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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 in all agricultural areas of Western Australia, irrespective of soil type and rainfall.
- Root-lesion nematodes are found over 5.74 million ha (or ~65%) of the cropping area of Western Australia (WA). Populations potentially limit yield in at least 40% of these infested paddocks.
- The main species found in broadacre cropping in WA are *Pratylenchus neglectus, P. quasitereoides* (formerly known as *P. teres*), *P. thornei* and *P. penetrans*.
- There are consistent varietal differences in Pt resistance within chickpea varieties
- Successful management relies on:
- farm hygiene to keep fields free of RLN;
- soil test to determine whether RLN are an issue and which species are present;
- growing tolerant varieties when RLN are present, to maximise yields; and
- rotating with resistant crops to keep RLN at low levels.

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 Western 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. [1]

WATCH: GCTV6: Root lesion nematodes.

1 DAFWA. Desi Chickpea Essentials. https://www.agric.wa.gov.au/chickpeas/desi-chickpea-essentials

8.1 Root-lesion nematode (RLN)

Key points

- Root-lesion nematodes are found over 5.74 million ha (or ~65%) of the cropping area of Western Australia (WA).
- Populations potentially limit yield in at least 40% of these infested paddocks.
- The main species found in broadacre cropping in WA 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. [2]
- *P. quasitereoides* is unique to WA, has a wide host range and is capable of causing significant yield damage.
- Crop rotation and resistant cultivar selection are the keys to management of Root-lesion nematode (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.
- Ongoing DAFWA research is developing rotational recommendations through the characterisation of wheat cultivar resistance and tolerance levels.
- Become familiar with root and crop symptoms associated with nematode damage.
- Make use of available testing services to determine nematode species and levels, but be aware that PreDicta-B™ cannot currently detect *P. quasitereoides* present in WA crops.
- AGWEST Plant Laboratories can conduct in-season nematode diagnosis.
- Consider the influence of soil nematode levels not only on the current, but also subsequent crops in the rotation. [3]

Figure 1: *Microscopic 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: DAFWA. Photo: Sean Kelly, DAFWA, Nematology

Root-lesion nematodes (RLN, *Pratylenchus* spp.) are microscopic migratory endoparasites (Figure 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

2 GRDC. Tips and tactics, Root Lesion Nematode–Western Region. https://grdc.com.au/Resources/Factsheets/2015/03/Root-Lesion-Nematodes

3 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, GRDC.

million per annum in western and southern Australia. [4] These huge losses are put into perspective when the magnitude of the area affected by RLN in WA alone is considered. It is estimated that one or more species of RLN occur in at least 60% of WA cropping paddocks–that is over at least 5.3 million ha of the WA cropping zone (Figure 2).

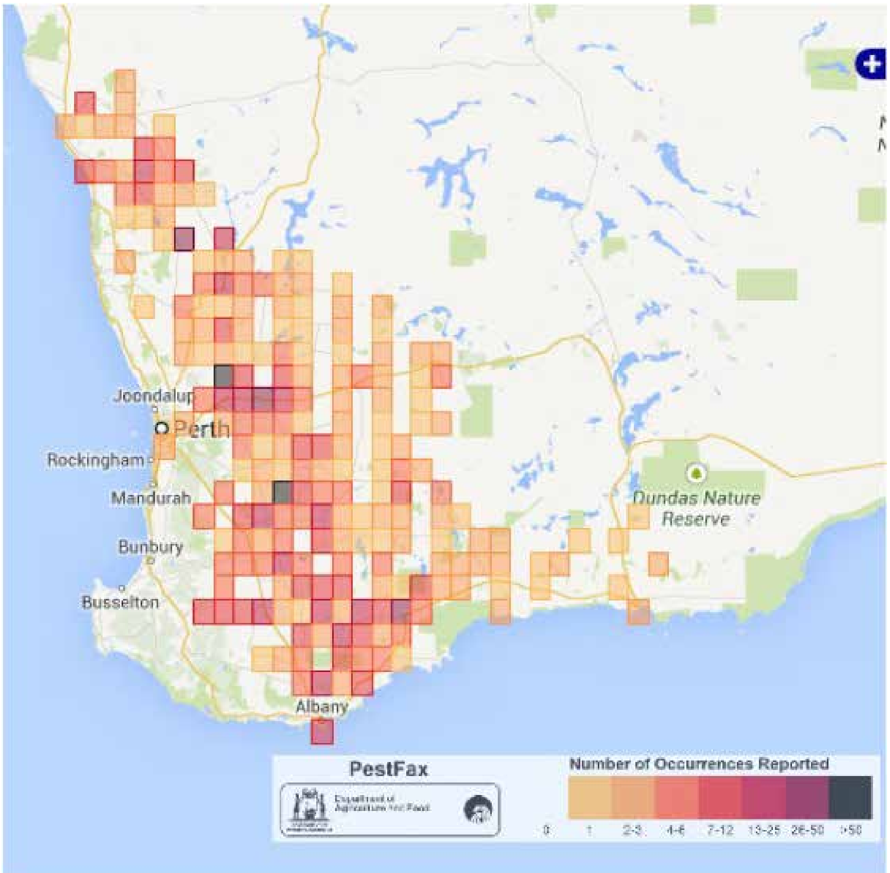

Figure 2: *Positive detection of root-lesion nematodes in Western Australian broadacre cropping between 1997 and 2013.*

Source: GRDC

Surveys also found that RLN is at yield limiting levels in at least 40% of paddocks. Several types of RLN are responsible and paddocks usually have one or more species: *P. neglectus* is the most frequent RLN identified in WA, occurring in at least 40% of paddocks; *P. thornei* occurs rarely (around 8% of paddocks); *P. quasitereoides* is unique to WA, can reach high populations and cause more significant and widespread damage within a crop than *P. neglectus*. Although *P. quasitereoides* is less frequent, 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 therefore imperative that in field diagnoses the species of RLN is correctly identified, to enable growers to deploy appropriate crop cultivars and species and minimise current and future losses. [5]

Pratylenchus penetrans is rare in broadacre crops but can cause severe damage to some crops. These estimates represent a compilation of more than 2,300 confirmed RLN reports gathered since 1997 by the Department of Agriculture and Food, Western Australia (DAFWA), including research trials, surveys and Agwest Plant Laboratory diagnostic samples. Yield losses in broadacre cropping caused by *P. quasitereoides* or *P. penetrans* are a problem unique to WA. Research is under way to learn more

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4 Vanstone et al. (2008) Australasian Plant Pathology 37, 220–234

5 S Collins, S Kelly, H Hunter, B MacLeod, L Debrincat, J Teasdale, C Versteeg and X Zhang. (2013). Pratylenchus teres—WA's home grown Root Lesion Nematode (RLN) and its unique impacts on broadacre crops. DAFWA, GRDC.

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 3).

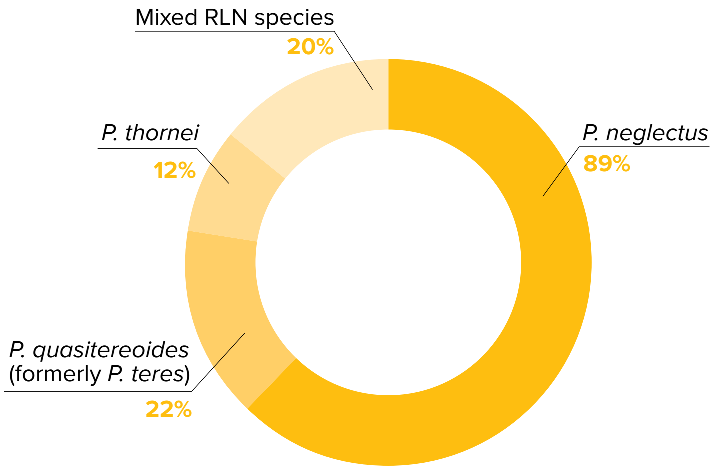

Figure 3: *Relative abundance of the main root-lesion nematode species identified in infested broadacre paddocks in Western Australia.*

Source: GRDC

DAFWA has been conducting 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. During this time, 486 varieties across a wide range of crops have been assessed for resistance to the four main RLN species. All species of RLN have a wide host range. Identification of nematode species is important to management decisions because varieties and crop species differ in their resistance or susceptibility to different members of the *Pratylenchus* genus, with chickpea being susceptible to *P. neglectus* and *P. penetrans*.

8.1.1 *Pratylenchus quasitereoides* (formerly *teres*)—WA's home grown RLN

- *P. quasitereoides* is unique to WA, has a wide host range, and is capable of causing significant yield damage.
- Crop rotation and resistant cultivar selection are the keys to management of Root-lesion nematode (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.
- Ongoing DAFWA research is developing rotational recommendations through the characterisation of wheat cultivar resistance and tolerance levels.
- Become familiar with root and crop symptoms associated with nematode damage.
- Make use of available testing services to determine nematode species and levels, but be aware that PreDicta-B™ cannot currently detect *P. quasitereoides* present in WA crops.
- AGWEST Plant Laboratories can conduct in-season nematode diagnosis.
- Consider the influence of soil nematode levels not only on the current, but also on subsequent crops in the rotation.

8.1.2 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*. [6] 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 root lesion nematode *(Pratylenchus neglectus, P. thornei)*, newer varieties are not as susceptible to root lesion nematode multiplication. [7]

Research in the Northern growing region indicates that there are consistent differences in *Pt* resistance between commercial chickpea varieties. Figure 4 shows a summary of key chickpea variety performance in eight trials sampled by DAFF QLD, NSW DPI or NGA.

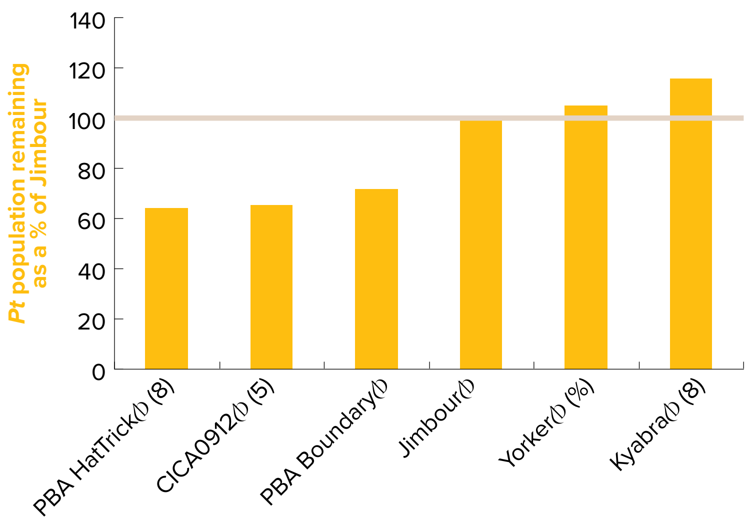

Figure 4: *Comparison of Pt population remaining as a % of Jimbour, 2010–2012 (Number) indicates the number of trials compared to Jimbour. The red broken line indicates the Pt level remaining after Jimbour.*

Source: GRDC

6 GRDC Tips and Tactics Root-Lesion nematode–Western region. http://www.grdc.com.au/TT-RootLesionNematodes

7 Pulse Australia. Chickpea production: Southern and Western Region. http://www.pulseaus.com.au/growing-pulses/bmp/chickpea/southern-guide

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

8.1.3 Damage caused by RLN

Root-lesion nematodes 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. Root-lesion nematode 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. [8]

8.1.4 Symptoms

Root-lesion nematodes 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, poor tillering of cereals, and plants possibly wilting despite moist soil. Nematodes are usually distributed unevenly across a paddock, resulting in irregular crop growth (Figure 5). Sometimes symptoms are confused with nutrient deficiency, and can be exacerbated by a lack of nutrients.

Figure 5: *Chickpea field infested with nematode.*

Source: IIPR

8 DAFQLD. Root-Lesion nematode management. https://www.daf.qld.gov.au/__data/assets/pdf_file/0010/58870/Root-Lesion-Nematode-Brochure.pdf

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) will be 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-BTM soil test (SARDI Diagnostic Services) is a useful tool for several nematode species and is available through accredited agronomists. [9]

Root-lesion nematodes 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 root-lesion nematodes 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. [10]

WATCH: How to diagnose Root-lesion nematode.

Root damage—dark lesions and poor root structure

Root-lesion nematodes invade the root tissue, resulting in light browning of the roots or localised deep brown lesions (Figure 6). 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 root-lesion nematodes 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.

9 GRDC Tips and Tactics Root-lesion nematode–Western region. http://www.grdc.com.au/TT-RootLesionNematodes

10 A Wherrett, V Vanstone The National Soil Quality Monitoring ProgramFact Sheets–Root Lesion Nematode. http://soilquality.org.au/factsheets/root-lesion-nematode

Figure 6: *Brown lesions indicate entry points of RLN on chickpea roots.*

Photo: Vivien Vanstone, DAFWA, Nematology

Plant tops—stunted, yellow lower leaves, wilting

When root-lesion nematodes are present in very high numbers, the lower leaves of the 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 root-lesion nematodes. 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. [11]

8.1.5 Conditions favouring development

The adult root-lesion nematodes are nearly all self-fertile females. They lay eggs inside the 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 7). 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. [12]

11 DAFQLD. Root-Lesion nematode management. https://www.daf.qld.gov.au/__data/assets/pdf_file/0010/58870/Root-Lesion-Nematode-Brochure.pdf

12 DAFQLD. Root-Lesion nematode management. https://www.daf.qld.gov.au/__data/assets/pdf_file/0010/58870/Root-Lesion-Nematode-Brochure.pdf

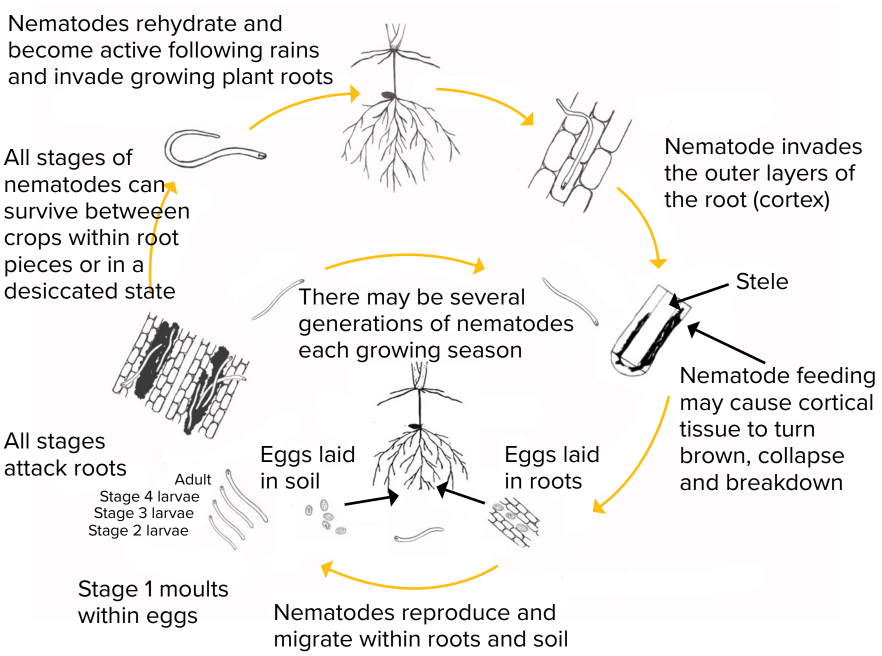

Figure 7: *Disease cycle and damage of root-lesion nematode, adapted from: GN Agrios (1997).*

Illustration: Kylie Fowler. Source: GRDC

8.1.6 Thresholds for control

The damage threshold has been estimated at 2,000 nematodes/kg soil (or 2/g soil). Control is warranted for paddocks with populations over this density threshold. [13]

8.1.7 Management of RLN

There are four key strategies for the management of RLN:

1. Test soil for nematodes in a laboratory.
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. [14]
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 8 is a simplified chart that highlights the critical first step in the management of RLN: to test your soil and determine whether or not you have an issue to manage.

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

14 KJ Owen, J Sheedy, N Seymour (2013) Root-lesion nematode in Queensland. Soil Quality Pty Ltd Fact Sheet.

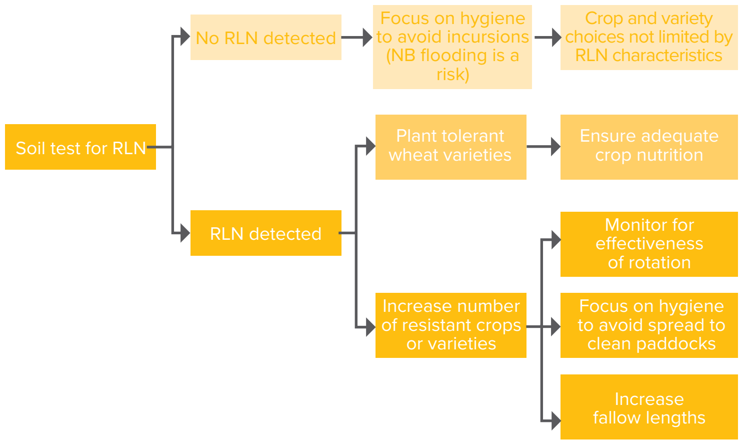

Figure 8: *RLN management flow chart.*

Source: GRDC

WATCH: 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-BTM 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* and *P. quasitereoides* in the soil, and any results from Western Australian soils using Predicta-BTM 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. [15]

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

15 A Wherrett, V Vanstone The National Soil Quality Monitoring ProgramFact Sheets–Root Lesion Nematode. http://soilquality.org.au/factsheets/root-lesion-nematode

MORE INFORMATION

DDLS – Seed testing and certification services

Predicta-BTM - SARDI

reveal evidence of infestation in the roots, which warrants laboratory analysis. Testing services are available at the DAFWA Diagnostic Laboratory Services (DDLS). Growers are advised to contact their local DAFWA office for advice. [16]

Soil testing

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 (Figure 9) or shovel/spade
- Plastic bags to hold 500 g of soil
- Labels
- Waterproof marker

Figure 9: *Soil sampling probe.*

How to sample

Fallow or bare fields:

Do not collect samples when the field is dry or extremely wet. For sampling, the field should be divided into 1–2 ha 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 m in a 'W' or in a 'Zigzag' pattern (Figure 10). Place sub-samples in a bucket and mix thoroughly with hands, and collect a 500 g composite sample in a labelled plastic bag.

16 GRDC Tips and Tactics Root-Lesion nematode—Western region. http://www.grdc.com.au/TT-RootLesionNematodes

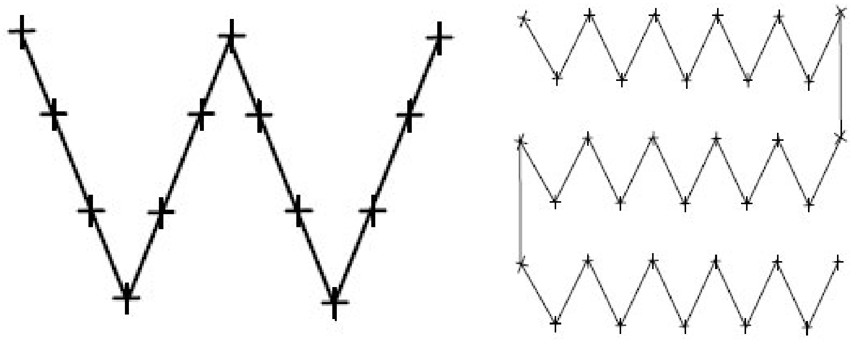

Figure 10: *'W' pattern (left) and 'Zigzag' pattern (right) for randomising soil sampling in a paddock.*

Source: AgVic

Field Crops:

Nematodes do not necessarily occur uniformly throughout a paddock, 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 ha. 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 that the results of the analysis can be interpreted correctly and satisfactorily. [17]

Strategies

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

17 Agriculture Victoria (2011) Collecting Soil and Plant Samples for Nematode Analysis. 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

- 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. [18]

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. [19]

Varietal choice and crop rotation options

Varietal choice and crop rotation are currently our most effective management tools for RLN. 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 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. Offsetting these benefits however is the fact that populations of root-lesion nematode (RLN; *Pratylenchus thornei*) increase with chickpea rotations, reducing its yield and negatively affecting the yield of subsequent intolerant wheat and other crops. [20]

Summer crops can play an important role in management of RLN. 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. [21]

MORE INFORMATION

GRDC Tips and Tactics Root-Lesion Nematode Factsheet – Western Region.

IN FOCUS

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

In Australia, root-lesion nematode (RLN; *Pratylenchus thornei*) 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. This research tested the effectiveness of crop

18 GRDC (2009) Plant Parasitic Nematodes Fact sheet Southern and Western region.

19 GRDC Tips and Tactics Root-Lesion nematode—Western region. http://www.grdc.com.au/TT-RootLesionNematodes

20 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.

21 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 Grains Research Update, July 2013.

rotation and nematicide against *P. thornei* populations for assessing yield loss in chickpea. First-year field plots included canola, linseed, canaryseed, wheat and a fallow treatment, all with and without the nematicide aldicarb. The following year, aldicarb was reapplied and plots were re-cropped with four chickpea cultivars and one intolerant wheat cultivar. Highest *P. thornei* populations were after wheat, at 0.45–0.6 m soil depth. Aldicarb was effective to just 0.3 m for wheat and 0.45 m for other crops, and increased subsequent crop grain yield by only 6%. 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. 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. [22]

Fallow

Populations of RLN will decrease during a 'clean' fallow, but the process is slow and expensive in lost 'potential' income. Additionally, long fallows may decrease arbuscular mycorrhiza (AM) levels and create more cropping problems than they solve. [23]

8.1.8 Breeding resistance

IN FOCUS

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

Chickpea cultivars, 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*. The population density of the nematodes in the soil and roots after 16 weeks of 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. 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.

22 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.

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

Resistant accessions of *C. reticulatum* and *C. echinospermum* were crossed and topcrossed with desi chickpea cultivars and resistant F 4 lines were obtained. Development of commercial cultivars with the high levels of resistance to *P. thornei* and *P. neglectus* in these hybrids 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. [24]

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 root-lesion nematode (RLN) of economic significance in the grain growing regions of Australia. Chickpea 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. A glasshouse method was developed to assess resistance of chickpea lines to *P. thornei*, which requires relatively low labour and resource input, and hence is suited to routine adoption within a breeding program. Using this method, good differentiation of chickpea cultivars for *P. thornei* resistance was measured after 12 weeks. Nematode multiplication was higher for all genotypes than the unplanted control, but of the 47 cultivars and breeding lines tested, 17 exhibited partial resistance, allowing less than two fold multiplication. The relative differences in resistance identified using this method were highly heritable (0.69) and were validated against *P. thornei* data from seven field trials using a multi-environment trial analysis. Genetic correlations for cultivar resistance between the glasshouse and six of the field trials were high (>0.73). These 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. [25]

24 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, 40(6), 601–611.

25 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, 45(3), 309–319.

8.2 Nematodes and crown rot

There is increasing evidence for the enhancing effect of nematodes on levels of crown rot. An extensive survey exploring the effect of crown rot on crops concluded that where RLN combines with high levels of crown rot (a common scenario), yield losses can be exacerbated if varieties are susceptible to the RLN. Instead of a 10% yield loss from RLN in a susceptible variety it could be 30–50% if crown rot is combined with a RLN-intolerant variety. [26]

8.2.1 Management

Variety choice is the key management option when it comes to managing nematode risk. However, when it comes to crown rot management, although varieties have some impact, rotation and stubble management are by far our most important management tools. Root lesion nematodes, need to be taken far more seriously and better factored into crop rotation considerations as well as variety choice. [27]

When including chickpea in cereal crop rotations to reduce crown rot, sow chickpea between the standing cereal rows. Sow the following cereal crop directly over the row of the previous year chickpea crop. [28]

Chickpea was thought to be one of the best break crops to use in crown rot management, however, recent trials have indicated that faba beans and canola are better break crops for crown rot than chickpeas. [29]

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

MORE INFORMATION

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

26 GRDC. 2010. Update paper. The additive yield impact of root lesion nematode and crown rot? https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2010/09/THE-ADDITIVE-YIELD-IMPACT-OF-ROOT-LESION-NEMATODE-AND-CROWN-ROT

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

28 A Verrell (2016). GRDC Update Papers: Integrated management of crown rot in a chickpea-wheat sequence. https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2016/02/Integrated-management-of-crown-rot-in-a-chickpea-wheat-sequence

29 S Simpendorfer. (2015). GRDC Update Papers: Crown rot, an update on latest research. https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2015/07/Crown-rot-an-update-on-latest-research