GRDC GROWNOTES™

GRDC
GRAINS RESEARCH & DEVELOPMENT CORPORATION

CEREAL RYE

SECTION 8

NEMATODE MANAGEMENT

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

Nematode management

Key messages

- Rye is resistant to cereal cyst nematodes and is a poor host to the root lesion nematode (*Pratylenchus neglectus*), providing an alternative management approach for these diseases. [1]
- Rye can reduce the amount of cereal cyst nematodes (CCN) in a paddock. In one study, the biggest reduction in CCN numbers occurred in cereal rye (cv. South Australia), which reduced populations by 92% in the first year. [2]
- Root lesion nematodes (*Pratylenchus thorne*i and *P. neglectus*) cost Australian growers in excess of $250 million/annum.
- At least 20% of cropping paddocks in south-eastern Australia have populations of root lesion nematodes (RLN) high enough to reduce yield. [3]
- Variety choice is critical in managing nematode populations in the soil.
- Soil testing is the best way to diagnose nematode infestations in paddocks and will subsequently inform management decisions.

The most important root and crown diseases of cereal crops in southern Australia are CCN, take-all, rhizoctonia root rot, crown rot and RLN. These diseases can cause significant yield loss in crops. Fortunately, they can be easily controlled with crop rotation and resistant varieties. [4]

Successful management relies on:

- farm hygiene to keep fields free of RLN;
- growing tolerant varieties when RLN are present, to maximise yields; and rotating with resistant crops to keep RLN at low levels.
- Test soil to monitor population changes in rotations and to determine RLN species and population density.
- Avoid consecutive susceptible crops in rotations to limit the build-up of RLN populations.
- Choose rotation crops with high resistance ratings, so that fewer nematodes remain in the soil to infect subsequent crops.

Cereal root disease management in Victoria and southern Australia

Take-home messages

- Minimise losses associated with root diseases by inspection of plant roots in the previous crop or by using a PreDicta B soil test prior to sowing to identify at risk paddocks.
- Crown rot will be an important disease if the season finishes with a dry spring, as inoculum levels are high from the previous season. Reduce risk by rotating to non-cereal crops.
- In paddocks with high numbers of RLN, yield losses can be minimised by selecting partially tolerant cultivars and avoiding late sowing. Resistant cultivars can reduce nematode densities and therefore reduce losses in subsequent intolerant crops.
- CCN is a very damaging nematode if numbers are allowed to increase by growing susceptible cereals.

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1 L Martin (2015) Growing Cereal Rye to increase carbon and prevent wind erosion. Liebe Group, http://www.liebegroup.org.au/wp-content/uploads/2015/03/Case-Study-Jeff-Pearse-March-2015.pdf

2 JM Fisher, TW Hancock (1991) Population dynamics of Heterodera avenae Woll. in South Australia. Crop and Pasture Science, 42(1), 53-68.

3 Agriculture Victoria, (2013), Cereal root diseases, http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/plant-diseases/grains-pulses-and-cereals/cereal-root-diseases

4 G Hollaway (2013) Cereal root diseases, http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/plant-diseases/grains-pulses-and-cereals/cereal-root-diseases

- Rhizoctonia root rot will likely be a low risk if there is a wet summer with multiple rainfall events, provided summer weeds are controlled.
- Take-all will be a low risk if there is a dry spring, limiting inoculum build up.

Cereal root diseases can have serious impacts on grain yield in the absence of adequate control. The key to preventing root diseases is to identify paddocks at risk by inspecting the roots of previous cereal crops or taking a PreDicta B soil test prior to sowing. Knowledge of the potential root diseases in a paddock then enables the most appropriate control strategies to be implemented prior to and/or at sowing. Management must be implemented prior to sowing as there are no in-crop management options available for the control of root diseases, compared with many foliar diseases. [5]

8.1 Root-lesion nematode (RLN)

Key points

- RLN reduce development of lateral roots, which decreases the ability of plants to extract water and nutrients.
- *Pratylenchus neglectus* and *Pratylenchus thornei* are the main RLN causing yield loss in the southern agricultural region of Australia. They often occur together.
- Wheat is the main host, however varieties vary in resistance and tolerance.
- Traditional break crops can also be hosts. Host range varies for each *Pratylenchus* species.
- Yield losses can be reduced by rotation with resistant and tolerant crops and varieties, good nutrition and sowing early.
- Over 90% of paddocks in the Wimmera and Mallee regions have RLN present. [6]

The RLN are a genus of microscopic plant parasitic nematode that are soil-borne, ~0.5 to 0.75 mm in length, and feed and reproduce inside roots of susceptible crops or plants. There are two common species of RLN in the southern region: *Pratylenchus thornei* (*Pt*) and *Pratylenchus neglectus (Pn)*. They often occur together.

At least 20% of cropping paddocks in south-eastern Australia have populations of RLN high enough to reduce yield. [7]

RLN are migratory root endoparasites that are widely distributed in the cereal-growing regions of Australia and can reduce grain yield by up to 50% in many current varieties.

Rye is a poor host to the root lesion nematode (*Pratylenchus neglectus*), providing an alternative management approach for these diseases. [8]

The extent of RLN occurrence across Australia has recently been estimated (Figure 1).

5 G Hollaway, J Fanning, F Henry, A McKay (2015) GRDC Update Papers: Cereal root disease management in Victoria, https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2015/02/Cereal-root-disease-management-in-Victoria

6 CropPro (2014) Root lesion nematode (RLN), http://www.croppro.com.au/crop_disease_manual/ch03s07.php

7 Agriculture Victoria (2013) Cereal root diseases, http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/plant-diseases/grains-pulses-and-cereals/cereal-root-diseases

8 L Martin (2015) Growing Cereal Rye to increase carbon and prevent wind erosion. Liebe Group,

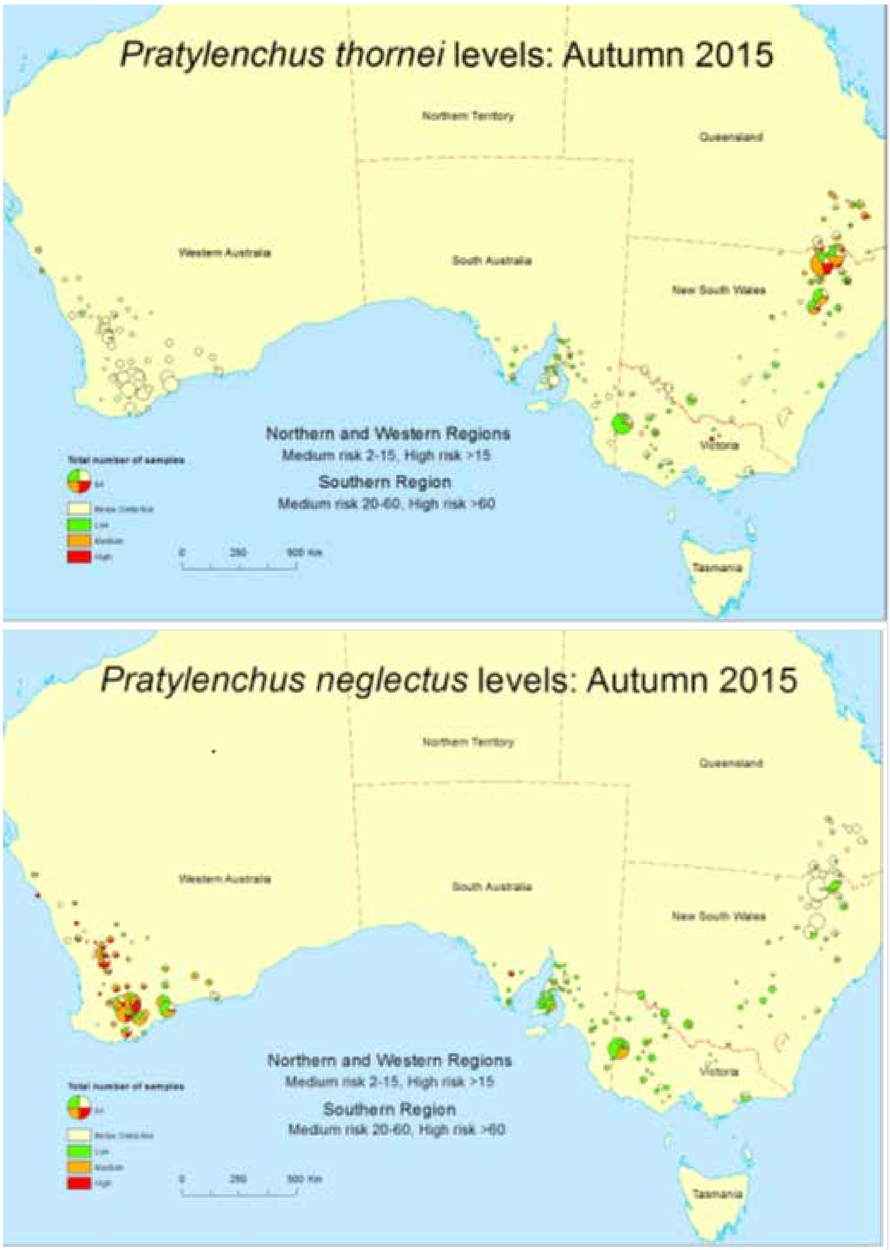


Figure 1: *The distribution and risk of causing yield loss of samples submitted to PreDictaB, SARDI in autumn 2015 for (top)* Pratylenchus thornei *and (bottom)* P. neglectus.

Maps are reproduced with permission from SARDI
Source: GRDC

RLN emerged as potential problems in cereals (and other crops) after management strategies were implemented to control CCN and take-all. 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. *Pratylenchus thornei* (Photo 1) occurs throughout the root zone and is often more damaging than *P. Neglectus*, which tends to be concentrated in the top 15 cm of the soil.

RLN survive summer as dormant individuals in dry soil and roots, and become active after rain. They can survive several wetting/drying cycles. About three generations of the nematodes are produced each season, with the highest multiplication in spring. [9]

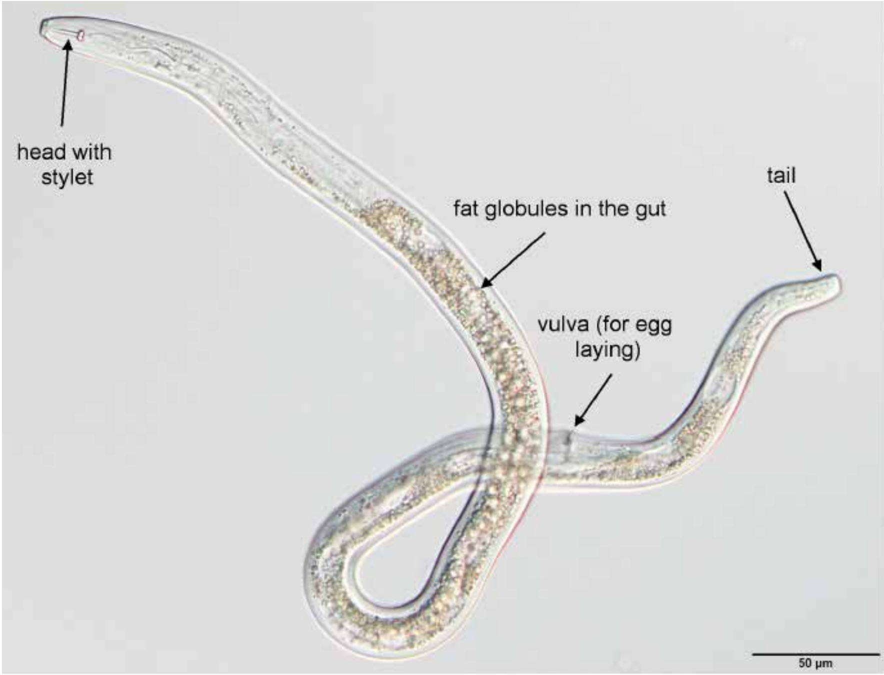


Photo 1: *A* Pratylenchus thornei *adult female viewed under the microscope. The nematode is approximately 0.65 mm long.*

Source: GRDC

VIDEOS

WATCH: GCTV6: Root-lesion nematodes.

WATCH: Understanding root-lesion nematodes.

8.1.1 Symptoms

Paddock

- Crops appear patchy with uneven growth, and may appear nutrient deficient (Photo 2).
- Double sown and more fertile areas are often less affected.
- There may be stunted growth and waviness across the paddock.

9 A McKay (2016) Root lesion nematode—South Australia, http://www.soilquality.org.au/factsheets/root-lesion-nematode-south-australia

Photo 2: *Poor vigour cereal in high RLN plot (left) compared to healthy plot with low RLN (right).*

Photo: Grant Hollaway. Source: Soilquality.org

Plant

- Affected plants are stunted and poorly tillered and can wilt despite moist soil.
- Roots can have indistinct brown lesions or, more often, generalised root browning (Photo 3).
- Badly affected roots are thin and poorly branched with fewer and shorter laterals.
- Roots may appear withered with crown roots often less affected than primary roots.
- Roots can assume a "noodle-like" root thickening appearance. [10]
- Unlike the CCN, RLN do not cause the roots to swell or knot and no cysts are produced. [11]

10 DAFWA (2016) Diagnosing Root lesion nematode in cereals, https://agric.wa.gov.au/n/2166

11 CropPro (2014) Root lesion nematode (RLN), http://www.croppro.com.au/crop_disease_manual/ch03s07.php

Photo 3: *Discolouration and lack of lateral roots on cereals is caused by root lesion nematodes.*

Photo: Frank Henry. Source: Soilquality.org

VIDEOS

WATCH: How to diagnose root-lesion nematode.

8.1.2 Soil testing

PreDictaB

Cereal root diseases cost grain growers in excess of $200 million a year in lost production. Much of this can be prevented.

PreDicta B (B = broadacre) is a DNA-based soil testing service that identifies which soil-borne pathogens pose a significant risk to broadacre crops prior to seeding (Photo 4).

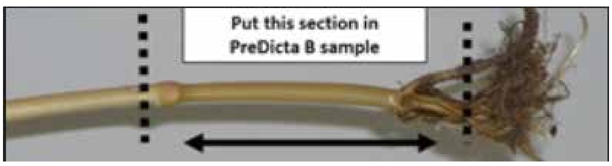


Photo 4: *Sampling for PreDicta B*

Source: GRDC

MORE INFORMATION

GRDC Update Paper: Root-lesion nematodes; importance, impact and management.

VIDEOS

WATCH: Root-Lesion Nematodes. Resistant cereal varieties have surprising impacts on RLN numbers.

PreDicta B includes tests for:

- Take-all (*Gaeumannomyces graminis var tritici (Ggt)* and *G. graminis var avenae (Gga)*).
- Rhizoctonia barepatch (*Rhizoctonia solani AG8*).
- Crown rot (*Fusarium pseudograminearum and F. culmorum*).
- Blackspot of peas (*Mycosphaerella pinodes, Phoma medicaginis var pinodella* and *Phoma koolunga*).

Access PreDicta B testing service

Growers can access PreDicta B diagnostic testing services through a SARDI accredited agronomist. They will interpret the results and give advice on management options to reduce your risk of yield loss.

SARDI process PreDicta B samples weekly between February and mid-May (prior to crops being sown) every year.

These timeframes help assist growers with cropping programs.

PreDicta B is not intended for in-crop diagnosis. See the crop diagnostic webpage for other services.

8.1.3 Varietal resistance or tolerance

Few cereals are resistant to RLN. It is important to check the resistance ratings of cultivars, as current research is highlighting differences between cultivars. Rye is thought to be resistant to *P. neglectus.* [12]

8.1.4 Damage caused by RLN

RLN are more likely to be a problem when:

- Susceptible varieties are grown sequentially increasing nematode numbers.
- An intolerant crop is sown.
- Sowing is delayed. [13]

During recent years the Department of Economic Development and SARDI have conducted field studies to quantify losses caused by RLN in the southern cropping region. This work measured grain yield in the presence of high and low numbers of the target nematode. Table 1 shows the average yield loss caused by RLN in the five most intolerant cereal cultivars in Victorian field trials. There was large seasonal effects observed. The yield losses caused by *P. neglectus* were less than those caused by *P. thornei*.

Table 1: *Average yield loss due to root lesion nematodes in the five most intolerant cereal cultivars across five growing seasons along with average rainfall.*

	P. thornei **(Banyena)**		***P. neglectus*** **(Dooen)**	
Year	**Yield Loss (%)**	**Rainfall (mm)**	**Yield Loss (%)**	**Rainfall (mm)**
2011	12.2	241	2.0	256
2012	9.9	268	6.7	254
2013	1.9	353	2.5	326
2014	4.3	253	6.7	215

Source: GRDC

12 Soilquality.org. Root lesion nematode Factsheet, http://soilquality.org.au/factsheets/root-lesion-nematode

13 G Hollaway (2013) Cereal root diseases, http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/plant-diseases/grains-pulses-and-cereals/cereal-root-diseases

8.1.5 Conditions favouring development

Nematodes can spread through a district in surface water (e.g. floodwater) and can be moved from one area to another in soil adhering to vehicles and machinery. They have the ability to quickly build up populations in the roots of susceptible crops and remain in the soil during fallow. As a result, the yield of following crops can be significantly reduced.

How long does it take to reduce Pt in soils?

Key points

- *P. thornei* (Pt) populations greater than 40,000/kg at harvest will require a double break of around 40 months free of a host to reduce the population below the accepted threshold of 2,000 Pt/kg.
- *P. thornei* populations greater than 10,000/kg at harvest will require a single break of around 30 months free of a host to reduce the population below the accepted threshold of 2,000 Pt/kg
- Weeds can be a host, so fallows must be weed free and free of volunteers.

Cereal cropping trials in the Northern region have highlighted the importance of the initial population when reducing nematode populations below the damage threshold. Over 30 months, the rate of decline in nematode populations with various starting populations and in a particular cropping sequence were monitored. High population of 80 nematodes/cm^3 (~80,000 Pt/kg) took four years to reduce below the threshold. This would require two non-host crops such as sorghum and fallows to reduce the population. A moderate initial population of 50 nematodes/cm^3 took three and a half years (Figure 2), requiring the equivalent of a single non-host summer crop and fallows. A population of 20 nematodes/cm^3 took 24 months.

The long survival mechanisms of root-lesion nematodes highlight the importance of knowing the size of the population at the end of each season. Once a population increases, non-host, resistant crops or fallows are required to reduce the population below the damage threshold. Planting susceptible or tolerant crops within this time period will increase populations to higher levels that will take longer to reduce, thereby limiting cropping options, and potentially reducing the profitability of the overall farming system. As resistant wheat varieties are released they can be used to provide a winter decline option to increase non-host periods within the rotation. [14]

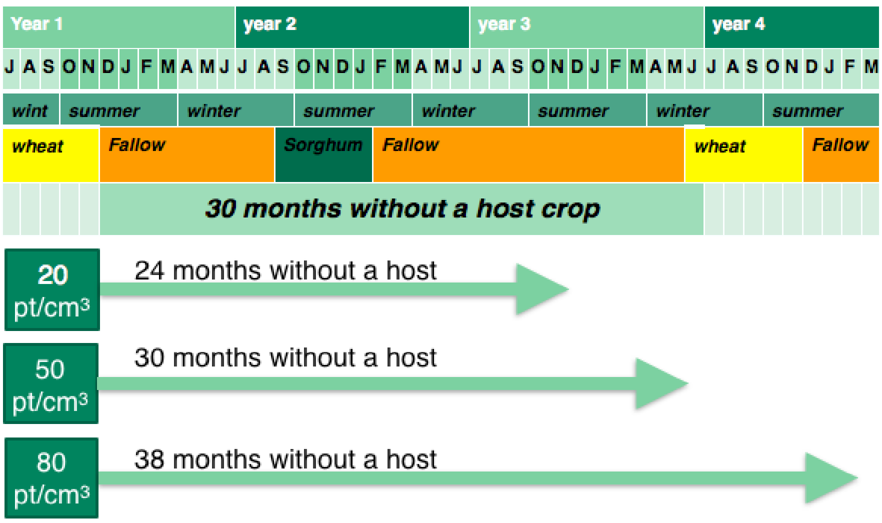


Figure 2: *An example of a non-host fallow showing the time required to reduce different starting populations of root-lesion nematode.*

Source: GRDC

14 J Which, J Thompson (2016) GRDC Update Paper: How long does it take to reduce *Pt* populations in the soil? https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2016/02/how-long-does-it-take-to-reduce-Pratylenchus-thornei-populations-in-the-soil

MORE INFORMATION

How long does it take to reduce *Pratylenchus thornei* (Root lesion nematode) population in the soil?

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. [15]

8.1.7 Management of RLN

Key points

- Know your enemy—soil test to determine whether RLN are an issue and which species are present.
- Select wheat varieties with high tolerance ratings to minimise yield losses in RLN infected paddocks.
- To manage RLN populations, it is important to increase the frequency of RLN resistant crops in the rotation.
- Multiple resistant crops in a rotation will be necessary for long term management of RLN populations.
- There are consistent varietal differences in *Pratylenchus thornei* (*Pt)* resistance within wheat and chickpea varieties.
- Avoid crops or varieties that allow the build-up of large populations of RLN in infected paddocks.
- Monitor the impact of your rotation.

There are four key strategies in reducing the risk of RLN:

1. Have soil tested for nematodes in a laboratory.
2. Protect paddocks that are free of nematodes by controlling soil and water runoff and cleaning machinery; plant nematode-free paddocks first.
3. Choose tolerant wheat varieties to maximise yields (go to nvtonline.com.au). Tolerant varieties grow and yield well when RLN are present.
4. Rotate with resistant crops to prevent increases in root-lesion nematodes (Figure 3, Table 2). When high 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 to ensure that the yield potential of tolerant varieties is achieved.

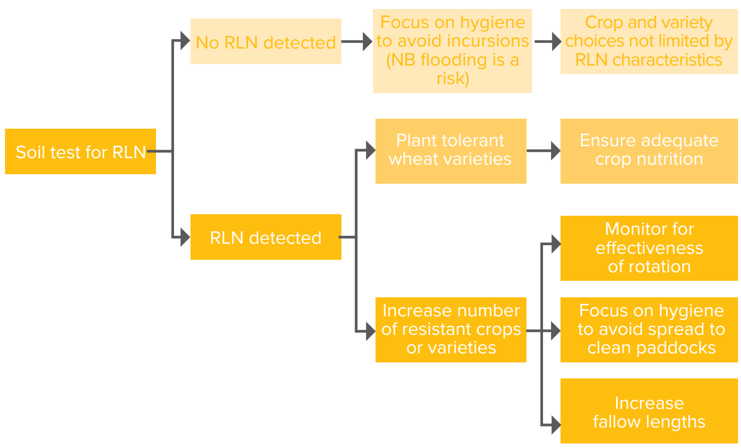


Figure 3: *RLN management flow chart—a simplified chart that highlights that the critical first step in the management of RLN is to test your soil and determine whether you have an issue to manage.*

NB: where RLN are present, growers should focus on both 1) planting tolerant wheat varieties and 2) increasing the number of resistant crops/varieties in the rotation.

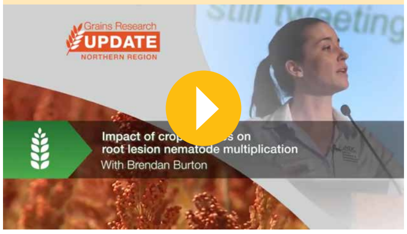
Source: GRDC

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

VIDEOS

WATCH: Root lesion nematodes—What can I do?

WATCH: Crop variety effect on nematode.



MORE INFORMATION

GRDC Tips and tactics: Root-lesion nematodes Southern Region.

Table 2: *Susceptibility of some non-cereal crop and pasture species to root lesion nematode infection. Cereal rye is thought to be resistant to P. neglectus.*

RLN Species	Susceptible	Moderately susceptible	Resistant
Pratylenchus neglectus	canola, chickpea, mustard	common vetch, lentil	field pea, narrow leaf lupin, faba bean, triticale, safflower, cereal rye, medic, clover
Pratylenchus thornei	chickpea, vetch, faba bean	canola, mustard, field pea, lentil	field pea, lupin

Source: Soilquality.org.

There are four major control strategies against RLN:

1. **Nematicides** (control in a drum): There are no registered nematicides for RLN in broadacre cropping in Australia. Screening of potential candidates continues to be conducted but RLN are a very difficult target with populations frequently deep in the soil profile.
2. **Nutrition**: Damage from RLN reduces the ability of cereal roots to access nutrients and soil moisture and can induce nutrient deficiencies. Under fertilising is likely to exacerbate RLN yield impacts however over-fertilising is still unlikely to compensate for a poor variety choice.
3. **Variety choice and crop rotation:** *These are currently our most effective management tools for RLN.* However, the focus is on two different characteristics—*Tolerance* (ability of the variety to yield under RLN pressure) and *Resistance* (impact of the variety on the buildup of RLN populations). NB varieties and crops often have varied tolerance and resistance levels to *Pt* and *Pn*.
4. **Fallow:** RLN populations will generally decrease during a “clean” fallow, but the process is slow and expensive in lost “potential” income. Additionally long fallows may decrease Mycorrhizal (VAM) levels and create more cropping issues than they solve. [16]

8.2 Cereal Cyst Nematode (CCN)

Key points

- CCN is a threat to cereals in the Southern and Western growing regions.
- Rye is resistant to CCN, providing an alternative management approach for these diseases. [17]
- Rye can reduce the amount of CCN in a paddock. In one study, the biggest reduction in CCN numbers occurred in cereal rye (cv. South Australia), which reduced populations by 92% in the first year. [18]
- CCN is most damaging in low rainfall districts/seasons, especially with late breaks.
- Rotations—use break crops to minimise carry-over of CCN host species (canola, lupins, chickpeas etc.) as non-host crops are more effective than resistant cereals in reducing levels of CCN.
- Be aware of and try to minimise consecutive cereal hosts during your rotation. CCN levels can become damaging after only one or two seasons of a susceptible crop.
- Grow resistant cereal cultivars to limit levels of CCN in the soil.

16 B Burton, R Norton, R Daniel (2015) GRDC Update Paper: Root-lesion nematode; importance, impact and management. NGA, https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2015/08/Root-lesion-nematodes-importance-impact-and-management

17 L Martin L (2015) Growing Cereal Rye to increase carbon and prevent wind erosion. Liebe Group, http://www.liebegroup.org.au/wp-content/uploads/2015/03/Case-Study-Jeff-Pearse-March-2015.pdf

18 JM Fisher, TW Hancock (1991) Population dynamics of Heterodera avenae Woll. in south Australia. Crop and Pasture Science, 42(1), 53-68.

- Control volunteer cereal hosts and grass weeds during late summer/early autumn and in break crops.
- Sow early where possible to ensure better root development.
- Maintain optimum soil fertility to "get-ahead" of CCN infections.

CCN is a pest of graminaceous crops worldwide. This nematode is a significant problem across eastern Australia. CCN becomes more problematic in areas where intensive cereal cropping occurs. CCN will only infect, feed and develop on cereals and other grasses (particularly wild oat). Non-cereal crops will not host the nematode, so are useful in rotations to limit damage caused to cereals.

Cereal Rye is tolerant and will yield well despite being attacked.

CCN usually occurs early in the season and can occur on heavy or light soils.

IN FOCUS

The effect of plant hosts on populations of the cereal cyst nematode (Heterodera a Venae) and on the subsequent yield of wheat

Microplots containing soil, naturally infested with the cereal cyst nematode (*Heterodera avenae*) were left fallow or sown to one of nine cereal cultivars or grass species for five consecutive years. Wild oat was the most efficient host and, after three plantings, the nematode reached a potential increase ceiling of 42.2 eggs/g soil. Of the cereal cultivars tested, wheat (cv. Olympic) and barley (cv. Prior) were the most efficient hosts and levels of approximately 40 eggs/g were reached after five plantings. Barley grass was less efficient than Wimmera ryegrass, which maintained a ceiling population of about 10 eggs/g. Under fallow, populations declined to 0.5 eggs/g after four years. The most inefficient cereal hosts were the oat, cv. Avon, and cereal rye, cv. South Australian. The low populations maintained under continuous cropping with these cereals suggested that a rapid selection of a resistance-breaking biotype is unlikely to result from the continued use of inefficient hosts. Growth and yield of a subsequent wheat crop on all plots reflected the relative levels of nematode populations. At the low levels of infestation, grain yields were more than double those on heavily infested plots. [19]

CCN juveniles hatch from eggs contained in the cysts remaining from previous seasons in response to lower temperatures and autumn rains. Hatching is delayed by late breaks or dry autumns and this increases the risk of crop damage. Once hatched, the young nematodes seek out the roots of host plants. While the male nematodes remain free-living in the soil, the females penetrate roots and begin feeding. Following mating, the females produce eggs within their body. As the season progresses the females remain feeding at the same infection site and begin to swell into the characteristic white spheres. This process takes 6–9 weeks, and the CCN females remain like this until the host plant begins to senesce. The females die and their cuticle hardens and turns brown to form a cyst. Cysts are particularly hardy, and remain in the soil over summer until temperatures fall and the autumn rains begin which stimulates hatching of the next generation. CCN have only one life cycle per

19 JW Meagher, RH Brown, (1974) Microplot Experiments On the Effect of Plant Hosts On Populations of the Cereal Cyst Nematode (Heterodera a Venae) and On the Subsequent Yield of Wheat. Nematologica, 20(3), 337-346.

year (Figure 4). However, each cyst contains several hundred eggs, so populations can increase rapidly on susceptible cereals. [20]

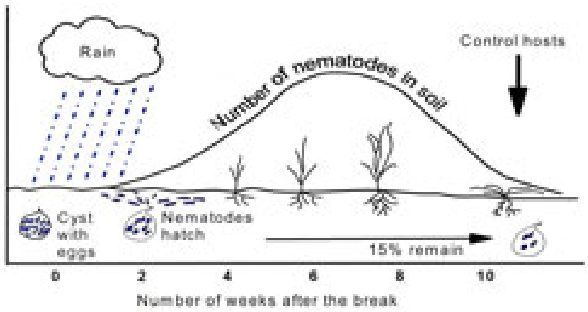


Figure 4: *Life cycle of the cereal cyst nematode.*

Source: AgVic

CCN survives between susceptible cereal crops as eggs inside protective cysts that form on the roots of host plants. In the autumn, nematodes hatch from eggs in response to moisture and low temperatures (<15°C). Nematodes hatch over a period of several weeks, with the peak hatch occurring about six weeks after the autumn break. In a further eight weeks these nematodes will form viable eggs. Therefore, to prevent CCN multiplying, it is necessary to control host plants within 10 weeks of crop germination.

Each year approximately 80% of nematodes hatch from cysts after the autumn break, while the remaining 20% stay dormant until the following season. This is why it will take at least two years with "break" crops to control CCN. However, under dry (drought) conditions up to 50% of nematodes remain dormant, and an extra year of "break" crop is advisable. [21]

8.2.1 Symptoms and detection

The symptoms of CCN infection can be readily recognised. Above ground, patches of unthrifty yellowed and stunted plants can be observed (Photo 5). Planting a susceptible crop in successive years will result in these patches becoming larger with time.

Closer examination of the roots will reveal symptoms that are typical of CCN. Below ground, cereal roots can appear 'knotted' (Photo 6), and 'ropey' or swollen (Photo 7). Development of root systems is retarded and shallow. In spring, characteristic white cysts (about the size of a pin head) can be seen with the naked eye if roots are carefully dug and washed free of soil. These are the swollen bodies of the female CCN, each containing several hundred eggs. [22]

20 A Wherrett V Vanstone V. Cereal cyst nematode. Soilquality.org, http://www.soilquality.org.au/factsheets/cereal-cyst-nematode

21 G Hollaway, F Henry (2013) Cereal root diseases. Agriculture Victoria, http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/plant-diseases/grains-pulses-and-cereals/cereal-root-diseases

22 A Wherrett V Vanstone V. Cereal cyst nematode. Soilquality.org, http://www.soilquality.org.au/factsheets/cereal-cyst-nematode

Photo 5: *CCN will cause distinct patches of yellowed and stunted plants. Note the likeness of symptoms to poor nutrition or water stress.*

Photo: Vivien Vanstone, DAFWA, Nematology. Source: Soilquality.org

Photo 6: *CCN produce 'knotting' of cereal roots.*

Photo: Vivien Vanstone, DAFWA, Nematology. Source: Soilquality.org

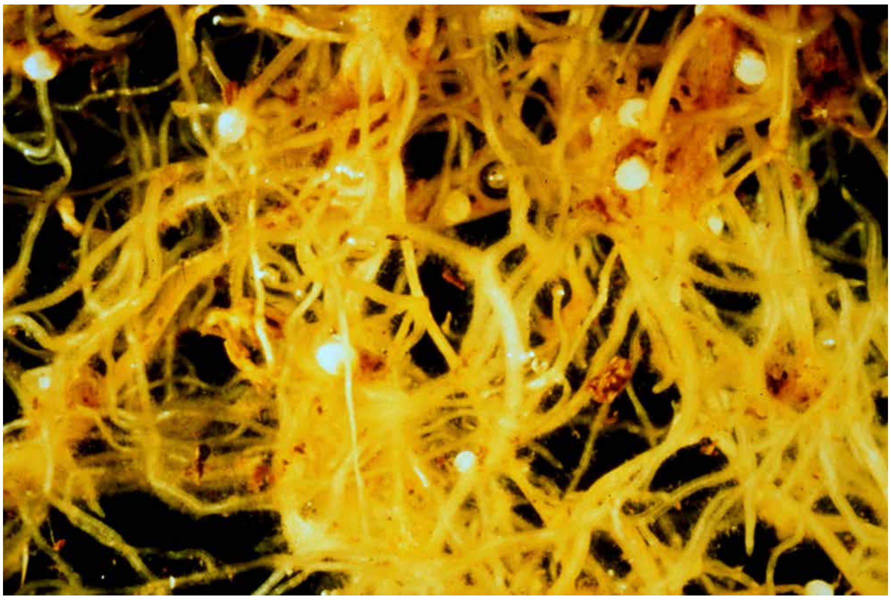


Photo 7: *Cereal roots infected with CCN appear "ropey" and swollen.*

Source: CropPro

8.2.2 Varietal resistance or tolerance

Rye is resistant to CCN, providing an alternative management approach for these diseases. [23]

8.2.3 Damage caused by CCN

In serious outbreaks of CCN, it may be important to avoid cereals for two years to ensure an adequate reduction in the population. Just two CCN eggs/g soil can cause significant economic loss to intolerant cereal crops. Levels of 1—5 eggs/g soil can reduce yield of intolerant cultivars by up to 20%. [24]

8.2.4 Management

In general, CCN has been well managed in Victoria through the widespread use of resistant cultivars.

Plan ahead and make sure there is at least a two-year disease break following susceptible cereals on paddocks infested with wild oats. Timing of host removal is critical when establishing a disease break. In calculating the critical date to chemical fallow or remove host species from break crops consideration should be given to the time taken for host plants to die after herbicide application. Nematodes will continue to feed until the plant is dead.

Host plants, particularly wild oats and susceptible self-sown cereals, must be controlled before the nematodes have completed the development of eggs. This is approximately 10 weeks after the autumn break (See Figure 4 above).

The use of resistant cereals and non-host crops, or fallow in rotations as part of a two-year break is an effective method to control CCN.

In areas prone to CCN, such as the Wimmera and Mallee, it is important to maintain a high proportion of CCN resistant cereals in the rotation.

Disease breaks for CCN

- Grass free pulse and oilseed crops or legume pasture.

23 L Martin (2015) Growing Cereal Rye to increase carbon and prevent wind erosion. Liebe Group, http://www.liebegroup.org.au/wp-content/uploads/2015/03/Case-Study-Jeff-Pearse-March-2015.pdf

24 A Wherrett, V Vanstone (2016) Cereal Cyst Nematode, http://www.soilquality.org.au/factsheets/cereal-cyst-nematode

- Resistant cereals (See local Cereal Diseases Guide for a list of CCN resistant cereal varieties).
- Chemical fallow prepared early in the season before nematodes have produced viable eggs.

As with other nematodes, there is no effective or economically feasible means of controlling CCN through chemical application. Chemical nematicides are expensive to use and toxic to humans, and the success of applications are often highly variable. Cereal cyst nematode is best controlled through effective rotation management. Only 70—80% of eggs hatch each season, regardless of the crop host. As a result, it can take several years for high CCN levels to be reduced by rotation with resistant or non-host crops. The use of a break crop (e.g. canola, lupins, chickpeas) ensures a large proportion of the CCN population is removed. In serious outbreaks of CCN, it may be important to avoid cereals for two years to ensure an adequate reduction in the population.

Ryegrass, wild oats and other grass are also good hosts for CCN, although reproduction rates may be lower than on the cropping species. For this reason, is important to realise that during a pasture phase in a rotation, the existence of cereal weeds will assist the development of a CCN population. Likewise, if there are grasses present following summer rains or around paddock borders it provides a carry over for the nematode population.

Ensuring optimum soil fertility is maintained helps to minimise the effects of CCN. Allowing the emerging crop access to adequate nutrition allows the root systems to establish and "get ahead" of any potential nematode infections. Although this does not decrease the nematode population, losses associated with CCN infections will be minimised.

Finally, in paddocks where there is a known population of CCN and the planting of a cereal cannot be avoided, it is important to choose cultivars displaying CCN resistance. [25]

8.3 Nematodes and crown rot

While all winter cereals host the crown rot fungus, yield loss due to infection varies with cereal type. The approximate order of increasing yield loss is cereal rye, oats, barley, bread wheat, triticale and durum wheat. [26]

Many trials concentrate on crown rot, and it is becoming more important to build a picture of the interaction of crown rot with other factors, especially in combination with *Pratylenchus thornei* (*Pt)* levels. As well as reducing yield, *Pt* reduces grain quality and nitrogen use efficiency, and increases the severity of crown rot infections. [27]

There have been numerous field trials since 2007 evaluating the impact of crown rot on a range of winter-cereal crop types and varieties. This work has greatly improved the understanding of crown rot impact and variety tolerance, but also indicates that we may be suffering significant yield losses from another "disease" that often goes unnoticed.

Although the trials were not designed to focus on nematodes, a convincing trend was apparent after 2008 that indicated *P. thornei* was having a frequent and large impact on wheat variety yield. [28]

Where Pt combines with high levels of crown rot (a common scenario), yield losses can be exacerbated if varieties are susceptible to Pt. Instead of a 10% yield loss from

25 A Wherrett, V Vanstone. Cereal cyst nematode. Soilquality.org, http://www.soilquality.org.au/factsheets/cereal-cyst-nematode

26 GRDC (2016) Tips and Tactics: Crown rot in winter cereals—Southern region.

27 Dixon T. (2013). Balancing Crown rot and Nematodes in wheat. Ground Cover Issue 104: May – June 2013. https://grdc.com.au/Media-Centre/Ground-Cover/Ground-Cover-Issue-104-May-June-2013/Balancing-crown-rot-and-nematodes-in-wheat

28 R Daniel (2013) Managing root-lesion nematodes: how important are crop and variety choice? Northern Grower Alliance/GRDC Update Paper, 16/07/2013.

Pt in a susceptible variety, it could be 30–50% if crown rot is combined with a Pt-intolerant variety (Photo 8).

The research has also shown that not only does Pt cause high yield loss in susceptible varieties, but Pt numbers can increase much faster than in an area in which tolerant varieties are growing. These increased Pt numbers can lead to even greater damage in future crops. [29]

Photo 8: *Grass plant showing both parasitic nematode damage to roots and crown rot in above ground tissues.*

Source: NCSU

8.3.1 Management

Variety choice is the key management option when it comes to managing Pt 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. RLN, especially Pt, need to be taken far more seriously and better factored into crop rotation considerations as well as variety choice. [30]

Soil testing

PreDictaB

Cereal root diseases cost grain growers in excess of $200 million a year in lost production. Much of this can be prevented.

PreDicta B (B = broadacre) is a DNA-based soil testing service that identifies which soil-borne pathogens pose a significant risk to broadacre crops prior to seeding (Photo 9).

VIDEOS

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

29 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

30 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

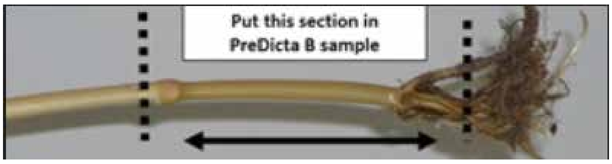


Photo 9: *Sampling for PreDicta B*

Source: GRDC

PreDicta B includes tests for:

- Take-all (*Gaeumannomyces graminis var tritici (Ggt)* and *G. graminis var avenae (Gga)*).
- Rhizoctonia barepatch (*Rhizoctonia solani AG8*).
- Crown rot (*Fusarium pseudograminearum and F. culmorum*).
- Blackspot of peas (*Mycosphaerella pinodes, Phoma medicaginis var pinodella* and *Phoma koolunga*).

Access PreDicta B testing service

Growers can access PreDicta B diagnostic testing services through a SARDI accredited agronomist. They will interpret the results and give advice on management options to reduce the risk of yield loss.

SARDI process PreDicta B samples weekly between February and mid-May (prior to crops being sown) every year.

These timeframes help assist growers with cropping programs.

PreDicta B is not intended for in-crop diagnosis. See the crop diagnostic webpage for other services.

Varietal choice

Crop rotation and variety choice are the important factors in protection against both diseases. Choosing a variety solely on crown rot resistance is not critical, especially if appropriate management techniques have been carried out, but choice of variety is crucial when it comes to RLN tolerance.

Further research into varietal tolerance to crown rot and nematodes has revealed that choosing a variety is difficult. Determining the relative tolerance of varieties to crown rot is complex as it can be significantly influenced by background inoculum levels, RLN populations, differential variety tolerance to *Pn* versus *Pt* and varietal interaction with the expression of crown rot. Other soil-borne pathogens such as *Bipolaris sorokiniana*, which causes common root rot, also need to be accounted for in the interaction between crown rot and varieties. Starting soil water, in-crop rainfall, relative biomass production, sowing date and resulting variety phenology in respect to moisture and/or temperature stress during grainfill can all differentially influence the expression of crown rot in different varieties. [31]

The approximate order of increasing yield loss to crown rot is: cereal rye, oats, barley, bread wheat, triticale and durum wheat. [32] There is limited research on the tolerance of cereal rye to *P. thornei*.

31 S Simpfendorfer, M Gardner, G Brooke, L Jenkins (2014) Crown rot and nematodes—are you growing the right variety? GRDC Update Papers 6 March 2014, https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2014/03/Crown-rot-and-nematodes

32 GRDC. (2016). Tips and Tactics: Crown rot in winter cereals. Southern region.