SOUTHERN
SEPTEMBER 2018

GRDC GROWNOTES™

GRDC GRAINS RESEARCH & DEVELOPMENT CORPORATION

CHICKPEA

SECTION 8

NEMATODE MANAGEMENT

ROOT-LESION NEMATODE (RLN) | NEMATODES AND CROWN ROT

Nematode management

Key messages

- Nematodes are common soil pests that feed on the roots of a wide range of crop plants, irrespective of soil type and rainfall.
- Root-lesion nematodes (RLN) reduce development of lateral roots, which decreases the ability of plants to extract water and nutrients.
- *Pratylenchus neglectus* and *Pratylenchus thornei* (Pt) are the main root-lesion nematodes causing yield loss in the southern agricultural region of Australia.
- While it needs to be considered, RLN susceptibility does not necessarily preclude chickpea from crop rotations in southern Australia.
- There are consistent varietal differences in Pt resistance within chickpea varieties.
- Successful management relies on:
  - farm hygiene to keep fields free of RLN
  - soil testing to determine whether RLN are an issue and which species are present
  - growing tolerant varieties when RLN are present, to maximise yields
  - rotating with resistant crops to keep RLN at low levels.
- Nitrogen fertilisers, particularly those containing ammonium, have been found to limit nematode infection. RLN may adversely affect the growth and yield of the chickpeas in some cases, but has more effect on the following cereal crop. [1]

Nematodes are microscopic worms that are sometimes known as 'roundworms' or 'eelworms'. Those living in soil are generally small (less than 1 mm long and only 15–20 µm wide) and can only be seen with a microscope. Nematodes are common soil pests that feed on the roots of a wide range of crop plants in all agricultural areas of southern Australia, irrespective of soil type and rainfall. Nematodes multiply on susceptible hosts. Consequently, as nematode populations increase, crop production is limited. Damaged roots have less efficient water and nutrient uptake, and plants are also less able to tolerate other stresses such as drought. [2]

VIDEOS

1. GCTV6: Root-lesion nematodes.

8.1 Root-Lesion nematode (RLN)

Chickpea growers in southern Australia need to be aware of RLN and its impacts. It should not necessarily deter them from growing chickpea in their crop rotations. RLN can however be a major issue in northern Australian crops and rotations.

Key points:

- RLNs are species of *Pratylenchus* nematodes that feed on the roots of crops and can cause yield loss.
- The main RLN species causing damage in the Southern region are *Pratylenchus* neglectus and *P. thornei*.
- RLN reduce development of lateral roots, which decreases the ability of plants to extract water and nutrients.
- The *Pratylenchus* species present in the soil will affect choice of management practices, in particular rotations.
- The host range of RLN is broad and includes cereals, oilseeds, grain legumes and pastures, as well as many broadleaf and grass weeds. [3]

1 Pulse Australia (2007) Chickpeas in South Australia and Victoria. http://www.pulseaus.com.au/storage/app/media/crops/2007_Chickpeas-SA-Vic.pdf

2 S Collins (2016) Root lesion and burrowing nematodes: diagnosis and management. DAFWA, https://www.agric.wa.gov.au/barley/root-lesion-and-burrowing-nematodes-diagnosis-and-management

3 GRDC Tips and Tactics Root-lesion nematodes – Western Region (2015), https://grdc.com.au/Resources/Factsheets/2015/03/Root-Lesion-Nematodes

- Crop rotation and resistant cultivar selection are the keys to management of RLN. Growers need to know which species of RLN are present as cultivars resistant to one nematode species may be susceptible to another, so suitable rotations will vary.
- Become familiar with root and crop symptoms associated with nematode damage.
- Make use of available testing services like PreDicta B™ to determine nematode species and levels.
- Consider the influence of soil nematode levels not only on the current, but also on subsequent, crops in the rotation. [4]

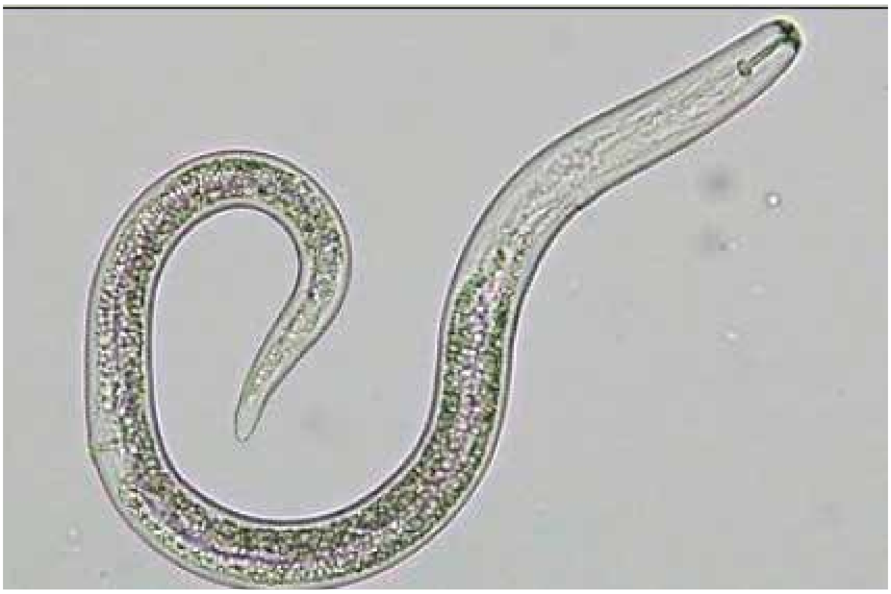

Photo 1: *Microscope image of a root-lesion nematode. Notice the syringe-like 'stylet' at the head end, which is used for extracting nutrients from the plant root. This nematode is less than 1 mm long.*

Photo by Sean Kelly, DAFWA, Nematology

RLN are microscopic migratory endoparasites (Photo 1). This means that RLN enter roots, feed on cell contents then either remain to continue feeding within the same root or exit and move to nearby root systems. This process damages the root system making water and nutrient uptake less efficient, therefore plants are less able to tolerate other stresses. Currently, RLN damage is estimated to cause crop losses in the order of $190 million p.a. in Southern and Western Australia (Figures 1 and 2). [5]

4 S Collins, S Kelly, H Hunter, B MacLeod, L Debrincat, J Teasdale, C Versteeg, X Zhang (2013) Pratylenchus teres—WA's home grown root-lesion nematode (RLN) and its unique impacts on broadacre crops. DAFWA 12 March 2013, https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2013/03/Pratylenchus-teres-WAs-home-grown-Root-Lesion-Nematode

5 Vanstone *et al.* (2008) Managing nematode pests in the southern and western regions of the Australian cereal industry: continuing progress in a challenging environment. Australasian Plant Pathology Society, Australasian Plant Pathology 37(3), 220–234.

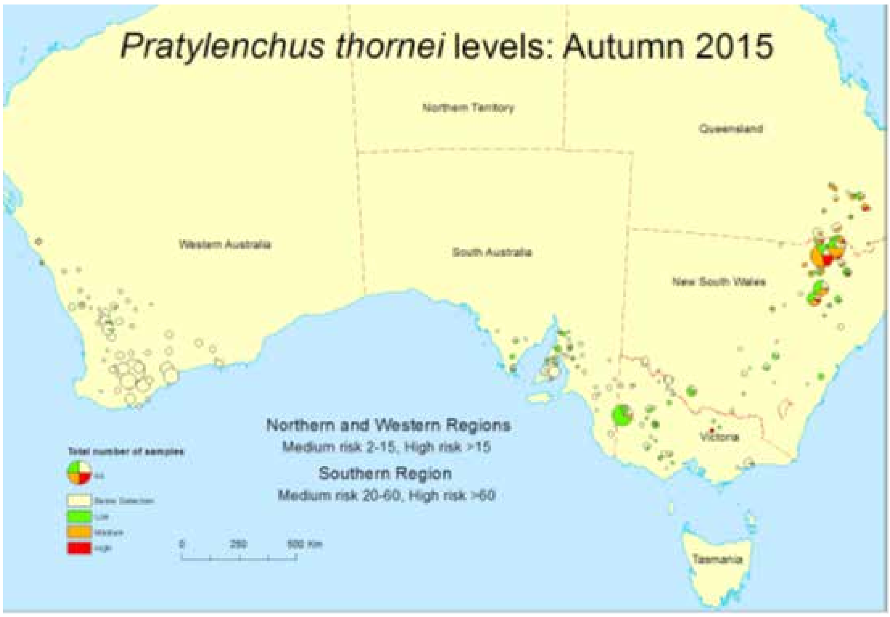

Figure 1: *Pratylenchus thornei levels in Autumn 2015.*

Source: GRDC

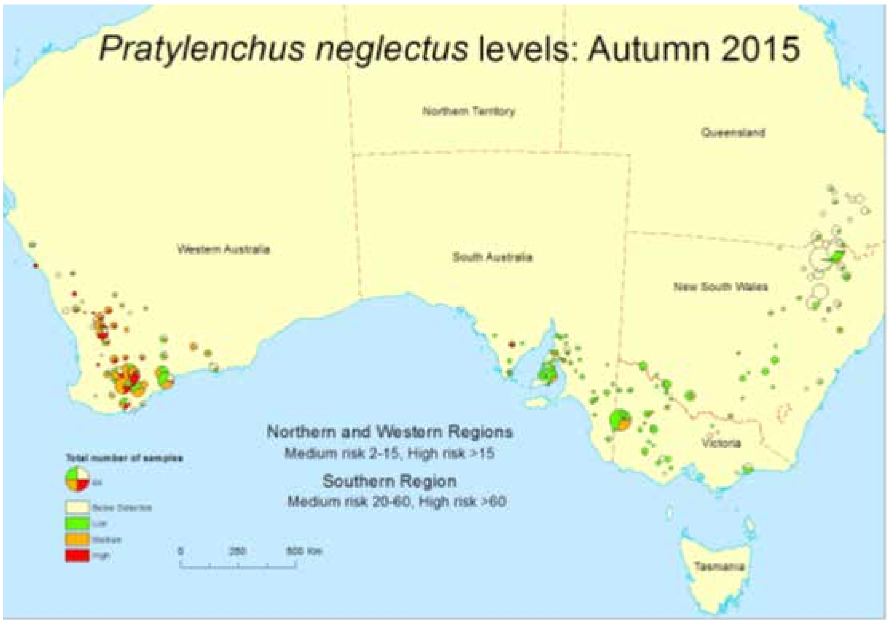

Figure 2: *Pratylenchus neglectus levels in Autumn 2015.*

Source: GRDC

Surveys also found that RLN is at yield-limiting levels in at least 40% of paddocks (Table 1). Several types of RLN are responsible and paddocks usually have one or more species. It is imperative that in field diagnoses, the species of RLN is correctly identified to enable growers to deploy appropriate crop cultivars and species to minimise current and future losses.

Pratylenchus penetrans is rare in broadacre crops but can cause severe damage to some crops. In the Southern Region, high densities of RLN generally cause yield losses of 10–20% in wheat crops. In field in Victoria and South Australian (2011 to

2013), P. thornei reduced grain yield in intolerant varieties by 2–12%, and P. neglectus reduced grain yield by 2–8%. [6]

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*	
	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: GRDC Tips and Tactics Root-lesion nematodes—Southern Region (2015), GRDC

IN FOCUS

Effect of field crops on population densities of RLNs in South-eastern Australia; Part 1 and 2.

Eighty-one cultivars from 12 field crop species were assessed for suitability as hosts to the RLN, *Pratylenchus neglectus*, in two field trials. Host status was assessed on the basis of either final *P. neglectus* densities in soil or multiplication rate under different crops. Both techniques gave consistent results for crop and cultivar ranking, and it was therefore concluded that, in these trials, final population density could be used for screening cultivars for resistance to *P. neglectus*. Differences were observed among crops and cultivars for host suitability to *P. neglectus*. Chickpea, wheat, and canola were good hosts, while barley, oat, durum wheat, medic, and vetch were moderate hosts. Field pea, faba bean, and triticale were poor hosts. A range in host suitability was observed for wheat, barley, and oat cultivars. [7]

VIDEOS

2. Root-lesion nematodes. Resistant cereal varieties have surprising impact on RLN numbers.

8.1.1 Varietal resistance or 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).

Chickpeas are susceptible to *P. neglectus*, *P. thornei* and *P. penetrans*. [8] Chickpea varieties differ in their resistance and tolerance to RLN but are generally considered more susceptible (allowing nematodes to multiply) than field pea, faba bean and lupin, but less so than wheat. While older chickpea varieties were a host for the RLN *(Pratylenchus neglectus, P. thornei)*, newer varieties are not as susceptible to RLN multiplication. [9]

Research in the Northern growing region indicates that there are consistent differences in *Pt* resistance between commercial chickpea varieties.

6 S Collins, S Kelly, H Hunter, B MacLeod, L Debrincat, J Teasdale, C Versteeg, X Zhang (2013) Pratylenchus teres—WA's home grown root-lesion nematode (RLN) and its unique impacts on broadacre crops. 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

7 SP Taylor, G J Hollaway, CH Hunt (2000) Effect of field crops on population densities of *Pratylenchus neglectus* and *P. thornei* in south-eastern Australia; Part 1: *P. neglectus*. Journal of Nematology, 32(4S): 591–599, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2620495/

8 GRDC Tips and Tactics Root-lesion nematodes—Western Region (2015), https://grdc.com.au/Resources/Factsheets/2015/03/Root-Lesion-Nematodes

9 Pulse Australia (2015) Chickpea production: Southern and Western region. Pulse Australia November 2015, http://www.pulseaus.com.au/growing-pulses/bmp/chickpea/southern-guide

8.1.2 Damage caused by RLN

RLNs cause poor plant growth in situations that otherwise appear favourable. They attack cereals and pulses and are thus a threat to the whole farming system. The nematodes feed and multiply on and in the roots of chickpea plants and, when in sufficient numbers, reduce growth and yield. RLN numbers build up steadily under susceptible crops and cause decreasing yields over several years. Intolerant chickpea varieties can lose up to 20% yield when nematode populations are high. [10] Yield losses in the southern region are variable and currently under investigation, but present estimates for intolerant varieties indicate a 1% yield loss per 2 nematodes per gram soil. [11]

8.1.3 Symptoms

RLNs are microscopic and cannot be seen with the naked eye in the soil or in plants. Aboveground symptoms are often indistinct and difficult to identify. The first signs are poor establishment, stunting and plants possibly wilting despite moist soil. Nematodes are usually distributed unevenly across a paddock, resulting in irregular crop growth (Photo 2). Sometimes symptoms are confused with nutrient deficiency and they can be exacerbated by a lack of nutrients. The typical symptom in the southern region is large areas of poor crop vigour due to poor root growth.

Photo 2: *Chickpea field infested with nematode.*

Source: IIPR

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.

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

Diagnosis is difficult and can be confirmed only with laboratory testing, particularly to identify the species because all RLN species cause identical symptoms. The PreDicta

10 DPI QLD (2009) Root-Lesion nematode management. https://www.daf.qld.gov.au/__data/assets/pdf_file/0010/58870/Root-Lesion-Nematode-Brochure.pdf

11 A McKay Root-lesion nematode—South Australia. Soilquality Fact Sheet,Soilquality.org.au, http://www.soilquality.org.au/factsheets/root-lesion-nematode-south-australia

VIDEOS

3. How to diagnose root-lesion nematode.

B™ soil test (SARDI Diagnostic Services) is a useful tool for several nematode species and is available through accredited agronomists. [12]

RLNs are microscopic and cannot be seen with the naked eye in the soil or in plants. The most reliable way to confirm the presence of RLNs is to test your farm soil. Nematodes are extracted from the soil for identification and to determine their population size. Look out for tell-tale signs of nematode infection in the roots and symptoms in the plant tops and if seen submit soil and root samples for nematode assessment. [13]

Root damage—dark lesions and poor root structure

RLNs invade the root tissue resulting in light browning of the roots or localised deep brown lesions (Photo 3). However, these lesions can be difficult to see on roots. The damage to the roots and the appearance of the lesions can be made worse by fungi and bacteria also entering the wounded roots. Roots infected by RLNs are poorly branched, lack root hairs and do not grow deeply into the soil profile. Such root systems are inefficient in taking up soil nutrients (particularly nitrogen, phosphorus and zinc under Northern region conditions) and soil water.

Photo 3: *Brown lesions indicate entry points of RLN on chickpea roots.*

Photo: Vivien Vanstone, DAFWA, Nematology

Plant tops—stunted, yellow lower leaves, wilting

When RLNs are present in very high numbers the lower leaves of wheat plants are yellow and the plants are stunted with reduced tillering. There is poor canopy closure so that the crop rows appear more open. The tops of the plants may exhibit symptoms of nutrient deficiency (nitrogen, phosphorus and zinc) when the roots are damaged by RLNs. Infected crops can wilt prematurely, particularly when conditions become dry later in the season because the damaged root systems are inefficient at taking up stored soil moisture. With good seasonal rainfall, wilting is less evident and plants may appear nitrogen deficient. [14]

12 GRDC Tips and Tactics Root-lesion nematodes—Western region (2015), https://grdc.com.au/Resources/Factsheets/2015/03/Root-Lesion-Nematodes

13 A McKay, Root-lesion nematode—South Australia. Soilquality Fact Sheet,Soilquality.org.au, http://www.soilquality.org.au/factsheets/root-lesion-nematode-south-australia

14 DPI QLD (2009) Root-Lesion nematode management. https://www.daf.qld.gov.au/__data/assets/pdf_file/0010/58870/Root-Lesion-Nematode-Brochure.pdf

8.1.4 Conditions favouring development

The adult RLNs are nearly all self-fertile females. They lay eggs inside roots and pass through a complete life cycle in about six weeks under favourable conditions (warm, moist soil) and so pass through several generations in the life of one host crop (Figure 3). The nematodes survive through fallow periods, particularly in the subsoil where they escape the hot, drying conditions of the surface soil. In drought or as plants and soil dry out in late spring, the nematodes can dehydrate (anhydrobiosis) to further aid their survival until favourable conditions return. [15]

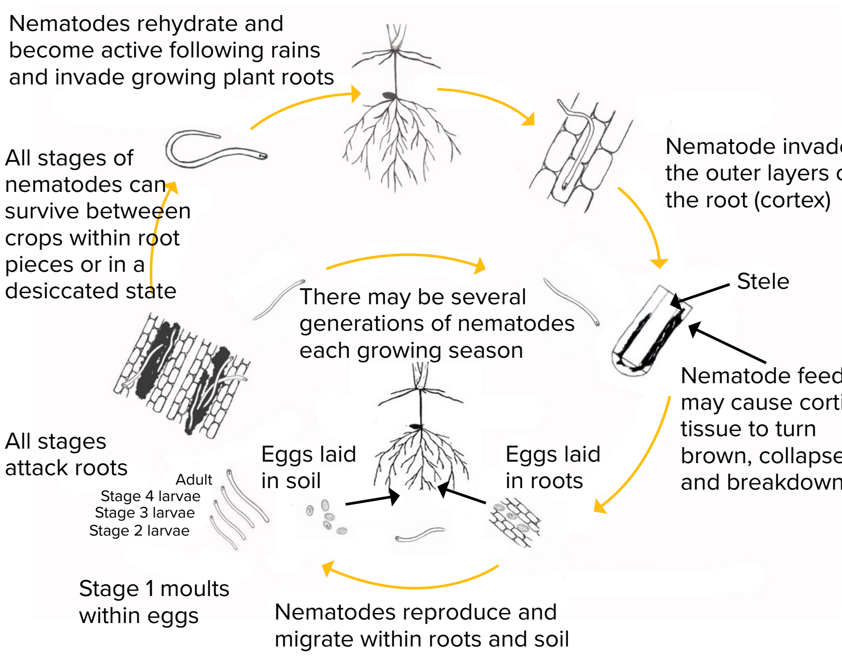

Figure 3: *Disease cycle and damage of root-lesion nematode, adapted from: GN Agrios (1997).*

Illustration: Kylie Fowler, GRDC

8.1.5 Thresholds for control

Yield losses in the southern region are variable and currently under investigation, but present estimates for intolerant varieties indicate a 1% yield loss per 2 nematodes per gram soil. [16]

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. [17]

8.1.6 Management of RLN

There are four key strategies for the management of RLN:

1. Test soil for nematodes in a laboratory.

15 DPI QLD (2009) Root-Lesion nematode management. https://www.daf.qld.gov.au/__data/assets/pdf_file/0010/58870/Root-Lesion-Nematode-Brochure.pdf

16 A McKay, Root-lesion nematode—South Australia. Soilquality Fact Sheet, Soilquality.org.au, http://www.soilquality.org.au/factsheets/root-lesion-nematode-south-australia

17 GRDC Tips and Tactics Root-lesion nematodes—Southern region (2015), https://grdc.com.au/resources-and-publications/all-publications/factsheets/2015/03/tt-rootlesionnematodes

2. Protect paddocks that are free of nematodes by controlling soil and water run-off and cleaning machinery; plant nematode-free paddocks first.
3. Choose tolerant varieties to maximise yields. Tolerant varieties grow and yield well when RLN are present. [18]
4. Rotate with resistant crops to prevent increases in RLN. When large populations of RLN are detected, you may need to grow at least two resistant crops consecutively to decrease populations. In addition, ensure that fertiliser is applied at the recommended rate so that the yield potential of tolerant varieties is achieved.

Figure 4 is a simplified chart that highlights the critical first step in the management of RLN is to test your soil and determine whether or not you have an issue to manage.

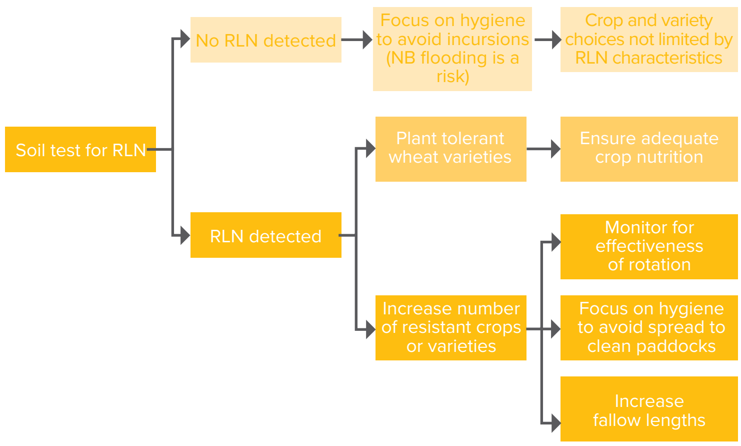

Figure 4: *RLN management flow chart.*

Source: GRDC

VIDEOS

4. What lies beneath – managing RLNs to combat yield loss.

Monitoring

Observation and monitoring of above and below ground symptoms of plant disease, followed by diagnosis of the cause(s) of any root disease, is the first step in implementing effective management. Although little can be done during the current cropping season to ameliorate nematode symptoms, the information will be crucial in planning effective rotations of crop species and varieties in following seasons.

Commercial pre-season testing of soil by the PreDicta B™ root disease testing service determines levels of *P. neglectus* and *P. thornei* present using a DNA detection technique. Currently, this test is limited in its ability to detect levels of *P. penetrans* in the soil, and any results from southern Australian soils using PreDicta B™ should be confirmed by traditional laboratory extraction and microscopic examination. During the season, plants with suspected RLN infections should be sent to a laboratory for extraction and identification. [19]

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.

18 KJ Owen, J Sheedy, N Seymour (2013) Root lesion nematode in Queensland. Soilquality Fact Sheet, Soilquality.org.au, http://soilquality.org.au/factsheets/root-lesion-nematode-in-queensland

19 A McKay, Root-lesion nematode—South Australia. Soilquality.com.au Fact Sheet, Soilquality.org.au, http://www.soilquality.org.au/factsheets/root-lesion-nematode-south-australia

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. [20]

Soil testing

Vertical distribution of *P. thornei* in soil is variable. Some paddocks have relatively uniform populations down to 30 cm or even 60 cm, some will have highest *P. thornei* counts at 0–15 cm depth, whereas other paddocks will have *P. thornei* populations increasing at greater depths, e.g. 30–60 cm. Although detailed knowledge of the distribution may be helpful, the majority of on-farm management decisions will be based on presence or absence of *P. thornei* confirmed by sampling. [21]

When to collect samples

The best time for sampling varies between crops, and is related to the growth stage of the crop and the objective of sampling. Many species of nematodes increase to high levels during the growing season and reduce to low numbers during the dry season. This is more easily seen in annual crops than in perennial and tree crops.

Sampling equipment:

- clean bucket for collecting samples
- soil probe (Photo 4) or shovel/spade
- plastic bags to hold 500 g of soil
- labels
- waterproof marker

20 GRDC Tips and Tactics Root-lesion nematodes—Southern region (2015), https://grdc.com.au/resources-and-publications/all-publications/factsheets/2015/03/tt-rootlesionnematodes

21 KJ Owen, J Sheedy, N Seymour (2013) Root-lesion nematode in Queensland. Soilquality Fact Sheet,Soilquality.org.au, http://www.soilquality.org.au/factsheets/root-lesion-nematode-in-queensland

Photo 4: *Soil sampling probe.*

Source: United soybean board

How to sample

Fallow or bare fields:

Do not collect samples when field is dry or extremely wet. For sampling, the field should be divided into 1–2 hectare blocks. Take about 20–30 cores/sub-samples of soil, at 15–20 cm depth from an area of 1–2 hectares. Collect these sub-samples at every 10–20 metres in a 'W' or in a 'Zigzag' pattern (Figure 5). Place sub-samples in a bucket and mix thoroughly with hands, and collect a 500 g composite sample in a labelled plastic bag.

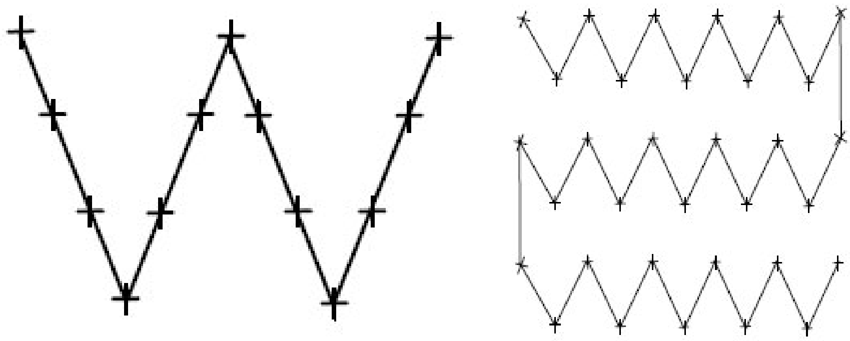

Figure 5: *'W' pattern (left) and 'Zigzag' pattern (right) for randomising soil sampling in a paddock.*

Source: AgVic

Field crops:

Nematodes do not necessarily occur uniformly throughout a field, therefore several sub-samples must be taken from across the field, and then combined. Collect 20–30 random sub-samples from each block of 1–2 hectares. Samples should be taken directly from the root zone. Mix sub-samples thoroughly and place 500 g of soil, with roots, in a plastic bag, for laboratory analysis. Because nematode damage within a crop can be patchy, collect samples from healthy plants, as well as from plants showing symptoms of decline. Keep these samples separate and label them as 'good' and 'bad' samples.

Care of samples

Place all samples in plastic bags to prevent drying. Generally, plant-parasitic nematodes remain alive at temperature between 5°C and 40°C, and die within seconds when exposed to temperatures above 50°C. Keep samples in a cool place at all times. Do not refrigerate samples. Do not leave samples exposed in the field, or in a vehicle, on very hot days. Do not wrap roots or any other plant material in damp tissue. Leave roots with soil in bag. Place other plant material in a separate plastic bag.

Label and information

Label samples with identification numbers and provide the following information on a separate sheet of paper:

- name and address of the grower as well as sender
- crop plant, symptoms and estimated damage
- a sketch map of the diseased area and the sampling site, and also an indication of the topography of the field
- cropping history of the field
- fertilisers, pesticides and herbicides applied
- relevant weather conditions and watering or drainage conditions

It is necessary to provide the above information so the results of the analysis can be interpreted correctly and satisfactorily. [22]

Control strategies

- Well-managed rotations with resistant or non-host break-crops are vital. To limit RLN populations, avoid consecutive host crops.

Use a state department of agriculture Crop Variety Guide to choose varieties with high resistance ratings, which result in fewer nematodes remaining in the soil to infect subsequent crops.

- Reducing RLN can lead to higher yields in following cereal 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. [23]

Nematicides

Nematicides are not used commercially in broadacre cropping in Australia. They are not recommended because of their cost and mammalian toxicity, and because rotational crops are available for nematode management. If they were used commercially, their efficacy would likely be poor, particularly in situations where the nematode occurs at depth. Currently, no nematicides are registered for use on broadacre crops in Australia. [24]

Variety choice and crop rotation options

Varietal choice and crop rotation are currently our most effective management tools for RLN. However, the focus is on two different characteristics: tolerance, i.e. ability of the variety to yield under RLN pressure; and resistance, i.e. impact of the variety

22 AgVic (2011) Collecting soil and plant samples for nematode analysis. Agriculture Victoria, Ag Note AG1444 July 2011, http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/plant-diseases/fruit-and-nuts/stone-fruit-diseases/collecting-soil-and-plant-samples-for-nematode-analysis

23 GRDC (2010) Plant parasitic nematodes fact sheet Southern and Western region. 28 October 2010, https://grdc.com.au/Resources/Bookshop/2010/10/Plant-Parasitic-Nematodes-Fact-Sheet-Southern-Western-Region

24 GRDC Tips and Tactics Root-lesion nematodes—Western region (2015), https://grdc.com.au/Resources/Factsheets/2015/03/Root-Lesion-Nematodes

MORE INFORMATION

For more information, see the GRDC Tips and Tactics Root-Lesion Nematode Factsheet – Southern Region.

on RLN build-up. Note that varieties and crops often have varied tolerance and resistance levels to *P. thornei* and P. neglectus.

Chickpea grown in rotations with wheat (*Triticum aestivum*) can reduce the build-up of pathogens of cereals such as *Fusarium pseudograminearum* (responsible for crown rot), improve soil nitrogen (N) fertility, and facilitate control of grass weeds. However, offsetting these benefits, populations of RLN increase with chickpea rotations, reducing its yield and negatively affecting the yield of subsequent intolerant wheat and other crops. [25]

Summer crops (where grown) have an important role in management of RLN. Research shows that when *P. thornei* is present in high numbers, two or more resistant crops in sequence are needed to reduce populations to low enough levels to avoid yield loss in the following intolerant, susceptible wheat crops. Summer crops that are partially resistant or poor hosts of *P. neglectus* include sunflower, mungbean, soybean and cowpea. When these crops are grown, populations of *P. neglectus* do not increase because the crops do not allow the nematode to reproduce. [26]

IN FOCUS

Yield response in chickpea cultivars and wheat following crop rotations affecting population densities of *Pratylenchus thornei* and arbuscular mycorrhizal fungi.

In Australia, RLN significantly reduces chickpea and wheat yields. Yield losses from RLN have been determined through use of nematicide; however, nematicide does not control nematodes in Vertosol subsoils in Australia. The alternative strategy of assessing yield response, by using crop rotation with resistant and susceptible crops to manipulate nematode populations, is poorly documented for chickpea. One study tested the effectiveness of crop rotation and nematicide against *P. thornei* populations for assessing yield loss in chickpea in the Northern cropping region.

Canola, linseed and fallow treatments reduced *P. thornei* populations, but low mycorrhizal spore levels in the soil after canola and fallow treatments were associated with low chickpea yield. Mycorrhizal spore densities are also imortant in maximising the effectiveness of crop rotations.

Canaryseed kept *P. thornei* populations low throughout the soil profile and maintained mycorrhizal spore densities, resulting in grain yield increases of up to 25% for chickpea cultivars and 55% for wheat when pre-cropped with canaryseed compared with wheat. Tolerance indices for chickpeas based on yield differences after paired wheat and canaryseed plots ranged from 80% for cv. Tyson to 95% for cv. Lasseter and this strategy is recommended for future use in assessing tolerance. [27]

25 RA Reen, JP Thompson, TG Clewett, JG Sheedy, KL Bell (2014) Yield response in chickpea cultivars and wheat following crop rotations affecting population densities of *Pratylenchus thornei* and arbuscular mycorrhizal fungi. Crop and Pasture Science, 65(5), 428-441.

26 K Owen, T Clewett, J Thompson (2013) Summer crop decisions and root-lesion nematodes: crop rotations to manage nematodes—key decision points for the latter half of the year, Bellata. GRDC Update Papers, 16 July 2013, https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2013/07/Summer-crop-decisions-and-root-lesion-nematodes

27 RA Reen, JP Thompson, TG Clewett, JG Sheedy, KL Bell (2014). Yield response in chickpea cultivars and wheat following crop rotations affecting population densities of *Pratylenchus thornei* and arbuscular mycorrhizal fungi. Crop and Pasture Science, 65(5), 428-441.

Fallow

Populations of RLN will decrease during a 'clean' fallow, but the process is slow and expensive in lost 'potential' income. [28]

8.1.7 Breeding resistance

IN FOCUS

Hybridisation of Australian chickpea cultivars with wild *Cicer* spp. increases resistance to root-lesion nematodes (*Pratylenchus thornei* and *P. neglectus*)

Development of commercial cultivars from wild hybrid parents with the high levels of resistance to *P. thornei* and *P. neglectus* will be most valuable for areas of the Australian grain region and other parts of the world where alternating chickpea and wheat crops are the preferred rotation.

Australian and international chickpea (*Cicer arietinum*) cultivars and germplasm accessions, and wild annual *Cicer* spp. in the primary and secondary gene pools, were assessed in glasshouse experiments for levels of resistance to the root-lesion nematodes *Pratylenchus thornei* and *P. neglectus*.

Lines were grown in replicated experiments in pasteurised soil inoculated with a pure culture of either *P. thornei* or *P. neglectus* and the population density of the nematodes in the soil plus roots after 16 weeks' growth was used as a measure of resistance. Combined statistical analyses of experiments (nine for *P. thornei* and four for *P. neglectus*) were conducted and genotypes were assessed using best linear unbiased predictions. Australian and international chickpea cultivars possessed a similar range of susceptibilities through to partial resistance. Wild relatives from both the primary (*C. reticulatum* and *C. echinospermum*) and secondary (*C. bijugum*) gene pools of chickpea were generally more resistant than commercial chickpea cultivars to either *P. thornei* or *P. neglectus* or both. Wild relatives of chickpea have probably evolved to have resistance to endemic root-lesion nematodes whereas modern chickpea cultivars constitute a narrower gene pool with respect to nematode resistance. Resistant accessions of *C. reticulatum* and *C. echinospermum* were crossed and topcrossed with desi chickpea cultivars and resistant F4 lines were obtained. [29]

28 R Daniel (2013) Managing root-lesion nematodes: how important are crop and variety choice? GRDC Update Paper 16 July 2013, https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2013/07/Managing-root-lesion-nematodes-how-important-are-crop-and-variety-choice

29 JP Thompson, RA Reen, TG Clewett, JG Sheedy, AM Kelly, BJ Gogel, EJ Knights (2011). Hybridisation of Australian chickpea cultivars with wild *Cicer* spp. increases resistance to root-lesion nematodes (*Pratylenchus thornei and P. neglectus*). Australasian Plant Pathology Society, Australasian Plant Pathology, 40(6), 601–611.

IN FOCUS

Highly heritable resistance to root-lesion nematode (*Pratylenchus thornei*) in Australian chickpea germplasm observed using an optimised glasshouse method and multi-environment trial analysis

Pratylenchus thornei is a RLN of economic significance in the grain growing regions of Australia. Chickpea (*Cicer arietinum*) is a significant legume crop grown throughout these regions, but previous testing found most cultivars were susceptible to *P. thornei*. Therefore, improved resistance to *P. thornei* is an important objective of the Australian chickpea breeding program. Results demonstrate that resistance to *P. thornei* in chickpea is highly heritable and can be effectively selected in a limited set of environments. The improved resistance found in a number of the newer chickpea cultivars tested shows that some advances have been made in the *P. thornei* resistance of Australian chickpea cultivars, and that further targeted breeding and selection should provide incremental improvements. [30]

8.2 Nematodes and crown rot

There is increasing evidence for the enhancing effect of nematodes on levels of crown rot (CR) in cereals. After an extensive NSW farm survey exploring the effect of CR on crops, the researchers concluded that where *P. thornei* (Pt) combines with high levels of CR (a common scenario), yield losses can be exacerbated if varieties are susceptible to Pt. Instead of a 10% yield loss from Pt in a susceptible variety it could be 30–50% if CR is combined with a Pt-intolerant variety. These trials were designed to evaluate the impact of CR on variety yield and quality. However, results strongly suggest that Pt 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 Pt tolerance than currently exists for CR tolerance. Put simply, variety choice appears a more valuable tool when under Pt pressure than as a tool for CR management. [31]

VIDEOS

5. GCTV9: Crown rot and root-lesion nematodes.

MORE INFORMATION

The additive yield impact of root-lesion nematode and crown rot

30 MS Rodda, KB Hobson, CR Forknall, RP Daniel, JP Fanning, DD Pounsett, JP Thompson (2016). Highly heritable resistance to root-lesion nematode (*Pratylenchus thornei*) in Australian chickpea germplasm observed using an optimised glasshouse method and multi-environment trial analysis. Australasian Plant Pathology Society, Australasian Plant Pathology, 45(3), 309-319.

31 GRDC (2010) The additive yield impact of root lesion nematode and crown rot. GRDC Update Papers 15 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