<td>2013</td>
<td>No trial</td>
<td>2.4</td>
<td>3.8</td>
</tr>
</tbody>
</table>

Figure 2. Aboveground symptoms of root-lesion nematode are often indistinct and difficult to identify. Affected plants (centre) generally show poor vigour and are often stunted, and cereals tiller poorly.

Figure 3. Left: symptoms of root-lesion nematode on wheat roots include darkening of the cortex and lack of root hairs. Right: symptoms on chickpeas include lack of root hairs and lesions giving roots a flecked appearance.
Disease diagnosis predicts potential yield loss

Originally developed in 1997, PreDicta B® is a DNA-based soil-testing service that quantifies the levels of a broad range of fungal pathogens and nematodes that affect broadacre cereals and some rotation crops.

The impact of maternal caffeine, nicotine and other drugs on the development of baby sleep patterns may seem a world away from crop disease management, but agricultural scientist and recent ex-grower Shawn Rowe says he is looking forward to combining his diverse research and farming skills to extend the benefits of the PreDicta B® disease-identification service.

Comming from a mixed-cropping and cross-bred lamb property on the border of Victoria and South Australia, Mr Rowe completed an agricultural science degree majoring in animal science at the University of Adelaide.

He side-stepped into medical research to investigate the impact of drugs on neurotransmitters in newborns and then returned to manage the family farm.

"After 12 years of farming I am back in the city at the South Australian Research and Development Institute (SARDI) to tackle a new GRDC-funded project with the aim of extending the value of the PreDicta B® service to growers across Australia," Mr Rowe says.

Mr Rowe says PreDicta B® was developed because most decisions to reduce the disease impact of soil-borne pathogens have to be made before crops are sown.

"Identifying the main disease risks before sowing means growers can implement management practices such as fungicide seed dressings, crop rotations and modifying sowing techniques and timing to lower their risk of crop yield loss."

PreDicta B® can test for most of the soil-borne pathogens (including fungal and nematode) that growers need to be aware of including take-all, rhizoctonia, crown rot, blackspot of peas, cereal cyst nematode, stem nematode and root lesion nematode (Pratylenchus species).

Testing for root-lesion nematodes

On-farm

Growers are advised to check the roots of the host crops if they suspect RLN infestations. Carefully dig up roots, then wash the soil from the roots of an infected plant and inspect for symptoms (as above). 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.

Commercial

A DNA test, PreDicta B®, is commercially available around Australia and growers should contact their state department of agriculture for advice.

Grain producers can access PreDicta B via agronomists accredited by SARDI to interpret the results and provide advice on management options to reduce the risk of yield loss.

PreDicta B samples are processed weekly from February to mid May (prior to crops being sown) to assist with planning the cropping program.

Crop diagnosis is best achieved by sending samples of affected plants to your local plant pathology laboratory.

Postal Address for PreDicta B samples
C/- SARDI RDTS, Locked Bag 100
Glen Osmond SA 5064

Courier address
SARDI Molecular Diagnostics Group
Plant Research Centre, Gate 2B
Hartley Grove, URRBRAE SA 5064

Further information
Russell Burns
Technical Officer
Russell.burns@sa.gov.au
Mobile: 0401 122 115

Shawn Rowe
Senior Research Officer
shawn.rowe@sa.gov.au
Phone: 0477 744 305

Nigel Percy
Research Officer
nigel.percy@sa.gov.au
Phone: (08) 8303 9665

Alan McKay
alan.mckay@sa.gov.au
Phone: (08) 8303 9375

"Each test result comes with a risk category, based on trial work, that indicates the likely impact of the pathogen load on potential crop yield," Mr Rowe says.

Regional risk categories have been implemented for Pratylenchus and work is underway to develop regional risk categories for other pathogens. Further tests under development include Bipolaris (common root rot), Pythium root rot and additional Pratylenchus species.

"At the moment these diseases are only reported as levels as we are still establishing their risk ratings for potential yield losses."

The SARDI researchers are also developing tests for stubble-borne pathogens, including those associated with yellow leaf spot, eyespot and white grain.

See the full article in the Ground Cover Root and Crown Diseases Supplement at http://grdc.com.au/Media-Centre/Ground-Cover-Supplements/GCS111
GRDC Radio (Southern Update)

Each week GRDC brings you news and information that is timely and relevant to the Southern cropping region of Australia.

You can listen to GRDC Radio online if you wish, but they really come into their own as a podcast that you can listen to in a vehicle.

To subscribe to GRDC Radio, either search iTunes for “GRDC” and subscribe to your relevant region’s podcast, or enter http://www.grdc.com.au/SWUpodcast into your podcast player when prompted for a feed address.

If you plan to subscribe to GRDC Radio on your iPhone, iPad or iPod, your podcasts will appear in the new Podcasts app, available for free from the App Store.

To listen to GRDC Radio online without subscribing to the podcast, click the links below to listen to or download individual episodes.


Are all nematodes harmful to crops? Nematodes reveal soil health

Nematodes are emerging as the biological tool that will open the way to measure soil health; an on-going quandary for researchers and growers.

“Free living soil nematodes are abundant in all soils and play important roles in soil food webs,” said SARDI researcher Katherine Linsell. “Some free living nematodes feed only on bacteria, some feed only on fungi and others are omnivores and predators that feed on other nematodes.”

The cropping industry has historically focused on plant parasitic nematodes such as cereal cyst nematode and Pratylenchus because of the damage to crops.

“The abundance of a particular type of free living nematode reflects the number of soil microbes on which they feed,” Dr Linsell said. “The availability of these food sources determines the number and types of nematodes in the soil, so analysis of the nematode community provides information on the status of the soil food web.”

This well-defined response is overlaid on population differences due to basic soil conditions and rainfall regimes, Dr Linsell said.

“All soils have a base-line level of bacterial and fungifeeding nematodes present. Different nematodes are favoured by different soil types and annual rainfall, so different nematodes dominate in different regions.

“Nematode communities are also impacted by farming management practices such as tillage, fertiliser application and the adding or increasing of organic matter.

“If a soil becomes enriched by the addition of nutrients or some form of disturbance then bacterial-feeding nematodes increase rapidly. As a soil becomes better structured and more mature, larger predatory and omnivorous nematodes become more prevalent.

“Using this knowledge we have identified which types of nematodes are most common in different soil environments – till or no-till, high or low nutrition, high or low organic matter.”

Nematodes are easily extracted from the soil, readily identifiable and the various groups each have distinct and stable genetics, making it relatively easy to use DNA to identify the presence and prevalence, of particular nematode populations.

These attributes combined, make free-living nematode populations ideal candidates for the role of indicators of the biological status of soils – and are closely linked to ‘soil health’. Researchers working as part of the GRDC Soil Biology Initiative are developing DNA tests to measure the biological status of Australian cereal soils based on the presence and prevalence of the different types of nematodes.

The sensitive, quick and robust nematode DNA assays are currently available only to researchers, but will become available to growers through the PreDicta B soil diagnostic service once regional validation has been completed.

For more information: Katherine Linsell, 08 8303 9459, katherine.linsell@sa.gov.au

Getting to the root of the problem

A suite of new national GRDC programs has launched a fresh attack on root and crown diseases, which collectively cost Australian growers hundreds of millions of dollars in lost production and control costs each year. This Ground Cover Supplement reports on some of the activities from these national projects.
Frequently asked questions

Q. Why is my resistant cereal showing root-lesion nematode root damage?

Resistant cereals sown into a paddock with RLN will be attacked and penetrated at a similar rate to a susceptible variety, causing the same damage. However, resistant cereals act by suppressing the development of RLN in the root, so very few nematodes mature.

Q. Does timing of sowing help?

There is limited information on the effect of time of sowing on the yield loss of intolerant crops in the presence of RLN. Trials in northern and southern Australia have shown that later sown wheat crops can be more severely affected than those sown early.

Q. What other plant-parasitic nematode species are found in the Southern Region?

Pratylenchus penetrans and P. crenatus have been reported, but at a very low frequency; P. quasitetereoides (formerly known as P. teres) has been identified only in crops in Western Australia and is not known to occur in other regions of Australia. Other species of RLN may occur, and if this is suspected, you should follow up with your state department of agriculture.

Cereal cyst nematode (CCN; Heterodera avenae) is a damaging pathogen of broadacre cereal crops in South Australia and Victoria. It affects wheat, barley, oats and triticale, and can cause yield losses of up to 80%. The damage caused by the feeding nematode results in a proliferation of roots at the feeding site, which forms a knot in the root, giving the plant the characteristic symptoms. CCN has been successfully managed by growing resistant cereal varieties.

Stem nematode (Ditylenchus dipsaci). Two races of stem nematode have been recorded in South Australia: the oat and the lucerne race. The oat race is found in parts of Yorke Peninsula and the Mid North of South Australia. The main hosts are susceptible oat and faba bean varieties. Symptoms on oats include stunted plants and the bases of each tiller becoming swollen. Other crops such as field peas, chickpeas, canola and lentils are damaged extensively by stem nematode when they are seedlings (i.e. there is seedling intolerance). Symptoms include stunted and distorted leaves and stems. As crops mature, they become both resistant and tolerant.

Useful Resources

- Researchers:
  - Dr Grant Hollaway, DEDJTR, (DEPI), ph. 03 5362 2111, email grant.hollaway@ecodev.vic.gov.au
  - Dr Alan McKay, SARDI, ph. 08 8303 9375, email alan.mckay@sa.gov.au
  - Josh Fanning, (DEDJTR), (DEPI), ph. 03 5362 2111, email joshua.fanning@ecodev.vic.gov.au

- PreDicta B: a soil analysis service delivered by accredited agronomists. PreDicta B can detect P. neglectus, P. thornei and a range of soil-borne diseases. Contact your local agronomist, or to locate your nearest supplier, email your contact details and location to: predictab@saagov.sa.gov.au


- For variety ratings see state department crop variety and disease guides published annually:
  - Victorian Cereal Disease Guide (depi.vic.gov.au)
  - (economicdevelopment.vic.gov.au)
  - South Australian Cereal Disease Guide (sardi.sa.gov.au)
  - State Department Cereal Disease Guides (extensionaus.com.au)
  - National Variety Trials (NVT) Crop Guides (nvtonline.com.au)

Acknowledgements

Grant Hollaway and Joshua Fanning, Department of Economic Development, Jobs, Transport and Resources (DEDJTR) (formerly Department of Environment and Primary Industries); Alan McKay, Paul Bogacki and Katherine Linsell SARDI; Dr Vivien Vanstone (formerly of DAFWA); Kylie Fowler, illustrations.

Disclaimer

Any recommendations, suggestions or opinions contained in this publication do not necessarily represent the policy or views of the Grains Research and Development Corporation. No person should act on the basis of the contents of this publication without first obtaining specific, independent, professional advice.

The Corporation and contributors to this Tips and Tactics may identify products by proprietary or trade names to help readers identify particular types of products. We do not endorse or recommend the products of any manufacturer referred to. Other products may perform as well as or better than those specifically referred to.

The GRDC will not be liable for any loss, damage, cost or expense incurred or arising by reason of any person using or relying on the information in this publication.

CAUTION: RESEARCH ON UNREGISTERED PESTICIDE USE

Any research with unregistered pesticides or of unregistered products reported in this document does not constitute a recommendation for that particular use by the authors or the authors’ organisations.

All pesticide applications must accord with the currently registered label for that particular pesticide, crop, pest and region.

Copyright © All material published in this Tips and Tactics is copyright protected and may not be reproduced in any form without written permission from the GRDC.