PLANT PARASITIC NEMATODES FACT SHEET

GRDC Grains Research & Development Corporation

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SOUTHERN AND WESTERN REGION

Managing cereal cyst and root lesion nematodes

Root lesion nematode (RLN, *Pratylenchus* species) and cereal cyst nematode (CCN, *Heterodera avenae*) are significant pests that feed on the roots of crop plants and cause yield loss.

KEY POINTS

- CCN has one life cycle per season whereas RLN is polycyclic with three to five generations per year.
- CCN hosts are restricted to cereals and grasses whereas the RLN host range is broader and includes cereals, oilseeds, grain legumes, pastures and broad leaf and grass weeds.
- A number of different RLN species are present, including *Pratylenchus neglectus*, *thornei*, *penetrans* and *teres*.
- Nematode type and species will affect choice of management practices, particularly rotation options.

Management of RLN and CCN in winter crops

- As a general rule, well-managed rotations with resistant or non-host break crops are vital. Avoid consecutive host crops to limit populations.
- Choose varieties with high resistance ratings, which result in fewer nematodes remaining in the soil to infect subsequent crops.
- Reducing RLN and CCN can lead to higher yields in following cereal crops.
- Healthy soils and good nutrition can, to some extent, ameliorate RLN and CCN damage through good crop establishment, and healthier plants recover more readily from infestation.
- Observe crop roots to monitor development of symptoms.
- Weeds can host parasitic nematodes and control of host weed species and crop volunteers is important.

TABLE 1: REACTION OF MAJOR CROP AND PASTURE SPECIES TO *PRATYLENCHUS NEGLECTUS*, *P. TERES* AND *P. PENETRANS*

P. neglectus			*P. teres* *	*P. penetrans* *
SUSCEPTIBLE	MODERATELY SUSCEPTIBLE	RESISTANT	SUSCEPTIBLE	SUSCEPTIBLE
Wheat	Barley	Field Pea	Wheat	Wheat
Canola	Oat	Narrow-leafed lupin	Barley	Oat
Chickpea	Medic	Faba and Narbon bean	Oat	Field pea
Mustard	Durum wheat	Lentil	Canola	Faba bean
Biserulla	Common vetch	Lathyrus		Narrow-leafed lupin
	Trigonella	Triticale		Chickpea
		Rye		Durum wheat
		Safflower		Triticale
		Clover and Lotus	MODERATELY SUSCEPTIBLE	MODERATELY SUSCEPTIBLE
		Legume pastures**	Narrow-leafed lupin	Barley
			Field pea	Canola
				Triticale

*Information for *P. teres* and *P. penetrans* is based on samples received by AGWEST Plant Laboratories for diagnosis, combined with data from preliminary field and glasshouse trials.

** Clover, Bitter vetch, Yellow serradella, French serradella, Sulla and Lotus.

Source: VA Vanstone, DAFWA.

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About the root lesion nematode

Pratylenchus spp. are microscopic worm-like organisms less than one-millimetre in length which feed on root tissues.

P. neglectus is the dominant RLN species in all regions. In WA, at least 60 per cent of cropping paddocks are infested with one or more of the *Pratylenchus* species. In about 40 per cent of cases the nematode is at levels capable of causing crop damage and yield loss of five to 15 per cent.

P. thornei is found in South Australia, Victoria, Queensland and NSW. This species occurs rarely in Western Australia.

P. teres and *P. penetrans* have both been identified in WA and research is underway to learn more about these species and the rotations that will limit their populations in cropping soils. Forty per cent of RLN identified in WA is *P. neglectus*; 10 per cent *P. teres* and 10 per cent mixed species.

P. penetrans is rare in WA but can cause severe damage to some crops.

More than one RLN species can be found in the roots of an individual crop, although one species usually dominates.

Species identification is important to help management as some varieties, crops and plant types have different resistance or susceptibility to different members of the *Pratylenchus* family. For example field pea, lupin and faba bean are resistant to *P. neglectus* but are susceptible to *P. penetrans*. Canola is more susceptible to *P. neglectus* than *P. thornei* (see Table 1).

Although there is no truly resistant variety of wheat, there is sufficient variation in susceptibility that variety selection in rotations can be a useful tool in managing the impact of RLN.

Oat and barley varieties range from moderately resistant to moderately susceptible to *P. neglectus.*

Pastures vary in their susceptibility to RLN and under some pastures, nematode levels could increase and become damaging to subsequent cereals. Pastures should therefore be monitored for RLN as other crops are, as well as considering their place in the rotation for RLN management. French and Yellow serradella, lotus and sulla varieties tested to date are resistant to *P. neglectus,* whereas clovers and medics can be more susceptible.

Intensive cropping of susceptible crops – particularly wheat – will lead to an increase in nematode levels. Rotations are the key to limiting nematode multiplication and reducing future crop damage.

Several studies have shown the extent of yield loss attributed to *P. neglectus* or *P. thornei* is directly related to the population density present at sowing.

All species of RLN have a wide host range.

RLN ABOVE AND BELOW GROUND: (Right) Symptoms of RLN on cereal root systems. Note discolouration of roots and reduction in lateral root growth.

(Far right) Patchiness, stunting and yellowing of cereal infested with RLN.

PHOTOS: VA VANSTONE, DAFWA

The symptoms

Above-ground symptoms are often indistinct and a poor diagnostic indicator. The first signs are poor emergence and establishment, stunting, cereals tiller poorly and plants may wilt despite moist soil. Symptoms of nematode damage can be confused with, or exacerbated by, nutrient deficiencies. Nematodes are usually distributed unevenly across a paddock, resulting in irregular crop growth.

When roots are damaged by RLN, the plants become less efficient in taking up water and nutrients, and in tolerating stresses such as drought or nutrient deficiencies. Depending on the extent of damage and the growing conditions, affected plants may partly recover if the rate of new root growth exceeds the rate at which nematodes damage the roots.

To gain the full picture, an examination of what is going on under the ground is needed. Primary and secondary roots of cereals will show a general browning and discolouration and there will be fewer, shorter laterals branching from the main roots. Chickpea roots can show distinct dark brown-orange lesions at early stages of infection and the lateral roots of chickpea can be severely stunted and reduced in number.

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

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

The life cycle of RLN

RLN is a migratory plant parasitic nematodes, meaning they migrate freely between roots and soil providing the soil is moist. The life cycle of RLN begins after the opening rains in autumn. Juvenile and adult nematodes rehydrate, become active and invade plant roots where they feed and multiply as they move through the root.

Individual eggs are laid within the root from which juvenile nematodes hatch, grow to adults and lay eggs. There may be three to five cycles within the plant host each season. As plants and soil dry out in late spring, RLN enters a dehydrated state called anhydrobiosis and can survive high soil temperatures and desiccation over summer.

As nematodes feed and multiply, lesions and/or sections of brown discolouration are formed on the plant root. Other symptoms include the reduction in the number and size of lateral roots and root hairs.

Management of RLN

The most important management tool is good rotations. In heavily infested paddocks break crops should be grown for one or two years to decrease the population. Resistant varieties should be selected for the following years.

Adequate nutrition (especially nitrogen, phosphorus (P) and zinc) normally allows plants to better tolerate plant parasitic nematodes, although this does not necessarily lead to lower nematode reproduction. Field trials in areas infested with *P. neglectus* have shown yield losses for intolerant wheat ranged from 12 to 33 per cent when minimal levels of P were applied but losses were reduced to only five per cent with a high (50 kilograms per hectare) rate of P.

Weeds can play an important role in the increase or persistence of nematodes in cropping soils. Thus, poor control of susceptible weeds compromises the use of crop rotations for RLN management.

Wild oat, barley grass, brome grass and wild radish are susceptible to *P. neglectus*.

When a pasture is included in the cropping rotation, weeds strongly influence nematode populations at the end of the pasture phase.

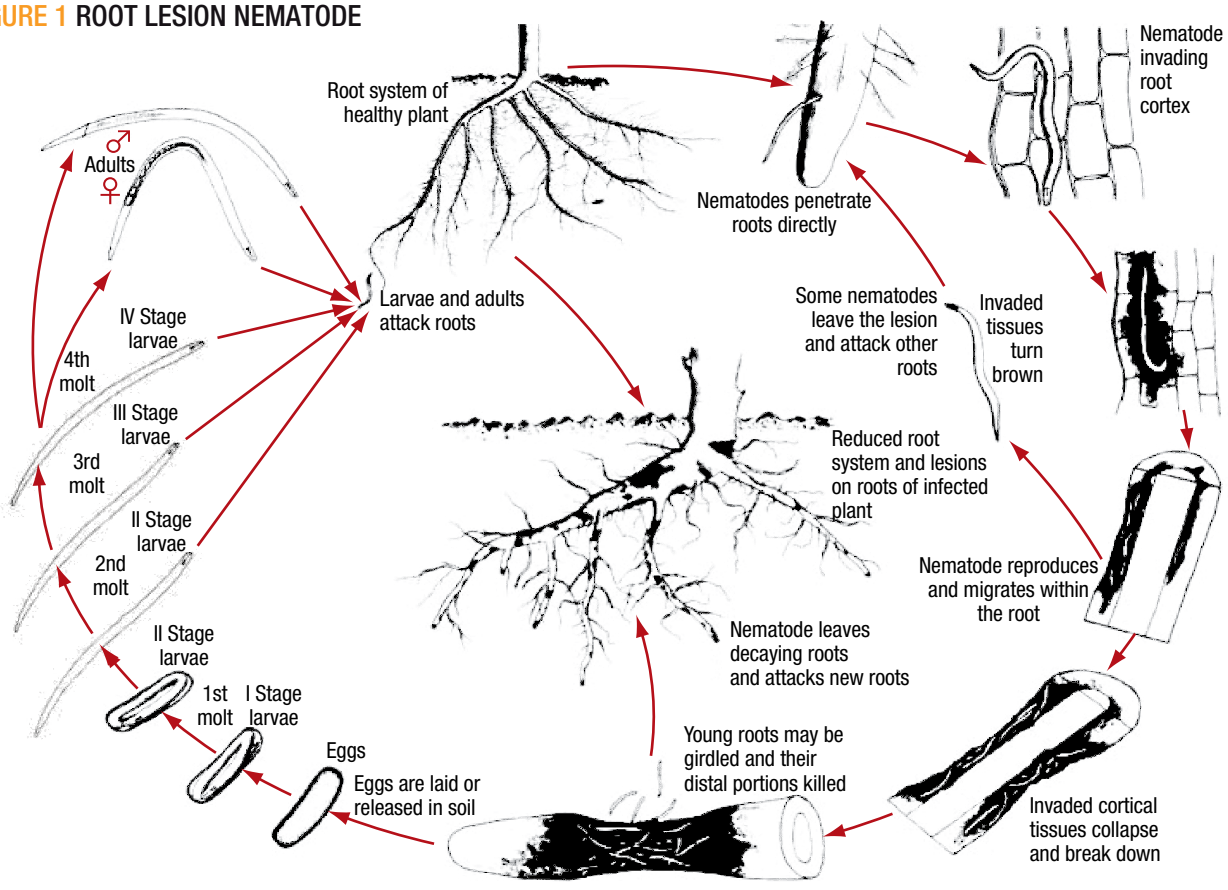
Manage volunteer susceptible crop plants that can harbour nematodes.

Nematodes cannot move great distances unaided. However, they can be spread by surface water, and in soil adhering to vehicles and farm machinery. In uninfested areas, good hygiene should be adopted. They can also be spread in dust when they are in a dehydrated state over summer.

Cultivation

Since RLN is vulnerable to death through soil disturbance while in its dehydrated state, mechanical disturbance through tillage has been considered as a method of reducing nematode populations. However, tillage of dry soil is not an option in southern or western Australian farming systems as this would expose the soil to wind erosion and also result in the loss of valuable soil moisture.

FIGURE 1 ROOT LESION NEMATODE



SOURCE: *AGRIOS GN, PLANT PATHOLOGY* 4TH EDITION. ACADEMIC PRESS: NEW YORK AND LONDON, 1997.

About the cereal cyst nematode

Only one race of CCN, *Heterodera avenae*, occurs in Australia and it causes cereal crop damage in Western Australia, South Australia, Southern NSW and Victoria.

It affects wheat, barley, oat and triticale varieties and can cause yield loss of up to 80 per cent in intolerant varieties. Barley varieties are tolerant, whereas wheat, and particularly oat, range significantly from moderately tolerant to very intolerant depending on the variety.

Although the majority of barley varieties are tolerant to CCN, they can still be susceptible. Although the tolerant barley crop will not be affected by the nematodes, they can still reproduce if that crop is susceptible, leaving high populations in the soil to infect a subsequent crop.

If CCN is a problem, the best choice is to grow a cereal variety that is both resistant and tolerant to the nematode.

CCN infested paddocks (regions) in southern Australia are now relatively rare following the widespread adoption of rotations using resistant cereals and non-host crops.

If CCN is present at moderate to high levels growers need to implement rotations using tolerant and resistant cereals and non-host crops for at least two years and then monitor nematode levels before considering the use of susceptible varieties.

The symptoms

The symptoms of CCN infection are readily recognised. Above-ground, patches of yellowed and stunted plants can be observed. Planting a susceptible crop in successive years will result in these patches becoming larger with time. Below-ground, wheat and barley roots will be 'knotted', and oat roots appear 'ropey' and swollen. Development of root systems is retarded and shallow. In spring, the characteristic pinhead-sized 'white females' can be seen, particularly on susceptible plants, with the naked eye if roots are carefully dug and washed free of soil.

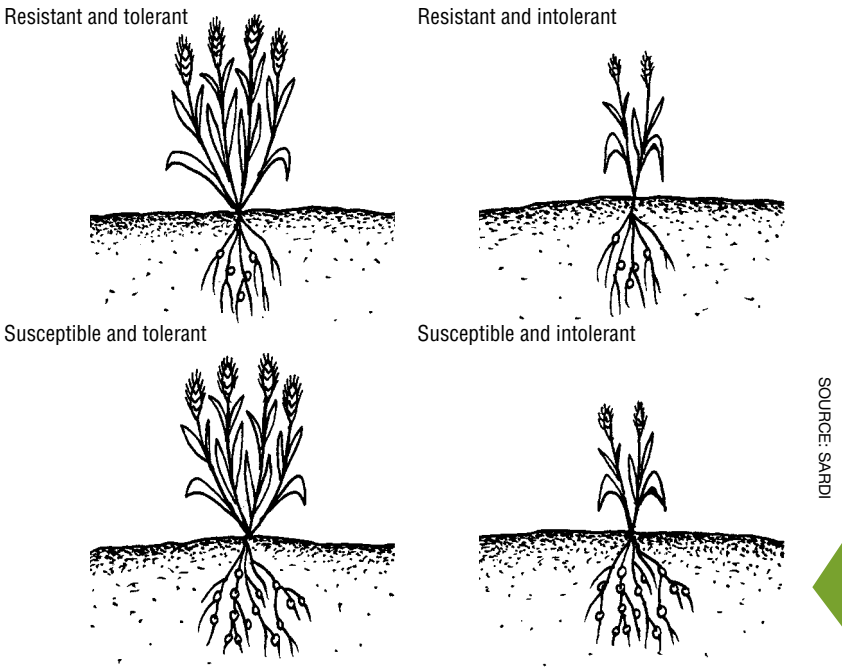
CCN is a sedentary plant-parasitic nematode which means after invasion of the host it sets up a fixed feeding site within the plant root. The life cycle of CCN, which has one generation per year, can be thought of as four stages beginning as an over summering stage as a brown cyst containing 200 to 300 eggs. Only 70-80 per cent of eggs hatch in the first year, regardless of conditions, leaving some in reserve for the second year which will infect a future host crop if planted.

The brown cyst develops from the swollen body of the female nematode as the crop matures in the previous late spring. Each cyst is approximately one millimetre in diameter and is covered with a hard, brown outer casing which enables the eggs to survive in soil over the hot dry Australian summer.

After opening rains (April-June), and when soil temperatures drop to 15 degrees C or below, juvenile nematodes hatch from the cyst and invade host plants. Each nematode sets up a feeding site called a syncytia. Female nematodes remain feeding in the root and gradually swell in the process of producing eggs.

The eggs are retained inside the body which eventually bursts through to the outside of the root. The white female can then be seen on the outside of the roots as a small cyst about the size of a pinhead and visible to the naked eye. Resistant plants may have a small number of white females present whereas susceptible plants may have large numbers where CCN is present in a paddock.

The female nematode dies as the crop ripens and forms a brown cyst that hardens and remains in the soil until the next season to complete the cycle.



SOURCE: SARDI

Variety ratings for nematodes

Varieties are rated according to their tolerance or intolerance and their susceptibility or resistance to nematodes. The mechanisms of resistance and tolerance are different and need to be treated as such.

- **Intolerance** means the crop yields poorly when attacked.
- **Susceptibility** means nematode numbers increase during the cropping season.
- **Tolerance** and **intolerance** ratings indicate the effect nematodes will have on the yield of the current crop.
- **Resistance/susceptibility** ratings indicate the effect the crop variety will have on reproduction of the nematodes, and hence the possible effect on the next crop via the nematode population remaining in the soil to infect the next crop.

Pictured are four combinations of ratings for nematodes. Tolerance/intolerance = the effect on the yield of the current crop, Resistance/susceptibility = the effect on building nematode numbers and the carryover to next year's crop.

Management of CCN

CCN is easy to manage which is evidenced by the widespread reduction in paddock CCN levels that has taken place since the introduction of resistant varieties and extension of management strategies. CCN is much easier to manage than RLN because of the greater range of resistant and non-host crops available.

CCN only feeds on cereals and other grasses. Wild oats are susceptible so will multiply the CCN population, but other grasses are resistant and produce low levels of CCN.

The use of CCN-resistant cereals and non-host crops such as pulses and oilseeds in rotation is the required management strategy. Where CCN levels are moderate to high the best choice is two years of resistant and tolerant cereal or non-host crops. The most profitable option will often be chosen, but growers should also be mindful of management of other diseases and weeds when making these choices to produce longer-term profits. While two years is generally accepted to reduce CCN to low levels, exceptions do occur. Monitoring paddocks and the use of diagnostic services to check CCN levels is encouraged. Less than five eggs per gram of soil can produce yield loss for intolerant cereals.

If susceptible cereal varieties are continually used in a rotation CCN can cause ongoing significant yield losses.

Soil testing can help ascertain the risk.

Break crops must be maintained free of wild oats and susceptible cereal volunteers. The benefit of a two-year break should be regarded as temporary because the nematode population rises quickly when susceptible cereals are returned to the system. The solution is not instant and it can take several years to reduce high levels.

Cultivation

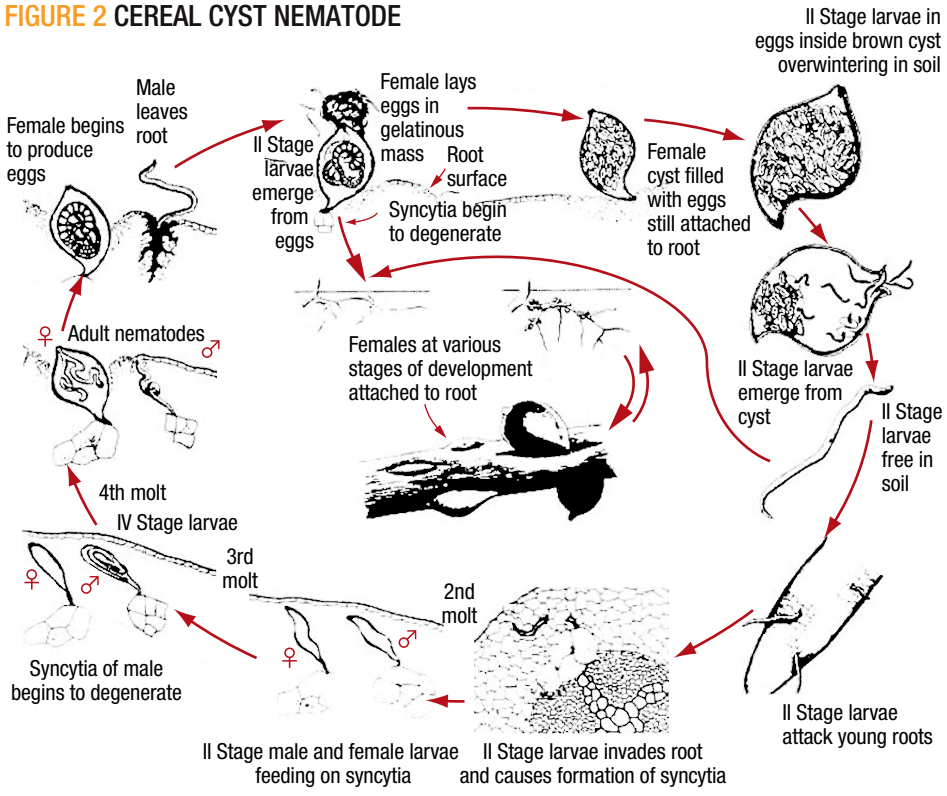
Cultivation exacerbates CCN damage, probably because it spreads cysts and hatched nematodes and/or facilitates the movement of nematodes to roots by lowering soil bulk density.

In contrast, there is less root damage under reduced tillage. Since there are also fewer white females on roots in non-till situations, there is less carry-over of cysts and eggs into the following season. The widespread adoption of no-till farming systems, along with the associated increase in row spacing, has probably played a role in reducing losses from CCN.

Testing

If cases of CCN or RLN infestation are suspected, growers are advised to check the roots of the host crops. Carefully digging up, then simply washing the soil from the roots of an infected plant can sometimes reveal evidence of infestation in the roots which warrants laboratory analysis. Testing services are available around Australia and growers are advised to contact their local agricultural department for advice.

FIGURE 2 CEREAL CYST NEMATODE



SOURCE: *GN AGRIOS, PLANT PATHOLOGY*, 4TH EDITION, ACADEMIC PRESS, 1997.

CCN cause roots to be retarded and shallow. Infected wheat and barley roots will appear knotted and oats appear 'ropey' and swollen.

Frequently asked questions

Q. Why is my resistant cereal showing CCN root damage?

Resistant cereals sown into a paddock with CCN will be attacked and penetrated at a similar rate as a susceptible variety causing the same damage. Resistant cereals act by suppressing the development of CCN in the root so very few can mature and cause multiplication whereas the CCN in the root of a susceptible variety will mature to produce large numbers of CCN white females.

Q. Can I spray for CCN or RLN?

Nematicides provide significant improvements in grain yield when applied to nematode-infested plots, but are no longer used commercially in Australia. They are not recommended because of their cost and inherent mammalian toxicity, and also because rotational crops are available for nematode management. If they were used commercially, it is likely their efficacy would be poor, particularly in situations where the nematode occurs at depth.

Currently, no nematicides are registered for use on broadacre crops in Australia.

Q: Is CCN ever likely to be a major problem in Australian farming again?

Yes. In SA and Victoria, the widespread adoption of resistant cereal varieties and non-host rotations has significantly reduced the problem. However, if susceptible varieties are grown in continuous rotation, CCN levels could easily increase again. Although CCN is less widespread in WA than in SA or Victoria, many Western Australian cereal varieties are susceptible to CCN. Intensive cultivation of susceptible cereals can lead to significant increase in CCN levels. So it is not a major problem at the moment but could be again if precautions are not taken, much the same way some human diseases could increase if inoculation programs were to stop.

Q: Does timing of sowing help?

There is limited information on the affect of time of sowing on the yield loss to intolerant crops in the presence of RLN. Trials in the northern region have shown later sown wheat crops can be more severely affected than those sown early. In Victoria, sowing in mid July compared with late May resulted in 60 per cent lower yield for an intolerant wheat variety, and 10 per cent lower yield for a tolerant variety where there was a high population of *P. thornei*.

Q: Could *P. teres* and *P. penetrans* spread to other states?

P. teres has only been identified in crops in WA and is not known to occur in other regions of Australia. In fact, *P. teres* is uncommon on broadacre crops anywhere in the world. *P. penetrans* does occur in other states, although it is generally known as a horticultural pest.

Useful resources:

Dr Vivien Vanstone, DAFWA	**(08) 9368 3141 Email vivien.vanstone@agric.wa.gov.au**
John Lewis, SARDI	**(08) 8303 9394 Email lewis.john@saugov.sa.gov.au**
PreDicta B™ – a soil analysis service delivered by accredited agronomists which can detect *P. neglectus*, *P. thornei* and CCN. This test is not currently able to detect *P. teres* and *P. penetrans*, so results need to be interpreted with caution, particularly for Western Australia. Contact your local agronomist or to locate your nearest supplier, email your contact details and location to:	**predictab@saugov.sa.gov.au**
Growing season tests can be carried out on affected plants and associated soil through state departments	
Testing laboratories	**WA (08) 9368 3721 or agwestplantlabs@agric.wa.gov.au SA (08) 8303 9360, VIC (03) 5362 2111**
***Cereal Root and Crown Diseases* (2000), Hugh Wallwork, GRDC and SARDI**	
DAFWA Bulletins	**www.agric.wa.gov.au**
For variety ratings see state crop variety and disease guides published annually	

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