Root diseases and nematodes

7.1 Overview

Incidence of root and hypocotyl diseases in Western Australian lupin crops has declined in the past 20 years, but remains an issue for some of the State's growers to manage.

If present, these diseases can reduce lupin stand density, plant vigour and yield.

Root rot occurs in nearly all narrow leafed lupin paddocks but, in most areas, has only a small impact on crop development and major losses are uncommon.

In some paddocks where high levels of root rot occurs, plant establishment and seedling vigour can be affected.

Pleiochaeta setosa and *Rhizoctonia solani* are the major pathogens causing root or hypocotyl infection of lupin.

Risk of hypocotyl rot is higher with legume-pasture rotations and it can be found in most soil types across WA.

When a root disease is present in a crop very little can be done to manage it in that cropping season.

It is therefore advised to correctly identify the cause to enable appropriate management before sowing the next lupin crop.

Correct identification can be made by assessing in-crop symptoms and the root and hypocotyl of affected plants.

Poor emergence, patches in crops, uneven and stunted growth, yellowing of plants and wilting or death under water stress – particularly at flowering and grain fill – can indicate the presence of root disorders.

These above-ground symptoms are rarely diagnostic, as many biotic and abiotic disorders will have similar above-ground expression.

Soil testing and monitoring can be done during the growing season through the Department of Primary Industries and Regional Development (DPIRD) – formerly Department of Agriculture and Food Western Australia (DAFWA) – Diagnostic Laboratory Services (DDLS)–Plant Pathology service.

Soil testing can be done year-round through the South Australian Research and Development Institute's (SARDI) PREDICTA® B sampling service. For more information go PREDICTA® B: http://pir.sa.gov.au/research/services/molecular_diagnostics/predicta_b.

Testing can help correctly diagnose, monitor and manage root and hypocotyl diseases and nematodes in lupin crops.

Growing lupin crops can be an excellent management tool for reducing some nematode species, but are highly susceptible to damage from others.

This reiterates the importance of correct species identification for rotation planning to manage root disease and nematode issues.

MORE INFORMATION

DPIRD 'Lupin root disease': https://www.agric.wa.gov.au/lupins/lupin-root-diseases-diagnosis-and-management

DPIRD 'Lupin diagnostic tool': https://www.agric.wa.gov.au/lupin-diagnostic-tool

DPIRD-GRDC MyCrop and MyCropApp: https://grdc.com.au/apps

DPIRD Diagnostic Laboratory Services (DDLS)-Plant Pathology: https://www.agric.wa.gov.au/ddls-seed-testing-and-certification

CropPro: http://www.croppro.com.au/crop_disease_manual/ch10.php

GRDC Fact Sheet 'Plant Parasitic Nematodes': www.grdc.com.au/GRDC-FS-Plant-Parasitic-Nematodes-SW

Australian Pesticides and Veterinary Medicines Association (APVMA) – for registered fungicides and herbicides: http://apvma.gov.au/

SARDI PREDICTA® B: http://pir.sa.gov.au/research/services/molecular_diagnostics/predicta_b

MORE INFORMATION

DPIRD-GRDC MyCrop 'Pleiochaeta root rot': www.agric.wa.gov.au/mycrop/diagnosing-pleiochaeta-root-rot-narrow-leafed-lupins

7.2 Pleiochaeta root rot (*Pleiochaeta setosa*)

Figure 1: *Pleiochaeta root rot infection on lupin stems.*

(SOURCE: GRDC Grain Legume Handbook)

- Rarely leads to major crop losses (except in some situations where lupin is sown after lupin on very infertile sands) in WA
- Minimum tillage and deep ripping can reduce crop effects
- Rotations with non-host crops can reduce spore concentrations in soil.

Pleiochaeta root rot is caused by the fungus *Pleiochaeta setosa* that also causes Brown leaf spot of lupin.

Spores are produced on fallen brown spot-infected leaves and become incorporated into the top few centimetres of soil, where they can persist during summer and across several years.

The spores germinate in the next lupin crop and infect the plant roots of seedlings, causing pleiochaeta root rot.

Spores that have survived on the soil surface can also be splashed upwards by rain droplets and infect leaves and stems, causing Brown leaf spot. This continues the disease cycle.

Pleiochaeta root rot creates lesions on roots, but rarely leads to major crop losses in WA where reduced tillage and extended lupin rotations are used.

Incidence can be higher in paddocks with close lupin rotations and where seeding operations place spores in the root zone.

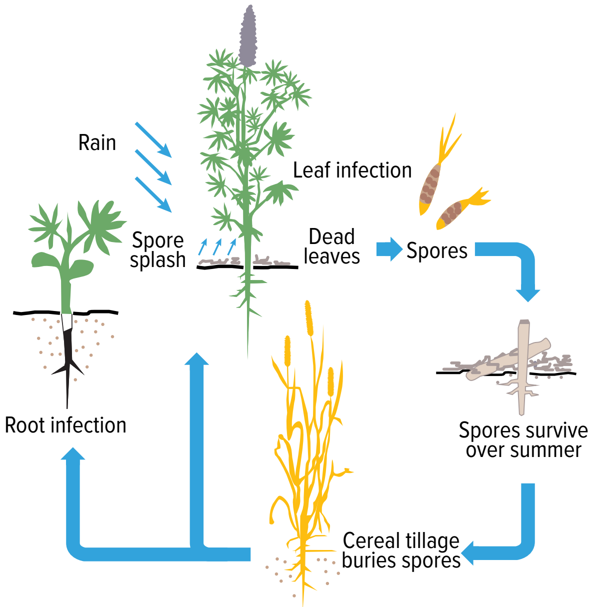
Disease severity and yield impact is determined by the number and distribution of spores in the soil. A high number of spores distributed close to the seed can cause severe disease.

In-crop symptoms of pleiochaeta root rot include wilted, weak or dying seedlings that can be scattered in the paddock or on particular soil types.

Infection produces dark brown lesions on the tap and lateral roots, leading to stripping of the outer layer of the root. In severe cases there is complete rotting of the root.

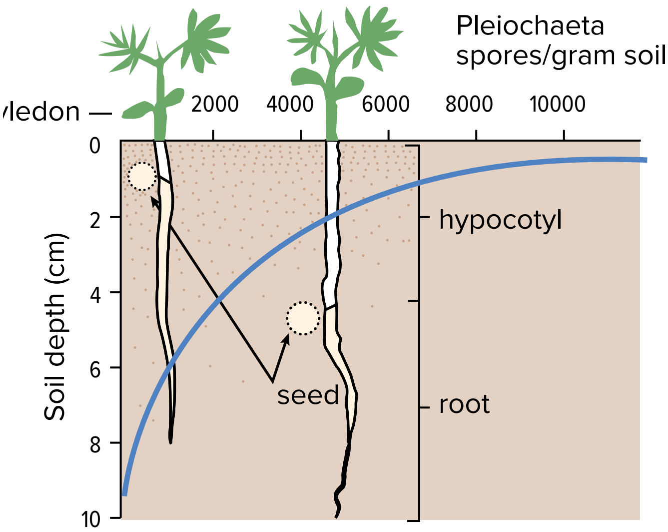
Tap roots are susceptible for six to eight weeks after germination. But new lateral roots are susceptible when they emerge during the season and are often pruned off.

Figure 2: *Pleiochaeta root rot spore profile in a direct drilled paddock.*



(SOURCE: DAFWA)

Figure 3: *Infection cycle of pliochaeta root rot.*



(SOURCE: DAFWA)

Management of Pleiochaeta root rot

- Use reduced or minimum tillage
- Deep tillage has been found to suppress disease severity in WA
- Rotate lupin with non-host crops (such as cereals, canola, pasture)
- Control Brown leaf spot in preceding lupin crops
- Fungicide seed treatment with Group 2 actives iprodione or procymidone can provide partial control
- No fungicide treatments are registered for in-crop use.[1]

1 DPIRD-GRDC (2016) MyCrop diagnostic tool – Diagnosing pleiochaeta root rot in narrow-leafed lupins, www.agric.wa.gov.au/mycrop/diagnosing-pleiochaeta-root-rot-narrow-leafed-lupins

FEEDBACK

Minimum or reduced tillage sowing systems used in WA have been shown to reduce the incorporation of pleiochaeta root rot spores into the rooting zone of the soil profile.

Deeper sowing, such as with spading or mouldboard ploughing, has also been effective in placing emerging crop roots below the spore-laden soil layer.

Rotating lupin with non-host crops, such as cereals, canola or pasture, will typically cut the concentration of soil-borne spores. Controlling Brown leaf spot in preceding lupin crops can also reduce the amount of spores returned to soil.[2]

Fungicide seed treatments containing Group 2 actives iprodione or procymidone are registered for control of Brown leaf spot in WA lupin crops, but not for pleiochaeta root rot control.

These actives do not give consistent control of pleiochaeta root rot, but trials have found they can provide partial control at registered rates.[3] There are no registered fungicide treatments to use in-crop.

7.3 Rhizoctonia bare patch (*Rhizoctonia solani* AG8)

- Occurs on most WA soil types
- Affects lupin and most other crops and pastures grown in WA
- Rotations tend not to break the disease cycle
- All commercial lupin varieties are equally susceptible
- Affected paddocks have distinct patches of stunted or dying crops three to six weeks after sowing
- Yields are severely depleted in patch areas
- Tillage systems affect disease impact
- Seed or in-furrow fungicides are not registered for use in lupin.

Rhizoctonia bare patch is caused by the fungus *Rhizoctonia solani* (AG8) and has a wide plant host range, making rotation with cereals, canola or other pulses mostly ineffective in suppressing disease incidence in lupin crops.

But research in WA and SA has found grass-free canola and pulse crops and pastures can help to reduce inoculum levels in soil to benefit subsequent crops.[4]

Rhizoctonia bare patch is found in most WA grainbelt soil types, especially sandplain areas, and effects all commercially available lupin varieties.

The fungus colonises either living plant tissue or dead organic material, allowing it to survive across years.

After autumn rain, it grows rapidly to infect young seedlings and distinct patches of stunted or dying plants are visible in the crop three to six weeks after sowing.

Long-term trials show rhizoctonia bare patch can also attack crops throughout the growing season.[5]

Yield losses from this root disease in lupin crops are typically proportional to the area of paddocks affected by patches, which can range from 0.5–5 metres in diameter and produce virtually no grain.[6]

MORE INFORMATION

GRDC Tips and Tactics 'Rhizoctonia – Western Region': www.grdc.com.au/TT-Rhizoctonia

DPIRD-GRDC MyCrop 'Rhizoctonia bare patch': https://www.agric.wa.gov.au/mycrop/diagnosing-rhizoctonia-bare-patch-grain-legumes-0

DPIRD 'Monitoring root diseases': https://www.agric.wa.gov.au/mycrop/monitoring-root-disease

GRDC Hot Topic 'Managing Rhizoctonia bare patch in WA': https://grdc.com.au/Media-Centre/Hot-Topics/Managing-rhizoctonia-bare-patch-in-WA

2 DPIRD-GRDC (2016) MyCrop diagnostic tool – Diagnosing pleiochaeta root rot in narrow-leafed lupins, www.agric.wa.gov.au/mycrop/diagnosing-pleiochaeta-root-rot-narrow-leafed-lupins

3 DPIRD-GRDC (2016) MyCrop diagnostic tool – Diagnosing pleiochaeta root rot in narrow-leafed lupins, www.agric.wa.gov.au/mycrop/diagnosing-pleiochaeta-root-rot-narrow-leafed-lupins

4 GRDC (2016) Tips and Tactics, Rhizoctonia – Western Region, www.grdc.com.au/TT-Rhizoctonia

5 McKay, A (2006) Fungicide Control of Rhizoctonia Part B Syngenta, SARDI, University of SA, CSIRO Adelaide, DAFWA, http://projects.grdc.com.au/projects.php?action=view_project&project_id=653

6 DPIRD-GRDC (2016) MyCrop Diagnostic Tool – Diagnosing rhizoctonia bare patch in grain legumes, https://www.agric.wa.gov.au/mycrop/diagnosing-rhizoctonia-bare-patch-grain-legumes-0

The tap and lateral roots of affected plants are 'pinched off' by dark brown lesions, often having a 'spear tipped' appearance. As the season progresses, damaged plants often die.

Management of rhizoctonia bare patch

- Use deep cultivation at sowing with a narrow tyne 10–15 cm below seed
- Deep ripping to 25–30 cm immediately prior to sowing can suppress disease
- Ensure good crop nutrition
- Avoid herbicide damage to roots
- No fungicide seed dressing or foliar products are registered for use in lupin
- Rotation and variety selection will not provide total control.[7]

Deep cultivation at sowing with a narrow tyne 10–15 cm below the seed, or deep ripping to 25–30 cm prior to sowing, are the most effective methods for reducing lupin crop damage caused by rhizoctonia bare patch in WA conditions.[8]

Cultivation with knife-point soil openers can disturb fungal growth in the soil and encourage better root growth, compared to disc sowing systems.

It is advised that sowing at the optimal time, ensuring good crop growth with adequate plant nutrition and avoiding herbicide damage to roots will reduce disease impact.

Research has shown control of the green bridge of weeds and crop volunteers between crops and ensuring good weed control in-crop can also help to reduce crop losses.[9]

Crop rotation and variety selection will not totally control rhizoctonia root rot and there are no registered fungicide seed dressings or foliar actives for use in lupin.

MORE INFORMATION

DPIRD-GRDC MyCrop 'Rhizoctonia hypocotyl rot': https://www.agric.wa.gov.au/mycrop/diagnosing-rhizoctonia-hypocotyl-rot-narrow-leafed-lupins

GRDC Tips and Tactics 'Rhizoctonia – Western Region' at: www.grdc.com.au/TT-Rhizoctonia

7.4 Rhizoctonia hypocotyl rot, or rhizoctonia root rot (*Rhizoctonia solani*)

Figure 4: *Figure: Rhizoctonia can affect roots of lupin crops in WA, but incidence is relatively low.*

(SOURCE: GRDC)

7 DPIRD-GRDC (2016) MyCrop Diagnostic Tool – Diagnosing rhizoctonia bare patch in grain legumes, https://www.agric.wa.gov.au/mycrop/diagnosing-rhizoctonia-bare-patch-grain-legumes-0

8 DPIRD-GRDC (2016) MyCrop Diagnostic Tool – Diagnosing rhizoctonia bare patch in grain legumes, https://www.agric.wa.gov.au/mycrop/diagnosing-rhizoctonia-bare-patch-grain-legumes-0

9 GRDC (2016) Tips and Tactics, Rhizoctonia – Western Region, www.grdc.com.au/TT-Rhizoctonia

- Affects all lupin varieties and most other crop and pasture legumes grown in WA
- Incidence is relatively low in WA lupin crops
- Affected crops can have poor plant establishment
- Rotation with non-legumes can break disease cycles
- Cultivation practices are ineffective
- Iprodione is registered for suppression.

Rhizoctonia hypocotyl rot, or root rot, is caused by the soil-borne ZG3, ZG4 and ZG6 strains of the fungus *Rhizoctonia solani*.

These pathogens are related to the strains causing rhizoctonia bare patch and effect all lupin varieties – and most other crops and pasture legumes – grown in WA.

Although incidence of rhizoctonia hypocotyl rot in this State is typically relatively low, it can occur in most soil types and reduce plant establishment in affected crops.

The bulk of fungal inoculum is found in the top 5 cm of soil, where it can survive for at least two years in remnant organic matter.

With the onset of opening rains, the fungus grows and infects susceptible seedlings. It is more active with warm soil temperatures and tends to be more prevalent in early sown crops.

Risks of infection are highest in lupin crops following a legume pasture phase as a result of disease build-up and the capacity of fast-germinating pasture seedlings to host infection prior to lupin germinating.

When a root disease such as hypocotyl rot is present, very little can be done to manage it during that cropping season.

It is, therefore, important to correctly identify the cause with soil sampling to allow appropriate management before sowing the next lupin crop.

Above ground symptoms of rhizoctonia hypocotyl rot in WA lupin crops include clumps of poor emergence, uneven and stunted plant growth, wilting or death.

It is the most easily diagnosed of all lupin root diseases, causing reddish-brown sunken lesions on the hypocotyl (below ground portion of the stem).

From emergence until about eight-leaf stage, infected seedlings wilt and die as lesions grow and rot through the hypocotyl.

Infected plants that survive past the eight to 10-leaf stage often remain stunted and tend to be less productive than healthy plants.[10]

Management of rhizoctonia hypocotyl rot

- » Avoid lupin rotations after legume pasture
- » Shallower sowing can reduce hypocotyl exposure to the fungus
- » Avoid sowing very early into warm soil in high-risk paddocks
- » Higher sowing rates may compensate for establishment losses
- » Iprodione-based seed dressings are registered for suppression in WA lupin
- » Avoid sowing lupin crops within 24 hours of glyphosate application where a big biomass of weeds have been sprayed on high risk paddocks.[11]

Crop rotation can be useful to break the rhizoctonia hypocotyl root rot cycle and, in high-risk areas, it may be beneficial to not sow consecutive lupin sequences or lupin after a legume pasture.

Shallower sowing can reduce exposure of the hypocotyl to the fungal inoculum and sowing very early into warm soil in paddocks with known disease risk should be avoided.

10 DPIRD-GRDC (2016) MyCrop Diagnostic Tool – Diagnosing rhizoctonia hypocotyl rot in narrow-leafed lupins, https://www.agric.wa.gov.au/mycrop/diagnosing-rhizoctonia-hypocotyl-rot-narrow-leafed-lupins

11 DPIRD-GRDC (2016) MyCrop Diagnostic Tool – Diagnosing rhizoctonia hypocotyl rot in narrow-leafed lupins, https://www.agric.wa.gov.au/mycrop/diagnosing-rhizoctonia-hypocotyl-rot-narrow-leafed-lupins

Increasing sowing rate by 10–25 percent can help to compensate for establishment losses in high-risk paddocks.[12]

MORE INFORMATION

DPIRD-GRDC MyCrop 'Eradu patch': https://www.agric.wa.gov.au/mycrop/diagnosing-eradu-patch-narrow-leafed-lupins

7.5 Eradu patch

- Caused by a thin, binucleate *Rhizoctonia* (TBR)
- Found in WA in the late 1990s
- West midlands and northern agricultural region are most affected
- Causes severely stunted patches in lupin crops, suppressing yields
- Use non-host crops to reduce incidence
- Cultivation, fungicide seed dressing and lupin variety choice are not effective control tactics.

Eradu patch is caused by a thin, unnamed binucleate rhizoctonia (TBR) pathogen that is different to the rhizoctonia bare patch pathogen.

It is less common in WA than rhizoctonia bare patch, but surveys in the past decade have found it present in 8–10 percent of lupin paddocks sampled – particularly in the west midlands and sandplain areas of the northern agricultural region. It has also been found in WA's eastern grainbelt areas.[13]

Eradu patch causes roughly circular patches in narrow leafed lupin crops, with distinct edges that become evident seven to eight weeks after sowing.

It does not affect albus or WA blue lupin, wheat or canola.

Patches in narrow leafed lupin can be 0.5–10 m in diameter and may have a 'doughnut' appearance. Typically, the most severely stunted plants are near the edge and the area may coalesce over time into larger irregular patches.

Light brown-red lesions occur on the tap root of infected plants, often with the outer layer of the root stripped off.

Lateral roots can be pinched off by similar colored lesions.

Management of Eradu patch

- » Rotation with non-host crops or pasture/fallow can reduce patches
- » Cultivation, fungicide seed dressing and lupin variety are ineffective
- » Soil testing is useful to monitor disease presence and level.[14]

This fungus survives between seasons in the soil, but two or three years of rotation with non-host crops or pastures can reduce the impact of disease in lupin.

It is advised not to grow a barley crop prior to lupin in susceptible areas, as this can increase disease severity.

Research has found cultivation, fungicide seed dressing and lupin variety are ineffective tools to manage Eradu patch.[15]

It can be useful to test the soil for presence and levels of rhizoctonia pathogens through DPIRD's Diagnostic Laboratory Services (DDLS) –Plant Pathology or SARDI's PREDICTA® B service.

12 DPIRD-GRDC (2016) MyCrop Diagnostic Tool – Diagnosing rhizoctonia hypocotyl rot in narrow-leafed lupins, https://www.agric.wa.gov.au/mycrop/diagnosing-rhizoctonia-hypocotyl-rot-narrow-leafed-lupins

13 DPIRD (2016) Lupin root diseases: diagnosis and management – Eradu patch, https://www.agric.wa.gov.au/lupins/lupin-root-diseases-diagnosis-and-management?page=0%2C2#smartpaging_toc_p2_s0_h3

14 DPIRD (2016) Lupin root diseases: diagnosis and management – Eradu patch, https://www.agric.wa.gov.au/lupins/lupin-root-diseases-diagnosis-and-management?page=0%2C2#smartpaging_toc_p2_s0_h3

15 DPIRD (2016) Lupin root diseases: diagnosis and management – Eradu patch, https://www.agric.wa.gov.au/lupins/lupin-root-diseases-diagnosis-and-management?page=0%2C2#smartpaging_toc_p2_s0_h3

FEEDBACK

MORE INFORMATION

DPIRD-GRDC MyCrop 'Rhizoctonia hypocotyl rot': https://www.agric.wa.gov.au/lupin-diagnostic-tool

GRDC 'Grain Legume Handbook': https://grdc.com.au/grainlegumehandbook

7.6 Minor root diseases affecting WA lupin crops

Table 1: A summary of minor root diseases affecting WA lupin crops.[16]

Disease	
CHARCOAL ROT (*MACROPHOMINA PHASEOLINA*)	
Risks	Moisture-stressed crops; survives in soil for multiple years.
Symptoms	Premature senescence of individual plants or patches in-crop. Stems and taproots have ash-grey discoloration (when split open) due to masses of tiny black microsclerotia embedded in the tissue.
Management	Avoid sowing lupin in water-logging prone soils; crop rotations.
Useful resources	https://www.agric.wa.gov.au/lupins/lupin-root-diseases-diagnosis-and-management
PYTHIUM ROOT ROT	
Risks	Most WA soil types, especially shallow duplex soils and other soils prone to sub-soil saturation.
Symptoms	Roots develop a black rot, hypocotyls can develop water-soaked lesions. Infection can kill emerging seedlings or create weak and stunted plants that wilt at the start of stem elongation.
Management	Avoid sowing lupin in water-logging prone soils; crop rotations.
Useful resources	GRDC Fact Sheet 'Root disease', https://grdc.com.au/uploads/documents/GRDC_FS_Pythium.pdf and DAFWA Lupin disease hub, https://www.agric.wa.gov.au/lupins/lupin-root-diseases-diagnosis-and-management
ABIOTIC ROOT DAMAGE	
Risks	Various soil structures and properties.
Symptoms	Impermeable hardpans and duplex soils can cause damaged or bent taproots and poorly developed root systems. Waterlogging can result in soft discolored roots, poorly developed root systems and yellowing of plants. Chemical damage from triazine or sulfonylurea herbicides or poor fertiliser placement can cause rotting, pruning or reduced development of roots.
Management	
Useful resources	https://www.agric.wa.gov.au/lupins/lupin-root-diseases-diagnosis-and-management

(SOURCE: DAFWA)

MORE INFORMATION

GRDC Tips and Tactics 'Root Lesion Nematodes – Western': https://grdc.com.au/Resources/Factsheets/2015/03/Root-Lesion-Nematodes

GRDC Paddock Practices 'Managing root lesion nematodes pre-sowing': https://grdc.com.au/Media-Centre/Media-News/West/2016/03/Managing-root-lesion-nematodes-presowing

SARDI PREDICTA® B test results/Maps: http://pir.sa.gov.au/__data/assets/image/0003/293142/Australia_P_penetrans_map_2016.jpg

7.7 Nematodes

Figure 1: *Root lesion nematodes are worm-like microscopic endoparasites that feed on plant roots and can cause patches in crops.*

(SOURCE: © Western Australian Agriculture Authority (Department of Agriculture and Food, WA))

- Lupin in the crop rotation can help reduce RLN species *P. neglectus* and *P. quasitereoides* (formerly *P. teres*) in WA soils
- Lupin is very susceptible to *P. penetrans*
- There are no in-crop options to control nematodes
- Crop rotation can help reduce crop damage
- Rotation is influenced by species of nematode present in soil
- Soil and/or plant root testing can identify species and levels of nematodes.

Root lesion nematodes (RLN) are the main nematode species that affect all WA crops, including lupin, and incidence is increasing across the grainbelt.

These worm-like microscopic endoparasites feed on plant roots.

Research indicates they are present in soils covering about 5.74 million hectares of the State's cropped area.[16]

Surveys in recent years have shown RLN populations are at yield-limiting levels in at least 40 percent of cropping paddocks and cause crop losses typically ranging from 15–50 percent.[17]

The three main species found in WA are *Pratylenchus neglectus*, *P. quasitereoides* (formerly *P. teres*) and *P. thornei* (not as widespread).

Of the 360-plus PREDICTA® B WA soil samples tested in 2015, 65 percent had *P. neglectus* present and 30 percent had *P. quasitereoides* present.[18]

In 2014, testing by DPIRD through its long-term Focus Paddock project found the average number of RLN in infested plant samples it received had increased to about 31,000 RLN per gram root from about 7000 RLN/g root in 2011. Paddocks with the highest numbers were from barley crops infested with *P. quasitereoides*, including one with 55,000 RLN/g root in 2012 and one with 220,000 RLN/g root in 2014.[19]

16 GRDC (2015) Tips and Tools – Root lesion nematodes Western Region, www.grdc.com.au/TT-RootLesionNematodes

17 GRDC (2015) Tips and Tools – Root lesion nematodes Western Region, www.grdc.com.au/TT-RootLesionNematodes

18 GRDC (2015) Tips and Tools – Root lesion nematodes Western Region, www.grdc.com.au/TT-RootLesionNematodes

19 DAFWA (2015) PestFax – Root Lesion Nematode levels are increasing, www.agric.wa.gov.au/newsletters/pestfax

Lupin crops are an excellent management tool for helping to reduce *P. neglectus* and *P. quasitereoides* burdens in paddocks, but are very susceptible to damage from *P. penetrans*.

This reiterates the importance of correctly diagnosing the RLN species that are present in paddocks through accredited laboratories.

Correct RLN identification will also assist researchers to characterise nematode distribution in WA and gather further resistance information for crop types and varieties grown in the western region.

Such research is vital because there are no chemicals available to economically control nematodes in broadacre cropping systems.

In-crop symptoms of nematodes are often indistinct, difficult to identify and commonly mistaken for nutrient deficiencies, soil-limiting factors or presence of rhizoctonia.

Big patches, or uneven waves of crop growth, may be evident in paddocks. Up close, plants are often smaller, look chlorotic (yellowing), have reduced tillering, wilt easily and may be dying-off.

If nematodes are present, roots may be stunted, lack lateral roots and may have brown lesions from nematode pruning.

7.7.1 Testing to identify nematodes

A pre-sowing soil test using PREDICTA® B, offered by accredited advisers through SARDI, can diagnose *P. neglectus* and *P. thornei*, along with Cereal cyst nematode (*Heterodera avenae*). Soil testing and plant root testing for nematode diagnosis in-season can also be carried out by DPIRD's Diagnostic Laboratory Services (DDLS)–Plant Pathology (formerly AGWEST Plant Laboratories).

Soil sampling guidelines include:

- Dig soil to a depth of 0–10 cm
- Take samples in the crop row, close to roots
- Sample at six to 12 locations towards the margins of poor growth areas
- Place all samples in a bucket and mix gently
- Remove a 500 g sample from the bucket and put in plastic bag
- Collect a second sample from a healthy crop area
- Include paddock history and notes on each sample to send to the laboratory.

Plant sampling guidelines include:

- Collect plants from several locations towards the margins of poor crop growth
- Use a trowel/shovel to keep root systems intact
- Retain the soil ball to protect roots in transit to the laboratory.[20]

MORE INFORMATION

PREDICTA® B: http://pir.sa.gov.au/research/services/molecular_diagnostics/predicta_b

DPIRD Diagnostic Laboratory Services (DDLS)–Plant Pathology: https://www.agric.wa.gov.au/ddls-seed-testing-and-certification

20 Collins, S (2014), Know your nematodes and set up a crop defence system in 2015, GRDC, https://grdc.com.au/Media-Centre/Media-News/West/2014/07/Know-your-nematodes-and-set-up-a-crop-defence-system-in-2014

7.7.2 Management of nematodes

- No in-crop options can stop nematode damage
- Diagnose and monitor species and concentration levels using soil and root testing
- Avoid growing lupin crops where *P. penetrans* is present
- Maintain healthy soils and adequate crop nutrition.

Planning crop rotations with resistant varieties or non-host break crops and pastures can help inhibit nematode reproduction/build-up (resistance) and potentially boost crop yields to non-limiting levels under RLN pressure (tolerance).

If there are high or very high RLN levels in a paddock (greater than 10 nematodes/mL of soil or greater than 10,000 nematodes/gram dry root – severity score three and four), it is recommended to grow a moderately resistant (MR) or resistant (R) crop for one to two cropping seasons.[21]

Lupin shows good resistance for *P. neglectus* and *P. quasitereoides* and can be grown where these are present to help break nematode cycles.

But lupin is susceptible to *P. penetrans* and it may be advisable to avoid planting them where this nematode is present.

Maintaining healthy soils and good crop nutrition, especially at crop establishment, can also help to reduce the long-term impact of nematodes on lupin production.

A wide range of parasites and predators of nematodes is found in healthy soils and can provide a degree of protection against plant-parasitic nematodes.

Preliminary results from soil sampling of well-managed, no-tillage and residue-retained cropping systems in WA and SA indicate natural suppressiveness to plant-parasitic nematodes in crop soils may exist and can be improved.[22]

21 Collins, S (2014), Know your nematodes and set up a crop defence system in 2015, GRDC, https://grdc.com.au/Media-Centre/Media-News/West/2014/07/Know-your-nematodes-and-set-up-a-crop-defence-system-in-2014

22 Collins, S (2014), Know your nematodes and set up a crop defence system in 2015, GRDC, https://grdc.com.au/Media-Centre/Media-News/West/2014/07/Know-your-nematodes-and-set-up-a-crop-defence-system-in-2014