A farming systems approach to sustainable management of nematodes in Western Australia

Summary
At least 60% of Western Australian (WA) cropping paddocks are infested with Root Lesion Nematode (RLN - *Pratylenchus* spp.). *Pratylenchus neglectus* is predominant (40%) followed by *P. teres* (10%). *P. thornei* is rare. Additional species (notably *P. penetrans*) were identified. RLN species are more diverse in WA than in eastern Australia. Two species of Burrowing Nematode (*Radopholus*) occur. Cereal Cyst Nematode (CCN) is increasing under intensive cereal cropping. Stem Nematode does not occur. Crops were tested for *P. neglectus* resistance. More data are needed for *P. teres*, *P. penetrans* and *Radopholus* spp. Rotations are the key to management of these pests, but since break crops vary with nematode species, diagnosis and identification are critical.

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Conclusions

ROOT LESION NEMATODE

At least 60% of Western Australian (WA) cropping paddocks are infested with one or more species of Root Lesion Nematode (RLN, *Pratylenchus* spp.). *P. neglectus* is predominant (detected in 40% of samples), followed by *P. teres* (in 10% of samples). *P. thornei* is rare. Additional RLN species occur. *P. penetrans* is identified from only 1% of samples, but has the potential to reach high levels and cause significant damage to cereal and field pea crops. *P. zeae* is found in less than 4% of samples (including wheat, barley and oat), scattered throughout the cropping zone and usually in mixed populations with *P. neglectus* or *P. teres*. *P. scribneri* is infrequent and occurs at low levels in mixed-species populations.

Rotations are the key to nematode management, through the use of crop species or varieties that will reduce nematode levels during the growing season. However, since all RLN have wide host ranges and present identical symptoms, it is critical to diagnose not only the levels but also the species present so rotations effective for the predominant RLN can be implemented. Resistance to one RLN species does not necessarily imply resistance to all.

Since diverse species of RLN occur in WA crops, nematode species and levels need to be monitored. Nematode species composition can change in response to different rotations, so a previously effective rotation may need to be altered in response to a changing nematode population.

For *P. neglectus* lupin, field pea and faba bean are resistant and oat and durum moderately susceptible (MS). No cultivars of wheat, barley, canola or chickpea are resistant, but cultivars with lower RLN levels have been identified and these can lead to 50-70% fewer nematodes than the most susceptible cultivars of these crops.

Crop reaction to *P. teres* varies from that for *P. neglectus* but more data are required to refine rotational recommendations for this RLN. Oat and lupin are more susceptible to *P. teres* than to *P. neglectus*, so may be less effective in reducing levels of this RLN species.

Crops resistant to *P. neglectus* (notably field pea, faba bean and lupin) are susceptible to *P. penetrans*. Chickpea and wheat are also susceptible to *P. penetrans*, while barley and canola are moderately susceptible (MS).

BURROWING NEMATODE

Two species of Burrowing Nematode (*Radopholus*) have been identified, particularly in the Northern and Central Regions. Although found in less than 3% of samples, these nematodes can reach high levels and cause significant damage to cereal and canola crops. Rotations for management of these nematodes are yet to be determined, but preliminary results suggest that barley, wheat, durum and chickpea are more susceptible than canola, field pea and oat. Diagnostic testing is required to
discriminate between *Radopholus* and RLN since both can produce similar root symptoms. *Radopholus* can be associated with distinctive patches of poor growth in cereal crops, so damage due to these nematodes also needs to be differentiated from *Rhizoctonia*.

CEREAL CYST NEMATODE

Cereal Cyst Nematode (CCN - *Heterodera avenae*) is detected in the Northern and Central regions, associated with intensive cereal production. High CCN levels causing significant crop damage need to be addressed through rotation with resistant or non-host crops.

STEM NEMATODE

Stem Nematode (*Ditylenchus dipsaci*) has not been identified in WA.

**Recommendations**

There is little that can be done during the season to correct a nematode infestation. However, it is important to recognise their occurrence in crops so appropriate action can be taken in the following season. This involves management strategies (particularly choice of rotation) to limit nematode multiplication. Testing services should be used to identify nematode levels and species. PreDicta®® cannot yet detect some species of RLN that occur in Western Australia nor the Burrowing Nematode. AGWEST Plant Laboratories can diagnose nematodes during the growing season.

The following recommendations for nematode management have been widely extended.

ROOT LESION NEMATODE

- *P. neglectus* is the dominant RLN but there are additional species in Western Australia (WA) and RLN can occur as populations of mixed species.
- Rotation with poor host crops appropriate to the predominant nematode species is the key to management.
- Field pea, faba bean and lupin are resistant to *P. neglectus*, so will reduce nematode levels.
- There is useful variation in susceptibility to *P. neglectus* in cultivars of wheat, barley, canola and chickpea that can be exploited to manage nematode levels.
- Consider the impact of nematodes on current as well as subsequent crops.
- Crops resistant to one RLN species will not necessarily be resistant to all.
- Weeds can build-up and carry-over nematodes.
- Wild oat, barley grass, brome grass and wild radish are susceptible to *P. neglectus*.
- Manage volunteer susceptible crop plants that can harbour nematodes.
- Ensure adequate nutrition (especially nitrogen, zinc and phosphorus) to enable crops to better tolerate nematode infection.

BURROWING NEMATODE

Further testing is required to determine crops and cultivars useful in reducing soil populations of *Radopholus* and subsequent crop damage. *Radopholus* has been recorded in wheat, barley, lupin and canola, and can reach high levels leading to significant damage in cereals. Where this nematode occurs, there is potential for high populations to develop under intensive cereal cropping. Rotations incorporating lupin should be monitored. Although these nematodes may not damage lupin they could build up and affect subsequent cereal crops. Soil and/or plant tests should be performed to discriminate between RLN and *Radopholus* damage to plants. Similarly, diagnosis and/or root investigation may be needed to differentiate between *Rhizoctonia* and *Radopholus* if distinctive patches of poor growth are evident in cereal crops.

CEREAL CYST NEMATODE (CCN)

- Avoid susceptible cereals where CCN is present.
- With high CCN levels a break of at least two years is required.
- Control susceptible cereal volunteers.
- Control grasses (particularly wild oat).
- Non-cereal crops will not host CCN.
- Most WA cereal cultivars are susceptible, but resistant cultivars have been developed in South Australia and Victoria.
• Ensure that resistant cultivars are also tolerant: resistance limits nematode multiplication; tolerance ensures the crop does not suffer yield loss.
• Monitor nematode levels and maintain low populations with rotations.

STEM NEMATODE

Avoid introduction of this pest to WA. Field pea, oat, canola, lentil, chickpea, lucerne, clover, medic, vetch and faba bean are hosts. Infested areas would need to be managed by rotation with resistant crops. A break of at least three years (including good weed control) would be needed. Oat and faba bean cultivars with resistance to Stem Nematode have been bred in South Australia.

Outcomes

ECONOMIC OUTCOMES

Root Lesion Nematodes (RLN) significantly impact on the productivity of crops grown in Western Australia (WA). Gross annual value of production from WA broadacre cropping is estimated at $3,200 million. This includes 10.65 million tonnes of wheat with a five-year average price of $220/t. If the identified RLN species reduce wheat production by 5% ($33/ha over 60% of the cropping zone), this represents a loss of approximately $64 million a year. If improved nematode management enhances wheat yield by only 2%, the estimated benefit to WA cereal production will represent approximately $13 a hectare (ha) over 3.6 million ha. During the course of DAW00030, information regarding management of nematodes through the use of appropriate rotations has been widely extended and is available for adoption. Furthermore, the need to identify nematode species and tailor rotations accordingly has been well-publicised. However, further data are required for additional RLN and Burrowing Nematode species. Availability of this data is expected to enhance adoption and increase grower confidence in recommendations of rotations for nematode management. DAW00124 is continuing to seek this information and conducting trials to demonstrate the practical yield benefits of rotations suitable for management of *P. neglectus* and CCN.

ENVIRONMENTAL OUTCOMES

Information to enable management of RLN and other nematodes without the use of chemicals has been widely extended. Enhanced root growth resulting from improved nematode management will allow growth of higher-yielding crops with better water and nutrient efficiencies. We also anticipate that information on the severity and distribution of nematodes (particularly CCN) in WA will lead to greater future efforts in crop improvement to produce cultivars with enhanced resistance to these pests. Availability of nematode-resistant cereal cultivars adapted to WA will further improve adoption of nematode management and maintain flexibility in cropping systems.

SOCIAL OUTCOMES

Improved crop yields and stabilised production through incorporation of appropriate recommendations for management of nematodes within cropping systems will contribute to the profitability of crop production and the sustainability of rural communities.

Achievements/Benefits

BACKGROUND AND IMPORTANCE

At least 60% of Western Australian (WA) cropping paddocks are infested with one or more species of Root Lesion Nematode (RLN, *Pratylenchus* spp.). Yield-limiting densities occur in 40% of these paddocks. RLN reduce cereal yields by at least 5% annually and losses as high as 15-20% have been recorded. As in the Eastern States, *P. neglectus* is predominant (detected in 40% of samples) and occurs throughout the cereal cropping zone. Unlike Eastern Australia, *P. thornei* is rare, but seven other species of root pathogenic nematodes occur in WA.

*P. teres* is detected in 10% of samples and occurs throughout the cereal cropping zone on wheat, barley, oat and canola. It is likely that prior to 2003, many *P. teres* were misidentified as *P. thornei*. *P. teres* is not found in crops in other areas of Australia.

*P. penetrans* is identified from only 1% of samples (some may have been misidentified as *P. neglectus* prior to 2003). Records of this nematode are restricted to the western border of the wheat belt, from Geraldton in the North to near Albany in the South. Significant impact from *P. penetrans* has been observed on wheat and field pea, and this nematode can reach very
and lupin (MR=1.6) were more susceptible to

Limited data from 2003 trials indicate that crop reaction to this species varies from the reaction to \textit{P. teres} species can vary from that to the prevalent species, Resistance to one RLN species does not necessarily confer resistance to all. Different RLN species present identical symptoms.

Identity, impact and distribution of RLN species other than \textit{P. neglectus} has also been detected. These nematodes occur throughout the cropping zone, particularly in the Northern and Central Regions. \textit{Radopholus} occur in less than 3% of samples but can reach high levels and cause significant damage to wheat, barley and canola.

Cereal Cyst Nematode (CCN, \textit{H. avenae}) is becoming more widespread and damaging in WA areas under intensive cereal production. There are numerous instances of CCN in the North around Geraldton (associated with intensive cereal cropping) and in the Central Region around Northam (possibly associated with oat hay production). There have been fewer detections in the South. In many cases these nematodes have reached high population densities and are causing significant crop damage which needs to be addressed through rotation with resistant or non-host crops.

Stem Nematode (\textit{Dictylenchus dipsaci}) has not been identified in WA.

Rotations using poor or non-host crops (to reduce nematode levels during a growing season) are the key to effective and sustainable nematode management. However, all RLN species have wide host ranges, obfuscating the use of rotations for management, particularly in areas where several species occur. Furthermore, species vary in host plant preferences, imposing the need for correct species diagnosis when devising rotational strategies. Crops resistant to one RLN will not necessarily be resistant to all. It is therefore important to diagnose not only the levels of these nematodes but also the identity of species present.

**MAJOR ACHIEVEMENTS**

**Resistance/susceptibility of crop species and cultivars to \textit{P. neglectus}**

During 2003 and 2004, 124 cultivars were assessed from 47 Crop Variety Testing and pulse trials to determine relative resistance/susceptibility to \textit{P. neglectus}. These comprised 28 wheat, 20 barley, 12 oat, 16 durum, 13 canola, eight field pea, six faba bean, 12 chickpea and nine lupin cultivars. Nematode levels from plots were measured following sowing and again in mid spring. From these data, nematode multiplication rates over the growing season were determined. A multiplication rate (MR) of greater than one indicates susceptibility. Less than one indicates resistance.

Oat (MR=1.6) and durum (MR=2.5) have moderate susceptibility. All tested cultivars of lupin (MR=0.9), field pea (MR=0.3) and faba bean (MR=0.2) were resistant. No wheat, barley, canola or chickpea cultivar was resistant but there was variation in susceptibility that could be exploited in rotations to assist management of \textit{P. neglectus}. For wheat, GBA Sapphire\textsuperscript{(6)}, EGA Eagle Rock\textsuperscript{(6)}, Camm\textsuperscript{(5)}, GBA Ruby\textsuperscript{(6)}, Cascades and Wyalkatchem\textsuperscript{(6)} were less susceptible (MR=7 to 20) than Westonia\textsuperscript{(5)}, EGA Jitarning\textsuperscript{(5)}, Bullaring\textsuperscript{(5)}, Brookton\textsuperscript{(5)}, GBA Shenton\textsuperscript{(5)}, Chara\textsuperscript{(6)}, EGA Blanco\textsuperscript{(6)} and Mira\textsuperscript{(6)} (MR=30 to 50). Barley cultivars Gairdner\textsuperscript{(5)}, Stirling, Barque\textsuperscript{(5)}, Schooner\textsuperscript{(5)} and Cowabbie\textsuperscript{(5)} (MR=1 to 4) were less susceptible than Hamelin\textsuperscript{(5)}, Doolup\textsuperscript{(5)}, Harrington, Mundah\textsuperscript{(5)} and Baudin\textsuperscript{(5)} (MR=5 to 11). Beacon, Grace, Stubby\textsuperscript{(5)} and Pinnacle\textsuperscript{(5)} (MR=2 to 7) canola were less susceptible than Tranby\textsuperscript{(6)}, Hyden\textsuperscript{(6)}, Eyre\textsuperscript{(6)}, Surpass 603c\textsuperscript{(6)} and Surpass 501TT\textsuperscript{(5)} (MR=8-19). Rupali\textsuperscript{(6)} and Sonali\textsuperscript{(6)} chickpea (MR=3 to 7) were less susceptible than Howzat\textsuperscript{(6)}, Sona\textsuperscript{(6)}, Heera\textsuperscript{(6)}, Genesis\textsuperscript{(6)} 836 and Kaniva (MR=8 to 12). Although the least-susceptible cultivars of wheat, barley, canola or chickpea will still allow multiplication of \textit{P. neglectus}, these could result in 50 to 70% fewer nematodes than if more susceptible cultivars were sown. Alternatively, lupin, field pea and faba bean will not contribute to further increase in levels of \textit{P. neglectus}, so are the most effective rotational crops for management of this nematode.

**Identity, impact and distribution of RLN species other than \textit{P. neglectus}**

Resistance to one RLN species does not necessarily confer resistance to all. Different RLN species present identical symptoms. Diagnosis is therefore critical for implementation of rotations for management, particularly since crop reaction to other species can vary from that to the prevalent species, \textit{P. neglectus}.

\textit{P. teres} occurs throughout the WA cereal growing region, where it has been detected on wheat, barley, oat and canola. Limited data from 2003 trials indicate that crop reaction to this species varies from the reaction to \textit{P. neglectus}. Oat (MR=8.1) and lupin (MR=1.6) were more susceptible to \textit{P. teres} than to \textit{P. neglectus}. Some lupin cultivars may be less effective in
reducing *P. teres* levels. However, additional data are necessary to allow development of rotational recommendations for this RLN.

*P. penetrans* is not usually associated with broadacre crops but was identified at high levels (up to 900,000/g dry root) causing significant damage to some wheat, oat and field pea crops. In 2003, *P. penetrans* multiplied on eight field pea cultivars (MR=3.1) but *P. neglectus* did not (MR=0.4). In the glasshouse, five barley, four canola, two triticale, four oat, four field pea, three faba bean, four durum, five wheat, five lupin and four chickepea cultivars were grown in pots of infested field soil to assess these crops as hosts for *P. penetrans*. All were susceptible. Notably, this included crops that are resistant to *P. neglectus*: field pea (MR=5.4), faba bean (MR=6.0) and lupin (MR=7.1). Chickpea (MR=13.3) was the most susceptible, followed by lupin (MR=7.1) and wheat (MR=6.5). Barley (MR=2.5) and canola (MR=2.9) were the least susceptible.

### Identity, impact and distribution of *Radopholus* species

Prior to its recognition in WA cereal crops in 1998 (Riley and Kelly 2001 Nematology 3:25-30), *R. nativus* was not known to cause economic crop damage. Despite more than 20 years’ RLN research in Eastern Australia, *Radopholus* (burrowing nematode) has never been recorded from field crops in that region.

Burrowing nematode has since been identified from more than 30 locations throughout the WA cropping zone. Very high levels have been detected in wheat (176,000/g dry root) and barley (70,000/g dry root), moderate levels in lupin (12,000/g dry root) and low levels in canola (6,700/g dry root). Wheat and barley crops infested by *Radopholus* exhibited large areas of poor growth, patchiness, stunting and chlorosis. The appearance of these patches could be confused with *Rhizoctonia* unless roots were examined and nematodes extracted for diagnosis. Root damage consisted of shortened seminal roots, poor development of crown roots, reduction in length and number of lateral roots and extensive browning of the root system. In severe cases, roots were devoid of laterals and crown roots and the entire root system dark brown with disrupted cortical tissue. Less severe root symptoms resembled those of RLN.

*Radopholus* levels within patches of poor growth were very high (150,000/g dry root; 45/g dry soil) from the edge of patches, moderate in the plants (16,000/g dry root) and high in the soil (33/g dry soil). Populations were lower from apparently healthy areas of the crop (1,000/g dry root; 4/g dry soil).

In the glasshouse, five barley, four canola, two triticale, four oat, four field pea, three faba bean, four durum, five wheat, five lupin and four chickepea cultivars were grown in pots of infested field soil for 11 weeks to assess these crops as hosts of *R. nativus*. Canola (5/g dry root) and field pea (85/g dry root) were the least susceptible, with barley (1768/g dry root), wheat (1794/g dry root), durum (6418/g dry root) and chickpea (11,080/g dry root) the most susceptible. Additional information is required to better define rotational options for this nematode and for comparison with RLN species.

A second species of *Radopholus* causing identical damage has been detected at some locations. This species, which is yet to be identified by South Australian Research and Development Institute (SARDI) nematode taxonomist Dr Jackie Nobbs, putatively represents a previously undescribed nematode. Differences in host preferences between the two species are yet to be determined.

### Threat to Western Australian crop production from CCN

CCN is detected at multiple locations in the Northern and Central Regions. There are limited detections in the South. In many cases the nematodes have reached very high levels, impacting significantly on yield. This suggests populations have been developing unchecked over a number of years. This is undoubtedly due to the intensity of cereal cropping, exacerbated by the susceptibility of most WA cereal cultivars. Unlike RLN, CCN has a narrow host range and is readily managed through rotation. We are raising awareness and widely disseminating information on the recognition and management of CCN.

### Improved diagnostics for Western Australian RLN species

Significant collaborations have been developed with colleagues Australia-wide to improve diagnostics for the nematodes of significance to WA cropping.

AGWEST Plant Laboratories diagnose nematodes during the growing season, based on extraction and microscopic identification of live nematodes. The PreDicta®B test relies on detection of DNA using probes specifically developed for different nematodes or fungi. While this test can reliably detect *P. neglectus*, *P. thornei* and CCN, it is not currently designed to detect other nematode species. We are working with Drs Alan McKay and Herdina (SARDI Adelaide) and providing
samples of WA species required for development of probes that will be added to the currently available suite of tests, thus making the PreDicta® B test more reliable for WA growers.

Ms Diana Hartley (CSIRO Canberra) is sequencing nematodes to assist with probe development. Genetically, taxonomically and morphologically, WA P. neglectus are more variable than those from elsewhere. Sequencing has verified identities of RLN species other than P. neglectus and confirmed that the two Radopholus species detected are in fact different.

Nematode taxonomists Drs Jackie Nobbs (SARDI Adelaide) and Mike Hodda (CSIRO Canberra) are working with us to assist with determination of appropriate morphological features for use in routine microscopic identifications of diverse RLN species. This information is also utilised by AGWEST Plant Laboratories for nematode identifications carried out for clients of the Diagnostics Service.

With Drs Modika Perera and Mike Jones (State Agricultural Biotechnology Centre, Murdoch) we are developing nematode species-specific protein profiles. Significantly, Dr Perera has been able to use protein profiling to differentiate oat and lucerne races of Stem Nematode (D. dipsaci), which has not previously been possible. Morphologically, the races are indistinguishable. While Stem Nematode does not occur in WA, this technique would be of value if this nematode were to be detected in the State.

None of these diagnostic methods can be developed in isolation from taxonomic studies, as it is critical to first verify identity of nematodes used in their development. We are working closely with nematode taxonomists Drs Jackie Nobbs (SARDI Adelaide) and Mike Hodda (CSIRO Canberra). Nematode cultures developed at DAWA are being used in diagnostic development. They are, however, first verified taxonomically. This is also critical for their future use as inocula for nematode-hosting studies.

Development of laboratory cultures

Cultures of P. neglectus, each initiated from a single female have been developed from 11 locations. These will be used during DAW00124 for comparative studies between locations and between RLN species. Comparison will be made to South Australian P. neglectus that has been in culture since it was initiated by Dr Vanstone in 1989.

P. thornei has been cultured from one location and P. penetrans from two.

P. teres and Radopholus have proved difficult to establish in culture and success of DAWA cultures is yet to be determined. Dr Nobbs is also attempting to culture these species.

“Back-up copies” of all WA cultures are maintained by Dr Nobbs at SARDI.

Extend rotational recommendations

Information on rotations for management of nematodes in WA cropping areas has been widely extended.

INDUSTRY BENEFITS

Nematodes significantly impact on the productivity of WA crops. Diverse species with wide host ranges occur over an extensive area. If improved nematode management enhances wheat yield by only 2%, the benefit to WA cereal production will represent approximately $13/ha over at least 3.6 million hectares. Adoption of appropriate recommendations for management of nematodes within cropping systems will improve crop yields and stabilise production systems. Information on recognition and management of nematodes has been widely extended.

Other research

Rotations to reduce impact of nematodes in Western cereal cropping systems
GRDC DAW00124, DAWA (Vanstone) July 2005-June 2007
DAW00124 expands on DAW00030, including trials to demonstrate benefits of rotations for management of P. neglectus and CCN. Further studies will determine hosts for diverse nematode species to aid development of rotations and to define host commonalities that can be broadly applied.

Managing disease constraints in Western Region farming systems
GRDC DAW00106, DAWA (Loughman) July 2004-June 2007
DAW00124 will assess nematodes in root disease surveys and involve other collaborations as appropriate.

Developing novel methods to identify plant parasitic nematodes
ARC Linkage LP0219690, Murdoch/SABC/DAWA (Perera, Jones, Vanstone) Jan 2003-Jan 2005
This project provided proof-of-concept that MALDI-TOF MS could reliably produce species-specific protein profiles. Work with RLN, CCN, Stem and Burrowing Nematodes will continue in LP0560971. This method can distinguish oat and lucerne races of Stem Nematode, which has not previously been possible. Diagnostics for this nematode will be of enormous benefit should the pest be introduced to WA.

Field based molecular diagnostics for identification of plant parasitic nematodes
ARC Linkage LP0560971, Murdoch/SABC/DAWA (Perera, Jones, Vanstone) Jan 2005-Jan 2008
Methods are optimised for extraction and identification of species-specific proteins that will now be used to identify antibodies specific to target nematodes. This will ultimately lead to development of diagnostic ‘fingerprinting’.

Identify risks to Western Australian cropping from endemic parasitic nematodes
RIRDC Full Proposal unsuccessful, DAWA (Vanstone).
Identify risk to WA cropping from endemic plant parasitic nematodes. Improve capacity to address threats from nematodes. Generate knowledge to devise management for additional nematodes. Enhance diagnostic capacity for nematodes.

Exploring a model system to develop controls for plant parasitic nematodes
GRDC Response to Tender unsuccessful, Murdoch/SABC/Epichem Ltd/North Carolina State University/DAWA (Jones, Mounsey, Best, Bellgard, Bird, Vanstone)
The full genome of the nematode *Caenorhabditis elegans* has been sequenced. Epichem Ltd have synthesised more than 200 compounds with potential nematicidal activity. By screening compounds against *C. elegans* mutants produced with plant-parasitic homologous genes, compounds active against plant parasites can be determined.

Annual pasture legumes for management of plant and animal parasitic nematodes
RIRDC PRP submitted Oct 2005, DAWA (Vanstone, Revell, Besier)
There is limited information on the role of annual legumes in nematode management. Pastures will be screened for plant parasitic nematodes and for capacity to reduce populations of animal parasitic nematodes.

Existing collaborations enhancing current and future projects
Dr J Nobbs (SARDI Adelaide) - taxonomy and identification of nematodes
Dr S Taylor (SARDI Adelaide) - advises on Stem Nematode
Dr M Hodda (CSIRO Canberra) - investigation of inter- and intra-specific variation in RLN species
Ms D Hartley (CSIRO Canberra) - RLN and *Radopholus* DNA sequencing
Drs A McKay and Herdina (SARDI Adelaide) - diagnostic probes for WA nematodes
Mr J Lewis and Mrs M Matic (SARDI Adelaide) - advice on CCN and pathogenicity tests to compare WA and South Australian (SA) CCN
Mrs J Rowe (Rothamsted England) - comparison of WA Australian, SA, European and UK isolates and species of CCN

Intellectual property summary
IP for PreDicta® B is currently held jointly by SARDI, CSIRO and Bayer CropScience. SARDI has rights to the use of this technology for research purposes. Testing will be made available to DAWA nematology as a research tool during the validation phase of development for WA nematode species (including *P. teres*, *P. penetrans* and *Radopholus*). Dr Vanstone will be involved with any future delivery in WA of additional PreDicta® B tests for nematodes. These training courses will serve to disseminate GRDC project outcomes, raise awareness of nematode pests in WA cropping and emphasise rotational management options developed in this and future projects for the nematode species relevant to cropping in WA.

Additional information
DAFWA Bulletin 4698. Root Lesion and Burrowing Nematodes in Western Australian cropping systems (DAFWA Feb 2007). Vivien Vanstone  


DAFWA Farmnote 401. Lupin Root Diseases (DAFWA Jan 2010). Thomas G, MacLeod B and Vanstone V.  

GRDC Factsheet. Southern and Western Region – Managing Cereal Cyst and Root Lesion Nematodes. Vanstone V and Lewis J.  


Agribusiness Crop Updates


