Root-lesion nematodes

Management of root-lesion nematodes in the northern grain region

Index

Summary

- Root-lesion nematodes, *Pratylenchus thornei* and *Pratylenchus neglectus*, have been detected at potentially damaging levels in nearly 30% of fields in the northern grain region.
- Intolerant wheat varieties can lose more than 50% in yield and some chickpea varieties up to 20% yield when nematode populations are high.
- The best way to find out if there are nematodes in your fields and if they are at damaging levels is to have soil samples tested in a laboratory.
- Successful management relies on:
  1. Growing tolerant crop varieties to maximise yields when root-lesion nematodes are present.
  2. Rotating with resistant crops to keep root-lesion nematodes at low levels.
  3. Cleaning soil from farm machinery to keep fields/farms free of root-lesion nematodes.

What are nematodes?

Nematodes are minute (mostly less than 1 mm long) eel-like worms that live in many environments including the soil. They are the most numerous multi-cellular animal life-forms on earth. Many nematodes feed on soil microorganisms and contribute beneficially to the cycling of nutrients. However, some species feed on the roots of plants. These plant-parasitic nematodes are equipped with mouthparts that form a retractable, hollow, spear-like structure ('stylet') which they use to break the walls of root cells and withdraw the contents for their nutrition.

Endoparasitic nematode species enter into the root tissues by using their stylet and head to physically break root cell walls and by excreting enzymes that dissolve cell walls. Ectoparasitic nematodes remain outside the roots and use their stylet to feed on root hairs and surface cells of the root.

Photo 1: Root-lesion nematodes and egg viewed under a microscope. The stylet in the nematode's mouth is used to break plant cell walls and for feeding.

What are root-lesion nematodes?

There are two important species of root-lesion nematode in the northern grain region, *Pratylenchus thornei* (the most commonly found species) and *Pratylenchus neglectus*. Root-lesion nematodes feed and reproduce inside plant roots (endoparasitic nematodes). The damage to the plant roots leads to yield loss in crops such as wheat and chickpea. These nematodes can also build-up numbers under many other crops. Root-lesion nematodes in the northern grain region can be found deep in the soil profile and in some cases peak populations occur 30–60 cm deep in the soil (see Figure 1).

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Examples of root-lesion nematode distributions

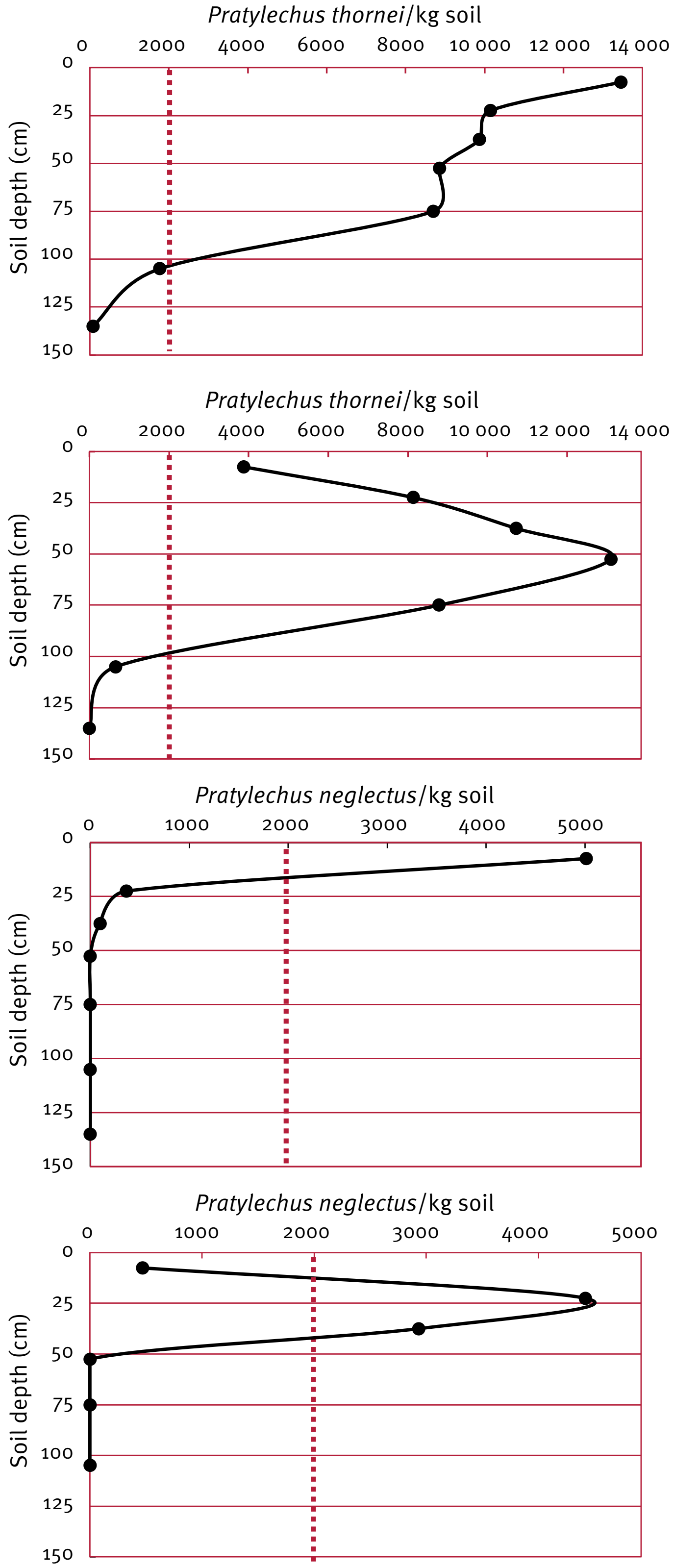


Figure 1: Examples of how root-lesion nematodes are distributed in soil profiles from a number of farms in the northern grain region just before planting in winter. In some cases, highest numbers are found in the upper layers of soil; in other cases, nematodes are more numerous deeper in the soil. If nematode numbers exceed 2000/kg soil (red dotted line) anywhere in the soil profile, then intolerant wheat varieties can lose yield.

What are the symptoms of root-lesion nematode infection?

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.

Root damage—dark lesions, poor root structure

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

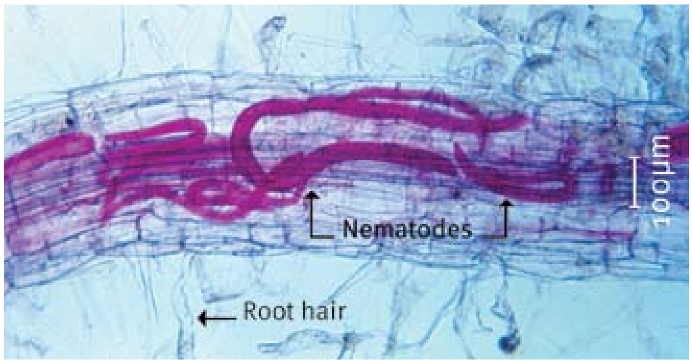


Photo 2: Stained nematodes in a wheat root.

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 wheat rows appear more open (see Photo 3).

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.

Deteriorating wheat yields over several years, called 'wheat sickness', may also indicate a nematode problem.

Photo 3: Symptoms of severe root-lesion nematode damage to an intolerant wheat variety.

Life cycle

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 6 weeks under favourable conditions (warm, moist soil) and so pass through several generations in the life of one host crop. The newly hatched nematodes can remain in the plant roots, or leave the plant to seek another root system to attack. The nematodes survive through fallow periods, particularly in the subsoil where they escape the hot, drying conditions of the surface soil. In drought, the nematodes can dehydrate (anhydrobiosis) to further aid their survival until favourable conditions return.

What is resistance and tolerance?

Resistance: nematode multiplication

- Resistant crops do not allow root-lesion nematodes to reproduce and increase in number in their roots.
- Susceptible crops allow root-lesion nematodes to reproduce so that their numbers increase. Moderately susceptible crops allow increases in nematode populations but at a slower rate.

Tolerance: crop response

- Tolerant varieties/crops yield well when sown in fields containing high populations of nematodes.
- Intolerant varieties/crops yield poorly when sown in fields containing high populations of nematodes.

Crop damage and potential losses

Root-lesion nematode numbers build up steadily under susceptible crops and cause decreasing yields over several years (see Figure 2). Yield losses greater than 50% can occur in some wheat varieties and up to 20% yield loss in some chickpea varieties. The amount of damage caused will depend on:

- the numbers of nematodes in the soil at sowing
- the tolerance of the variety of the crop being grown
- the environmental conditions.

Generally, a population density of 2000 root-lesion nematodes per kilogram soil anywhere in the soil profile has the potential to reduce the grain yield of intolerant wheat varieties.

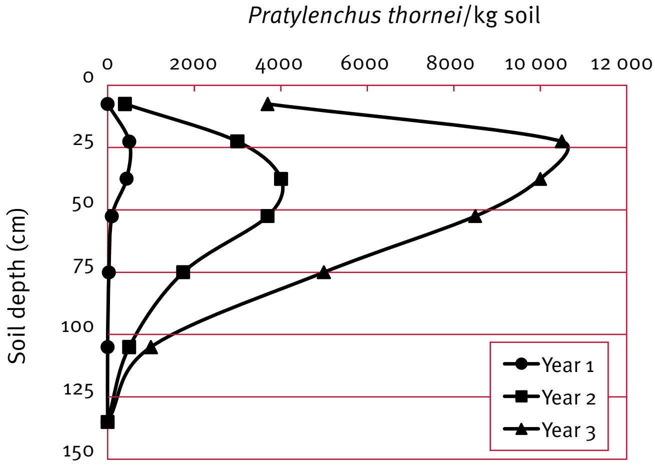


Figure 2: During 3 years of continuous wheat at Wellcamp, Queensland, numbers of root-lesion nematode (*Pratylenchus thornei*) increased from low levels to levels that would reduce yields of intolerant crops. The graphs show numbers in the soil sampled before sowing wheat each year.

How widely are root-lesion nematodes distributed?

Pratylenchus thornei is the most common root-lesion nematode and is present in about two-thirds of fields in the northern grain region. *Pratylenchus neglectus* is found in about one-third of fields and both species occur together in just over one-quarter of fields. About one-quarter of fields have no root-lesion nematodes (see Figure 3).

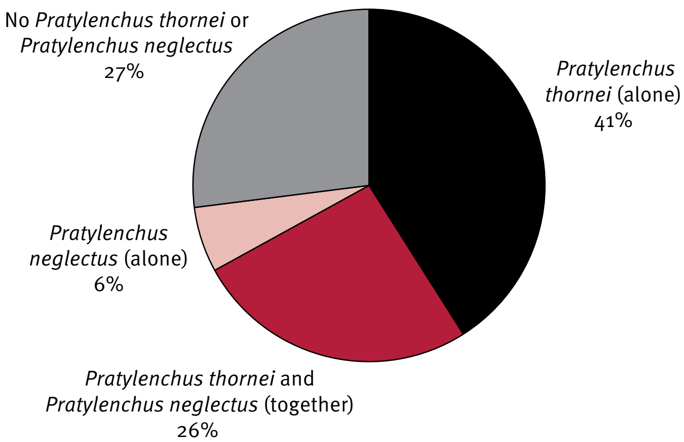


Figure 3: A survey of nematodes in close to 800 farmers' fields in the northern grain region revealed that *Pratylenchus thornei* is the most commonly found root-lesion nematode in the region and that *Pratylenchus neglectus* is also present.

How did root-lesion nematodes spread into the northern grain region?

Pratylenchus thornei was probably introduced into the northern grain region. Root-lesion nematode populations increase as the period of cultivation of wheat increases.

A good example of this is shown in Table 1. Samples taken from a farm at Pirrinuan on the Darling Downs, Queensland had no *Pratylenchus thornei* present in virgin grassland, or in a field that had been cropped for only 3 years, but they were present in large numbers in a field that had been cropped for 20 years and had grown 12 wheat crops. The effect on wheat yields was dramatic.

Table 1. The number of wheat crops and years of cultivation increase populations of root-lesion nematode (*Pratylenchus thornei*) which have negative effects on wheat yields (data from Pirrinuan, Queensland).

Number of years of cultivation	Total number of wheat crops	*Pratylenchus thornei*/kg soil	Wheat yield (t/ha)
0 (virgin grassland)	0	0	–
3	3	0	4.6
20	12	7700–11 700	2.5

The farm at Pirrinuan provided an ideal site for research and therefore paired trials of wheat varieties were grown on the nematode-free and nematode-infected sites. Some varieties were treated with a nematicide. Results are shown in Table 2 for the *P. thornei*-intolerant Australian variety Gatcher and the tolerant Mexican variety Potam. Where fertiliser was applied, the major difference in yield of intolerant varieties between the old and new cultivation was the presence of *P. thornei*. Nematicide gave substantial yield response but controlled the nematodes in the top soil only.

Table 2: The farm at Pirrinuan, Queensland was an ideal site for research and clearly showed that poor wheat yields were due to the damaging effects of high populations of the root-lesion nematode, *P. thornei*.

	Grain yield (kg/ha)		
	Nematode-infested site		*Nematode-free site*
	– nematicide	+ nematicide	
Intolerant wheat (Gatcher)	898	1656	2887
Tolerant wheat (Potam)	2462	2543	2852

What soil types do root-lesion nematodes prefer?

There are no hard and fast rules for the type of soil that root-lesion nematodes prefer. Root-lesion nematodes are found throughout the northern grain region in soil types ranging from heavy clays to sandy soils.

Tolerant and resistant wheat varieties

Tolerant wheat varieties

Valuable information has been obtained on the tolerance of northern wheat varieties to *Pratylenchus thornei* and breeding programs have actively selected for this trait. Examples of varieties that have been tested for tolerance to *Pratylenchus thornei* are given in Table 3. Up-to-date information is produced by QPIF every year in the *Wheat varieties for Queensland* guide (www.dpi.qld.gov.au/cps/rde/dpi/hs.xsl/26_5121_ENA_HTML.htm) and is also available at the National Variety Testing website (www.nvtonline.com.au). The ratings, ranging from tolerant to very intolerant, are based on a variety's yield as a percentage of the average of all varieties sown in the trials. The variety EGA Wylie has proved to be the most tolerant of the varieties tested so far.

The yield of each variety as a percentage of EGA Wylie's yield on *Pratylenchus thornei* infested sites is also given in Table 3. It represents the yield loss if a particular variety had been sown on a highly infested site instead of EGA Wylie; that is:

% yield loss of a variety = 100% – yield of that variety as % EGA Wylie's yield.

Clearly, sowing an intolerant variety in a paddock with high numbers of *Pratylenchus thornei* equates to a considerable economic loss for a wheat grower.

Table 3. Tolerance/intolerance of some wheat varieties to *Pratylenchus thornei*.

	Grain yield in fields heavily infested with *P. thornei*	
Wheat variety	***Yield (as a % of EGA Wylie)***	***Tolerance ranking***
EGA Wylie	100	T
QAL2000	91	MT
EGA Gregory	90	MT
Baxter	90	MT
Sunvale	89	MT-MI
Yallaroi (durum)	86	MT-MI
Rees	85	MT-MI
GBA Ruby	85	MT-MI
Sunstate	84	MT-MI
GBA Hunter	84	MT-MI
EGA Burke	83	MT-MI
Leichhardt	83	MT-MI
Ventura	82	MT-MI
Kennedy	80	MT-MI
Livingston	79	MI
Hartog	79	MI
Giles	76	MI
EGA Bellaroi (durum)	76	MI
EGA Wills	75	MI
Jandaroi (durum)	74	MI
EGA Kidman	72	MI
Wollaroi (durum)	71	MI
EGA Wentworth	66	MI-I
Lang	63	MI-I
QALBis	63	MI-I
GBA Sapphire	61	MI-I
Strzelecki	60	MI-I
Sunco	59	I
EGA Stampede	59	I
Petrie	57	I
Sunlin	57	I
EGA Hume	55	I
Ellison	53	I
Sunsoft98	37	VI

T = tolerant; MT = moderately tolerant; MT-MI = moderately tolerant, moderately intolerant; MI = moderately intolerant; MI-I = Moderately intolerant, intolerant; I = Intolerant; VI = Very intolerant

Only preliminary information on the tolerance of northern wheat varieties to *Pratylenchus neglectus* is available. Data that is available indicates that tolerance information for *Pratylenchus thornei* is not applicable to *Pratylenchus neglectus*, reinforcing the need for accurate species identification in soil samples.

Resistant wheat varieties

There are currently no bread wheat varieties with a high level of resistance to root-lesion nematodes. This means that root-lesion nematode populations will increase when wheat is grown. However, some wheat varieties are less susceptible than others (see the *Wheat varieties for Queensland 2009* for a complete list). Durum wheats generally have good resistance to *P. thornei* but growers need to be careful where crown rot is present. Choosing the least susceptible variety can limit the build-up of root-lesion nematodes (see Figure 4) and aid management.

Photo 4: Wheat variety trial

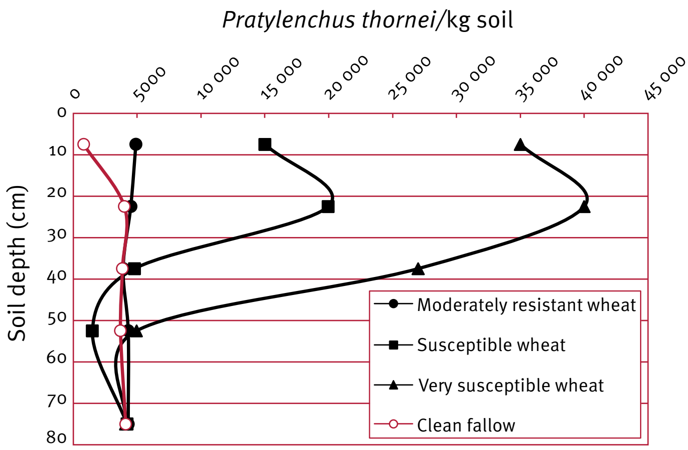


Figure 4: Choosing the least susceptible wheat variety can make a big difference to the populations of root-lesion nematode remaining at the end of the season.

On-farm experience—Alex Gwynne

Alex Gwynne, a grain farmer at Formartin on the Darling Downs, Queensland, was instrumental in QPIF researchers discovering the cause of poor yields of wheat. A poor Gatcher wheat crop (670 kg/ha), with symptoms of zinc deficiency when grown on country that had nearly continuous wheat and sorghum for 20 years, prompted Alex to contact QPIF's extension officer, Nev Douglas.

Alex was convinced there was a problem with some wheat varieties. Trials were later set up by John Thompson and the root-lesion nematode *Pratylenchus thornei* was identified as being the cause of the problem.

'I don't believe any grower in the northern wheat belt can consider his land as being clean of nematodes. Presume you have nematodes, rather than you do not, and plant tolerant wheat varieties with adequate nitrogen' said Alex recently.

'We cannot rid the land of these nematodes and rotations can only reduce numbers to low levels, so to be successful include nematode-tolerant wheat varieties. By choosing the most tolerant wheat variety your gross margin will increase and probably double your net profit.'

Photo 5: Alex Gwynne

Management of infested paddocks

Chemical control measures

There are no nematicides currently registered for use in cereal crops in the northern grain region. Nematicides are expensive and offer only partial control of root-lesion nematodes in the northern grain region due to poor penetration into the soil (root-lesion nematodes are often found deep in the soil profile).

Preventing spread to clean fields

A paddock that is free of parasitic nematodes is a valuable asset. Avoid contamination of fields by making sure farm machinery that enters this paddock is free of soil from other paddocks. It is essential to clean machinery with a pressure hose away from uninfested paddocks.

Nematodes may also be spread in run-off water. Therefore, all measures that control run-off and soil erosion can lessen the likelihood of nematodes spreading in this way.

Fertiliser

Increasing fertiliser rates to luxury levels beyond normally recommended commercial rates can give some reduction in plant symptoms and improve grain yield, but this is not a recommended method for managing root-lesion nematodes.

Resistant crops

Growing resistant crops is the main tool for managing nematodes. In the case of crops such as wheat or chickpea, choose the most tolerant variety available and rotate with resistant crops to keep nematode numbers at low levels. Information on the responses of crop varieties to root-lesion nematodes are regularly updated in grower and Queensland Primary Industry and Fisheries planting guides. It is worth noting that *Pratylenchus thornei* and *Pratylenchus neglectus* may prefer different crops (See Table 4). Additionally there are often useful levels of resistance within many crop varieties. For more information please contact the soil microbiology group (see page 8 for contact details).

Table 4. Choose resistant crops to keep root-lesion nematode numbers at low levels, avoid or limit the use of susceptible crops and choose tolerant varieties to maximise yields.

Crop	*P. thornei*	*P. neglectus*
Winter crops		
barley	MS–MR	MS–MR
canaryseed	R	MS
canola	R	S
chickpea	S	S
durum wheat	R	MS
faba bean	S	R
linseed	R	R
oats	MR	MR
triticale	MR	R
wheat	S	S
Summer crops		
blackgram	S	R
cotton	R	–
cowpea	S	R
lablab	R	R
maize	MR	MR
millet		–
• Japanese	R	
• Pearl	MR	
• Siberian	R	
• White French	MR	
mung bean	S	R
navybean	S	MR
panicum		–
• Foxtail	R	
• Panorama	R	
• Pearl	R	
pigeon pea	R	–
sorghum–grain	R	S
sorghum–forage	R	S
soybean	S	R
sunflower	R	R

S = susceptible; MS = moderately susceptible; R = resistant; – = not tested

On-farm experience—test early for optimal management

A progressive grower from Macalister, Queensland was surprised to find root-lesion nematodes had become a problem on his farm. His farm was well managed, with stubble retention, reduced tillage, tram-tracking, monitoring for soil water and nitrate, optimum fertiliser use and regular rotations with legumes in the system. The cropping history on one paddock is shown in Table 5. From 1995–1998 he grew sorghum, which is resistant to *P. thornei*, and barley which has moderate resistance. In 1999, he began a wheat/legume rotation and unsuspectingly grew 3 crops that were susceptible to *P. thornei*. The yield of the 2001 crop (wheat cv. Kennedy) was only 1.9 t/ha, so he had soil samples tested for nematodes and discovered that *P. thornei* was present at high populations (up to 12 000/kg soil).

On reflection, the grower decided that not only should he have tested his soil for nematodes earlier, but also rotated back to sorghum sooner. He decided that in the future he would choose a wheat variety with greater tolerance to *P. thornei*.

Table 5: The crops grown from 1999 until 2001 on a farm at Macalister, Queensland were susceptible to the root-lesion nematode, *Pratylenchus thornei*.

Year	Crop grown	Variety
1995–1998	sorghum	MR Buster
1998	barley	Skiff
1999	wheat	Hybrid Mercury
2000–2001	blackgram	Regur
2001	wheat	Kennedy

Crop rotation—research results

We have shown that wheat yields can be doubled if grown in rotation with resistant crops. We carried out a 4-year crop rotation experiment at Formartin on the Darling Downs, Queensland and followed the nematode numbers throughout the trial.

In the first year of the trial a susceptible wheat crop or a resistant canaryseed crop was grown to establish plots with high or low *Pratylenchus thornei* populations (see Figure 6a).

After a further 11 months of clean fallow, summer crops were grown. These included several varieties each of mung bean, soybean, maize, sunflower, millet, panicum and sorghum. (Figures 6b and 6c show the changes in root-lesion nematode populations following these crops). After the summer crops were harvested all plots had a 13-month clean fallow. Strzelecki wheat was planted over the entire site (see Photo 7 and Figure 5).

Photo 6: Crop rotation experimental site.

The best yields of the final Strzelecki wheat crop were obtained on plots previously planted with resistant crops such as sorghum, millet and panicum. This effect was more striking if the resistant canaryseed had been planted 3 years before (see Photo 7 and Figure 5).

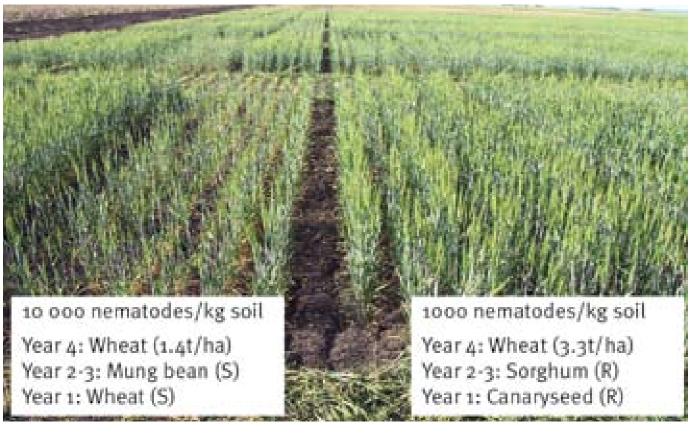


Photo 7: Wheat yields were doubled when grown after resistant crops (right-hand side) compared with those following susceptible crops (left-hand side). (S) = Susceptible (R) = Resistant

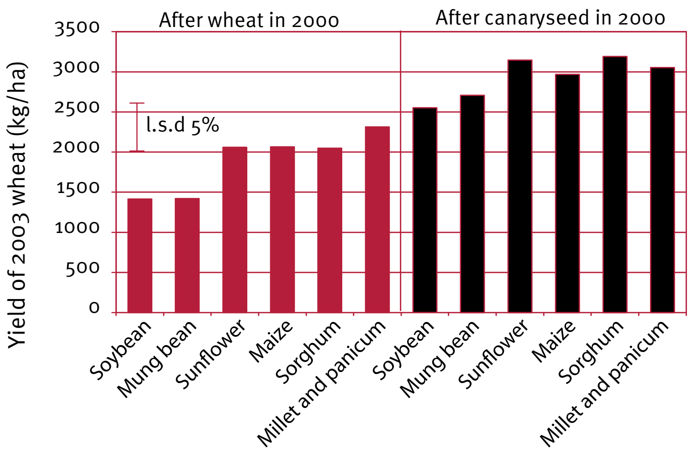


Figure 5: The highest yields (3.2 t/ha) of the *Pratylenchus thornei*-susceptible wheat variety, Strzelecki, were found when planted on plots that had grown two resistant crops in the previous 3 years of the experiment. Growing susceptible crops such as wheat followed by mung bean resulted in wheat yields of only 1.5 t/ha.

The changes in *Pratylenchus thornei* populations throughout the experiment are shown in Figures 6a, 6b and 6c.

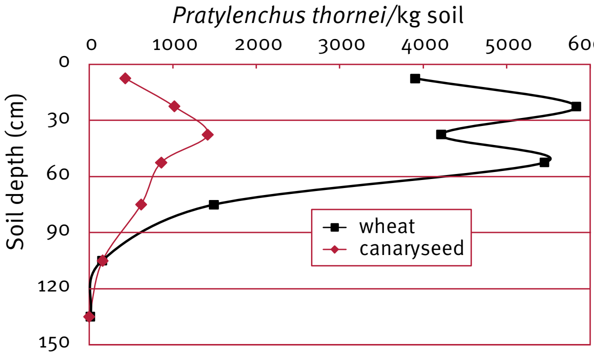
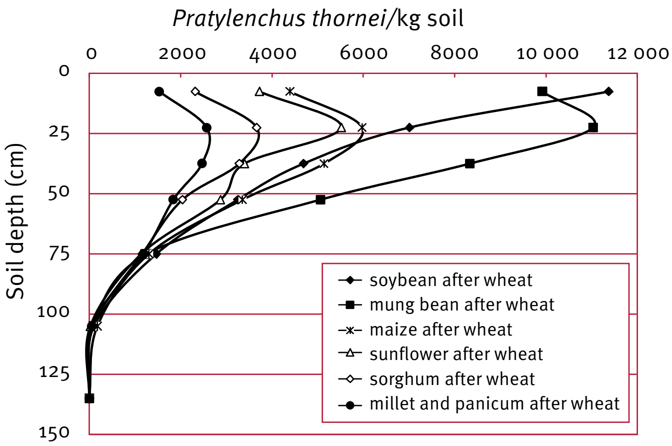
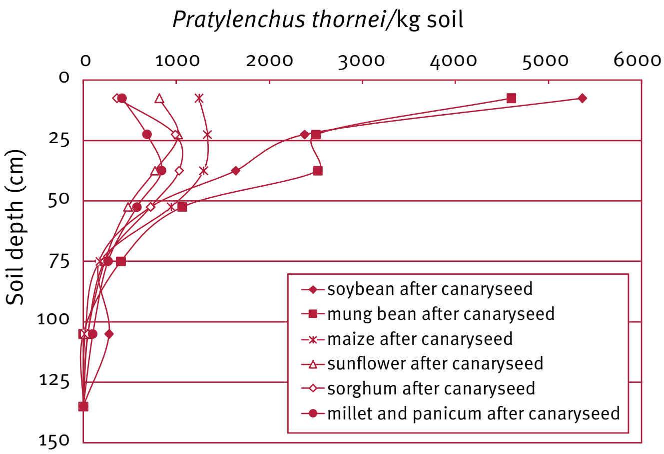


Figure 6a: In the first year of the trial, plots with high or low *Pratylenchus thornei* populations were established by growing the resistant canaryseed or susceptible wheat crops.





Figures 6b and 6c: Summer crops were planted on the high *Pratylenchus thornei* plots (after wheat) or low *Pratylenchus thornei* plots (after canaryseed). There were much larger populations of *Pratylenchus thornei* after the wheat crop than after the canaryseed. Mung bean and soybean were very susceptible to *Pratylenchus thornei*, while sorghum, millet and panicums were resistant.

Other nematodes in the northern grain region

- The stunt nematode (*Merlinius brevidens*) is widely distributed in the northern region (we find it in approximately three-quarters of fields). It feeds on the outside of plant roots (an ectoparasite) and is thought to be less damaging than root-lesion nematodes. In 2007, high populations were identified in winter cereals in northern New South Wales and we are currently investigating the interaction of these nematodes with fungi in causing root disease.
- In lighter textured soils, stubby-root nematode (*Paratrichodorus* sp.) and root-knot nematodes (*Meloidogyne* spp.) have been found on cereals and grain legumes. Other root-lesion nematodes occurring away from traditional wheat areas are *Pratylenchus zeae* on maize and sugarcane, and *Pratylenchus brachyurus* on peanuts.
- There have been isolated reports of cereal cyst nematode (*Heterodera avenae*) from near Tamworth and Dubbo, New South Wales, on lighter textured soils and friable clay soils.

Test your farm for nematodes

It is important to have paddocks diagnosed for plant parasitic nematodes so that optimal management strategies can be implemented. Testing your farm will tell you:

- if nematodes are present in your fields and at what density
- what species are present.

It is important to know what species are present because some of the crop management options are species specific. If a particular species is present in high numbers it is important to make immediate decisions to avoid losses in the next crop to be grown. With low numbers it is important to take decisions to safeguard future crops. Learning that a paddock is free of these nematodes is valuable information because it may be possible to take steps and avoid future contamination of that field.

Both testing soil samples taken before a crop is sown or while the crop is in the ground, provides valuable information.

Further reading

- Thompson JP, Owen KJ, Stirling GR, Bell MJ (2008). Root-lesion nematodes (*Pratylenchus thornei* and *Pratylenchus neglectus*): a review of recent progress in managing a significant pest of grain crops in northern Australia. *Australasian Plant Pathology* 37, 235–242.

Contact details

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Website: www.dpi.qld.gov.au

Business Information Centre: 13 25 23

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The information contained in this booklet is based on various GRDC- and QPIF-funded research projects conducted by Dr John Thompson, Dr Kirsty Owen, Tim Clewett, Jason Sheedy and Ros Reen on land provided by northern region grain growers.

Details of soil sampling methods, costs and where to send soil samples for testing for the presence of nematodes are available on the QPIF website (www.dpi.qld.gov.au) or by contacting the soil microbiology team as above.

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