Diseases concurrent session

Nematodes – latest summer and winter crop rotation results

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Key words

*Pratylenchus thornei*, root-lesion nematodes, mungbean, soybean, maize, sorghum, sunflower, wheat, fallow, tolerance, intolerance, resistance, susceptibility.

GRDC code

DAV00128

Take home messages

Choose tolerant rather than intolerant wheat varieties when *P. thornei* is present at damaging levels, or risk reducing your yields by 50%.

One resistant crop in sequence may not be enough to decrease damaging populations of *P. thornei*.

*P. thornei* survived after a sequence of five resistant crops, but in very low populations.

Management of *P. thornei* by growing several resistant crops works and populations can be reduced to very low levels. However on-going vigilance by testing soil for nematodes is essential when susceptible crops are planted.

Background

Root-lesion nematodes are microscopic thread-like animals that live in soil and plant roots. Plant roots that are damaged by the nematodes are inefficient at taking-up water and nutrients, causing up to 65% yield loss in intolerant wheat varieties. *Pratylenchus thornei* is found in approximately 70% of fields in the northern grain region.

Management of the root-lesion nematode *Pratylenchus thornei* requires:

- Growing tolerant wheat varieties so that yields are maximised
- Rotating with two or more successive resistant crops so that populations of the nematodes decrease.

Summer crop rotation trial

Two summer crop rotation trials were planted in adjacent fields in December 2011.

1) The first field had low *P. thornei* populations (<125/kg soil or 0.125/g soil). The previous cropping history was five resistant crops since 2004 (cotton, maize and sorghum) (Figure 1).

2) The second field had moderate *P. thornei* populations (range of 2000 to 3000/kg soil (or 2-3/g soil) at 0–90 cm soil depth). The previous cropping history was wheat, sorghum, wheat (Figure 1).

Several cultivars of mungbean, soybean, sunflower, maize and sorghum were planted in each field in December 2011 in a replicated design with sufficient plots to plant wheat cvv. EGA Wylie® (tolerant) and Strzelecki® (intolerant) in 2013. There was also an unplanted bare fallow treatment. After harvest of the summer crops nematode populations were recorded to 120 cm soil depth.
Figure 1. Starting populations of *Pratylenchus thornei* in the summer crop rotation experiments in adjacent fields.

**Results**

*Moderate P. thornei site*

*P. thornei* was found to 90 cm soil depth and populations were greatest at 0–15 cm soil depth (Figure 2).

Populations of *P. thornei* after growing sorghum, sunflower and maize were similar to bare fallow (range of 2,900–4,500/kg soil at 0–15 cm (Figure 2)). There were no significant differences between varieties within each of these crop species (Figure 3).

In contrast, populations of *P. thornei increased* after growing mungbean or soybean compared to sunflower, sorghum, maize or clean fallow (Figure 2). There were also differences between varieties of soybean and mungbean (Figure 3).

Soybean cv. Soya791 was moderately resistant (4,800 *P. thornei*/kg soil at 0–15 cm) and its effect did not differ significantly from the fallow treatment. However, all other soybean varieties were very susceptible. Populations of *P. thornei* increased 4–6.7 times to 12,000–20,600 *P. thornei*/kg soil at 0–15 cm (Figure 3).

Mungbean, cv. Emerald was moderately resistant (3,400 *P. thornei*/kg soil) and its effect did not differ significantly from the fallow treatment. However, all other mungbean varieties tested were susceptible and *P. thornei* populations increased 2.2–3.8 times to 6,700–11,700 *P. thornei*/kg soil at 0–15 cm (Figure 3).
Figure 2. Populations of *Pratylenchus thornei* increased after growing mungbean and soybean. After growing sunflower, maize and sorghum, populations were similar to the bare fallow (grey line). Means of varieties within each crop are presented for the moderate Pt site.

Figure 3. After harvest of the summer crops, *Pratylenchus thornei* was found in highest populations at 0–15 cm soil depth. Varieties of sunflower, maize, sorghum, mungbean cv. Emerald and soybean cv. Soya791 did not differ significantly from the fallow treatment. * indicates significantly higher *P. thornei* populations than the fallow treatment (P<0.05). Green Dia is mungbean cv. Green Diamond.
*Low P. thornei site*

*Pratylenchus thornei* was detected to 60 cm soil depth; below that depth populations were very low or zero (Figure 4).

There were no significant differences in *P. thornei* populations after the different summer crops or the varieties.

Overall, populations increased five times compared to before planting the summer crops, but remained below 250/kg soil (Figure 4).

![Graph](image)

**Figure 4.** *Pratylenchus thornei* populations after harvest of the summer crops at the low Pt site (black line). Mean data for all crops presented; there were no significant differences between crops or varieties. Letters indicate significant differences (P≤0.05) between depth intervals after harvest of the summer crops (black line). The grey line is the pre-plant populations.

*Summer crop biomass and yield*

There were no differences in biomass or grain yield of the summer crops between the low and moderate *P. thornei* sites.

**The summer crops used were tolerant to *P. thornei* so they did not suffer yield loss.**

*Impact on the next wheat crop*

At the site that started with moderate *P. thornei* populations the yield of the intolerant wheat cv. *Strzelecki* was reduced by 49% compared the tolerant wheat cv. *EGA Wylie* (1,900 kg/ha after *Strzelecki* compared to 3,700 kg/ha after *EGA Wylie*). In contrast, at the site that started with low *P. thornei* populations there was only a 4% difference in yield between cv. *Strzelecki* and *EGA Wylie* (3,600 kg/ha and 3,700 kg/ha respectively). The yield of cv. *Strzelecki* increased 47%, or 1,700 kg/ha, at the low *P. thornei* site compared to the moderate *P. thornei* site (Figure 5).
Figure 5. Yield of the intolerant wheat cv. Strzelecki was reduced by 47% in the experiment that started with moderate *P. thornei* populations (Mod Pt; 2000–3000/kg soil before the trial started) compared to the low *P. thornei* site (Low Pt; <125/kg soil before the trial started). Columns with the same letter are not significantly different (*P* >0.05). ‘†’ All varieties listed are protected under the Plant Breeders Rights Act 1994.’

Figure 6. Yield of the 2013 intolerant wheat cv. Strzelecki and tolerant cv. EGA Wylie at the site that started with moderate *P. thornei* populations (2000–3000/kg soil at 0–90 cm soil depth) before planting the summer crops in 2011-12. Strzelecki columns with the same letter are not significantly different (*P* >0.05).
Yield of wheat cv. Strzelecki was lowest following soybean (1,600 kg/ha) and greatest following maize and sunflower (2,100 kg/ha). An unexpected result was that there were no significant differences in yield of cv. Strzelecki after fallow, sorghum and mungbean. This result may be partly due to dry conditions during the 2011-12 summer and following winter season which limited nematode multiplication, particularly after the susceptible mungbean. Additionally and importantly, the results support that one resistant crop in sequence was not enough to sufficiently reduce populations of *P. thornei*. Nevertheless, there was a strong negative relationship between populations of *P. thornei* after the summer crops and yield of the following intolerant wheat cv. Strzelecki. In contrast, there was no relationship between populations of *P. thornei* and yield of the tolerant wheat cv. EGA Wylie (Figure 7) which is an expected result because of the good level of tolerance of EGA Wylie to *P. thornei*.

At the low Pt site, there was no relationship between yields of the tolerant and intolerant wheat and populations of *P. thornei* after growing the summer crops. Populations were below the damage threshold for wheat cv. Strzelecki.

![Graph](image-url)

**Figure 7.** There was a strong negative relationship between populations of *Pratylenchus thornei* after the 2011-12 summer crops and yield of following wheat cv. Strzelecki (*P*=0.01, n = 6). In contrast there was no significant relationship between yield of cv. EGA Wylie and populations of *P. thornei*. Data is from the moderate *P. thornei* site (2000–3000/kg soil at 0–90 cm soil depth before the trial began) and means for 5 summer crops and a fallow treatment are plotted.

**What did we learn from this experiment?**

Grow a tolerant wheat variety when populations of *P. thornei* are at damaging levels or risk losing up to half of your yield.

Growing one resistant crop, such as sorghum, maize or sunflower did not provide a quick fix in the field that started with 2,000–3,000 *P. thornei/kg soil. Populations of *P. thornei* did not fall below...
damaging levels and the next intolerant wheat lost 44–51% in yield compared to a tolerant wheat variety.

*P. thornei* does not die out completely even after five successive resistant crops. Management of root-lesion nematodes is on-going and requires regular soil tests to monitor nematode populations.

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Pre-sow assessment of crown rot risk in the northern region

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Key words
DNA soil testing, disease risk, crown rot, root lesion nematodes, common root rot

GRDC codes
DAS00137 – National improved molecular diagnostics for disease management
DAN00143 – Northern NSW integrated disease management

Take home message
- PreDicta B is a good technique for identifying the level of risk for crown rot (and other soil-borne pathogens) prior to sowing within paddocks. However, this requires a dedicated sampling strategy and IS NOT a simple add on to a soil nutrition test.
- Soil cores should be targeted at the previous winter cereal row if evident and DO NOT remove any stubble fragments.
- Short pieces of stubble (up to 15) from previous winter cereal crops and/or grass weed residues can be added to the soil sample to enhance detection of the Fusarium spp. that cause crown rot.
- If you are not willing to follow the recommended PreDicta B sampling strategies then DO NOT assess disease risk levels prior to sowing.

Introduction
PreDicta B is a DNA based soil test which detects levels of a range of cereal pathogens that is commercially available to growers through the South Australian Research and Development Institute (SARDI). The main pathogens of interest in the northern grains region detected by PreDicta B are Fusarium spp. (crown rot), Bipolaris sorokiniana (common root rot), Pythium (damping off) and both Pratylenchus thornei and P. neglectus (root lesion nematodes, RLNs). Over recent years PreDicta B has been shown to be a reliable method for assessing RLN populations but is perceived by industry to be less reliable in assessing levels of crown rot risk in the northern region. This is potentially due to the crown rot fungus being stubble-borne while PreDicta B is a soil based test. Consequently, there may be sampling issues which need to be resolved to improve the reliability of detecting crown rot inoculum levels prior to sowing.

The following paper reports on collaborative research conducted by NSW DPI and SARDI across central/northern NSW from 2010-2013 to determine the accuracy of PreDicta B to predict the risk of crown rot infection prior to sowing and progress in improving the reliability of this technique within the region.

Survey 2010-2012
NSW DPI conducted a winter cereal pathogen survey of 248 paddocks annually across 12 agronomy districts in central and northern NSW from 2010-2012. A one hectare area was established in each focus paddock and 20 small cores were collected in a grid across the trial area targeting the previous winter cereal crop rows to a depth of 0-30 cm prior to sowing in each year. The soil samples were sent to SARDI for PreDicta B analysis. Winter cereal stubble if evident was collected from each focus paddock when taking soil samples then trimmed, surface sterilised and plated on laboratory media for the recovery of Fusarium spp. Fifty crowns, collected from different plants, were plated from
each paddock to provide and incidence of crown rot (*Fusarium*) infection. Over the three survey years this allowed 307 comparisons of *Fusarium* DNA levels assessed at sowing using PreDicta B with the actual incidence of infection that developed by harvest as determined from laboratory plating (Table 1).

**Table 1.** Relationship between levels of Fusarium detected using PreDicta B at sowing and incidence of crown rot infection based on laboratory plating after harvest from 307 paddocks (2010-2012)

<table>
<thead>
<tr>
<th>PreDicta B</th>
<th>25%&gt;</th>
<th>11-24%</th>
<th>3-10%</th>
<th>0-2%</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;2.0</td>
<td>High</td>
<td>28</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>1.4-2.0</td>
<td>Medium</td>
<td>17</td>
<td>13</td>
<td>6</td>
</tr>
<tr>
<td>0.6-1.4</td>
<td>Low</td>
<td>12</td>
<td>15</td>
<td>9</td>
</tr>
<tr>
<td>&lt;0.6</td>
<td>BDL</td>
<td>30</td>
<td>27</td>
<td>65</td>
</tr>
</tbody>
</table>

PreDicta B risk categories have been established for crown rot based on log DNA levels at sowing (Table 1). Similarly, previous NSW DPI research has established what constitutes a low (3-10%), medium (11-24%) and high (>25%) level of crown rot infection based on laboratory plating (Table 1).

In 107 paddocks (35%) PreDicta B at sowing predicted the exact level of infection that developed in the crop when measured after harvest (darker grey shading Table 1). For example, soil DNA levels indicated a high risk of crown rot development in 28 paddocks and over 25% of plants were infected with *Fusarium* at harvest in these paddocks.

However, these categories are fairly tight. The predicted risk of crown rot development at sowing using PreDicta B was within one category of the actual level of infection measured after harvest in 121 paddocks (39%, light grey shading). For example, soil DNA levels indicated a medium risk of crown rot development in 17 paddocks (i.e. should have been between 11-24% infection) but greater than 25% infection actually occurred making this a high level of crown rot infection. In many of these situations these actual levels of infection that developed were only just outside the predicted levels at sowing. Hence, taking this approach PreDicta B correctly predicted the risk of crown rot development at sowing within one category of what developed in 74% (228) of the paddocks over the three years.

In 10 paddocks (3%) PreDicta B overestimated the risk of infection compared to that which actually developed. For example, soil DNA levels indicated a high risk of crown rot development in 8 paddocks but only low levels of infection (3-10%) were measured at harvest. This could potentially relate to inter-row sowing of the wheat crop between the previous cereal stubble rows which has been shown in previous research to significantly reduce the incidence of crown rot infection.

The bigger concern was that in 69 paddocks (22%) PreDicta B underestimated the risk of crown rot compared to the levels which actually developed. For example, soil DNA levels indicated crown rot levels were below the detection limit (BDL) in 30 paddocks but greater than 25% of plants were infected with *Fusarium* at harvest. This is considered a ‘failure to warn’ with the question being why?

**Detection issue?**

A potential cause of the failure to warn in 22% of paddocks could be the inability of the current PreDicta B tests to actually detect the species of *Fusarium* causing crown rot across the region. Currently there are three separate tests within PreDicta B that detect common species causing
crown rot across Australia. There are two tests which detect variations in *F. pseudograminearum* (*Fp*) populations and a third test which detects both *F. culmorum* (*Fc*) and *F. graminearum* (*Fg*) but cannot differentiate between these two species.

A total of 180 *Fusarium* isolates (1 or 2 isolates per paddock) were collected from crown rot infected winter cereal crops throughout central and northern NSW in late 2012 and early 2013. The isolates were sent to SARDI who extracted DNA and tested them against the three current PreDicta B *Fusarium* tests. The DNA was also sent to CSIRO laboratories in Canberra where each isolate was sequenced to confirm the species identification. A total of 84.5% of the isolates were identified by PreDicta B to be *Fp* which were all confirmed by sequencing to also be *Fp*. That is, there were no variants of *Fp* identified by sequencing which are not being detected by the current PreDicta B tests. A further 9.5% of isolates were identified by PreDicta B to be *Fc* or *Fg*. Sequencing determined that these isolates actually consisted of 5.6% *Fc* and 3.9% *Fg*. However, there were no variants of *Fc* or *Fg* which were not detected by the current PreDicta B test, it simply cannot differentiate between these two species. The remaining 6.0% of isolates were identified by sequencing to be a *Fusarium* sp. chlamydosporum complex which is not detected in the current PreDicta B tests. Further work is required to confirm the distribution and importance of these isolates and incorporate their detection into the PreDicta B tests if warranted.

**Sampling issues?**

Fifty crowns and 50 first above ground nodes were cut from primary tillers and plated separately from stubble collected out of each paddock. This allowed the relative survival of *Fusarium* below ground (crowns) and above ground (1st nodes) to be determined at each site. In around 5-10% of paddocks where PreDicta B underestimated the crown rot risk there was much lower survival of *Fusarium* in the crown tissue relative to the 1st node. For example at site WE9A in the Wellington district in 2011 there was 8% *Fusarium* recovery from the crowns but 54% from the 1st node above ground. PreDicta B is a soil based test so with the collection of cores targeted at the previous winter cereal rows it can provide a good measure of *Fusarium* levels in the crowns below ground but is restricted in its ability to detect levels in above ground stubble. This could potentially be an issue with sampling especially following wet summers which would reduce survival in the crowns relative to above ground residues.

In the remaining 5-10% of sites where PreDicta B underestimated the crown rot risk more traditional plating of winter cereal stubble from the site would also have failed to warn of the risk as generally there was no stubble evident to plate. This may be related to hosting of *Fusarium* inoculum on grass weeds that were not adequately sampled or cultivation/harrowing/mulching of the paddock after collecting soil cores which more evenly distributed inoculum across the paddock and into the main infection zones for the crown rot fungus. The impact of these practices on distributing crown rot inoculum requires further research.

**Can we improve PreDicta B assessment of crown rot risk?**

One of the big advantages of PreDicta B is its ability to assess the relative risk of a range of soil-borne cereal pathogens within the one sample. In the northern region PreDicta B has been primarily used to assess RLN populations. Consequently, a composite sample taken from the top 30 cm of soil has usually been used in the northern region based on this being the recommended sampling depth with traditional manual nematode counts within the region. In other regions a shallower sampling depth (0-10 cm or 0-15 cm) is recommended with PreDicta B. In 2013 we aimed to determine if this deeper sampling depth in the northern region, to account for RLN populations deeper in the soil profile, is potentially compromising the accuracy of PreDicta B to measure levels of other soil-borne pathogens including *Fusarium*. 

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In 2013 each of the six ranges in 11 NSW DPI pathology trials, 11 cereal NVT sites and 2 grain and graze trial sites were cored using PreDicta B. A separate 0-15 cm (40 cores) and 0-30 cm (20 cores) bulked soil sample was collected from each range at each of the 24 field sites spread from central NSW up into southern Qld. All cores were targeted at the previous winter cereal rows if evident. Previous winter cereal crop stubble was also collected across each separate range at coring if present and used to spike set soil samples. Twenty-five lowest nodes (1 cm segments around node) were cut from the corresponding stubble sample and added to half of samples collected at each depth. All samples were then sent to SARDI for PreDicta B analysis. After harvest stubble will be pulled from three check wheat varieties at each site and these plots will be re-cored for RLN numbers using PreDicta B. This information will be used to validate and calibrate if required the sampling strategy and resulting risk categories across the northern region. Unfortunately this information is not currently available and will also need to be repeated over a few seasons to fully refine risk categories and sampling strategies.

What have we found so far?

*Pratylenchus thornei* (*Pt*) populations did vary with sampling depth across the 24 sites (Figure 1a). Points above the 1:1 diagonal line indicate higher *Pt* populations in the 0-30 cm sampling then in the 0-15 cm sampling. Conversely, points below the diagonal line represent sites with higher *Pt* populations in the 0-15 cm then in the 0-30 cm sampling. Interestingly, there were five sites above the line and four sites below the line which varied from the 1:1 line by 0.3 *Pt* g/g or greater. However, this relatively minor variation in *Pt* numbers with sampling depth only resulted in a slight shift in risk category at one site. At the Coolah NVT site the 0-30 cm samples indicated a low risk of *Pt* with 1.8 *Pt* g/g soil but the 0-15 cm sampling averaged 2.1 *Pt* g/g soil which just pushed the site into a medium risk category (2.1 to 15.0 *Pt* g/g soil). Even though the Bullarah NVT site averaged 1.3 *Pt* g/g soil in the 0-15 cm sampling and only 0.2 *Pt* g/g soil in the 0-30 cm sampling both depths would still have resulted in this site being classified in the low risk category (0.1 to 2.0 *Pt* g/g soil).

![Figure 1a](image1.png)

![Figure 1b](image2.png)

**Figure 1.** Populations of *Pratylenchus thornei* (a) and *Bipolaris sorokiniana* (b) detected using PreDicta B at 24 sites in 2013 at two samplings depths (0-15 cm vs 0-30 cm). Diagonal lines represent a 1:1 relationship.

*Bipolaris* levels are expressed on a log scale which flattens out variation in numbers with sampling depth (Figure 1b). However, levels do not appear to vary greatly between a 0-15 cm versus a 0-30 cm sampling depth. Generally there were more sites with higher levels in the 0-15 cm compared to the 0-30 cm indicating that *Bipolaris* is more concentrated in the surface which is being diluted with a deeper sampling.

Similarly, *Fusarium* DNA is expressed on a log scale. There was only one site (Bullarah NVT) where a higher level in the 0-30 cm sample would have classified the crown rot risk as medium while the 0-15 cm sampling indicated a low risk (Figure 2). However, there were four sites (Tulloona, Gilgandra, Westmar and Narrabri) where greater values in the 0-15 cm samples indicate a higher...
crown rot risk level than in the 0-30 cm samples. As with Bipolaris, this indicates that Fusarium is more concentrated in the surface which is being diluted with a deeper 0-30 cm sampling depth.

![Graph showing the relationship between Fusarium log DNA/g (0-15 cm) and Fusarium log DNA/g (0-30 cm).](image)

**Figure 2.** Populations of Fusarium detected using PreDicta B at 24 sites in 2013 at two samplings depths (0-15 cm vs 0-30 cm). Samples spiked with stubble fragments excluded from comparison.

 Addition of stubble to soil samples

Previous cereal stubble was only present at 7 of the 24 sites in 2013 to allow addition of stubble fragments to soil samples. Bithramere was the only site where the addition of stubble did not increase the predicted crown rot risk level. Even though the log Fusarium DNA/g increased from 2.5 to 4.3 with the addition of stubble, both values represented a high risk of crown rot development at the Bithramere site in 2013. The addition of stubble at the remaining six sites increased the crown rot risk level from low to high at two sites (Coonamble and Westmar), low to medium at two sites (Gilgandra and North Star) and medium to high at two sites (Bullarah and Tamworth).

Laboratory plating of harvest samples will determine if the addition of stubble to soil samples improves the accuracy of PreDicta B to determine crown rot risk prior to sowing. Adding stubble is likely to increase the overestimation of crown rot risk while reducing the likelihood of underestimation or ‘failure to warn’. This is probably a preferred situation for growers and advisors. The addition of stubble will also reduce sampling issues following wetter summers which can result in greater survival of Fusarium in above ground residues then in the crowns as occurred in some of the previous survey paddocks between 2010-2012. Research to refine the sampling strategy is continuing.

Conclusions

RLNs being soil-borne appear to be more flexible with sampling technique to obtain an accurate risk level prior to sowing. However, the crown rot fungus is stubble-borne so detection is more sensitive to the sampling technique used to collect the soil samples. Punching 3-6 cores between the previous crop rows in a paddock, as with a soil nutrition test, may give a reasonable estimate of RLN levels but is likely to provide a poor indication of the crown rot risk. Recent collaborative research in the northern region between SARDI and NSW DPI has demonstrated that use of a smaller diameter soil core (e.g. Accucore) to collect 15-30 cores (depending on sampling depth) targeted at the previous cereal row if evident provides a good measure of both RLN and crown rot risk along with a range of other pathogens. This number of cores collected spatially across the paddock is required to account for the potential variability in the distribution of crown rot inoculum. Important change to sampling;
it is now recommended up to 15 short pieces of cereal stubble from previous cereal crops and/or grass weeds be added to PreDicta B soil samples to enhance detection of the *Fusarium* spp. that cause crown rot. Where stubble is present, add one piece per sampling location. Each piece should be selected from the base of separate crowns; discard stubble above the first node.

Soil cores – collect up to three cores from 15 different locations within the target area; take cores from the previous cereal rows and retain any stubble collected by the core. The number of cores per location will vary depending on core diameter and sampling depth. Maximum sample weight should not exceed 500g. Sampling depth (0-15 cm or 0-30 cm) does not appear to greatly impact on detection of the various pathogen levels in the northern region when the collection of cores is targeted at the previous cereal rows. However, the actual sampling depth needs to be recorded on the sample bag when collected as it is used to refine reporting of results to adjust for pathogens which are more concentrated at the soil surface. Significant stubble disturbance (harrowing, cultivation, mulching etc.) increases the risk of crown rot development if the stubble is infected with *Fusarium*. Collection of soil samples prior to stubble disturbance is likely to underestimate the crown rot risk.

If you are not willing to follow the recommended PreDicta B sampling strategies then DO NOT assess disease risk levels prior to sowing.

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Crown rot and nematodes: are you growing the right variety?

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Key words
Root lesion nematodes, yield loss, tolerance

GRDC codes
DAN00175: National crown rot epidemiology and management program

Take home messages
- Two durum and 10 bread wheat varieties were evaluated in the presence of added or no added crown inoculum across 11 field sites in 2013.
- Under high crown rot pressure (added CR inoculum) Suntop was 0.42 t/ha, LRPB Lancer 0.51 t/ha, Sunguard 0.61 t/ha and LRPB Spitfire 0.63 t/ha higher yielding than EGA Gregory on average across sites.
- Where no additional CR was added EGA Gregory had similar yield to other varieties at sites with low background levels of crown rot but was between -0.52 t/ha (Suntop) to -0.37 t/ha (Sunguard) lower yielding at sites with medium-high background levels of crown rot.
- EGA Gregory production should be specifically targeted to paddocks with lower levels of crown rot risk based on testing such as PreDicta B.
- Some newer wheat varieties have a measurable improvement in their tolerance to crown rot but these current levels are not a complete solution to crown rot. The best varieties still suffered up to 34% and 41% yield loss at the two sites with the highest impact from crown rot infection.

Introduction
Crown rot, caused predominantly by the fungus Fusarium pseudograminearum (Fp) is a significant disease of winter cereals in the northern region. Root lesion nematodes (RLNs) are also a wide spread constraint to wheat production across the region. Two important species of RLN exist throughout the northern region, namely Pratylenchus thornei (Pt) and P. neglectus (Pn). Previous surveys of the northern NSW have found that Pt is more widespread and generally at higher populations than Pn. Recent collaborative research between Northern Grower Alliance and NSW DPI has also established that the presence of RLN feeding within root systems increases the severity of crown rot.

Cereal varieties differ in their tolerance to crown rot and either species of RLN. This can have a significant impact on the relative yield of varieties in the presence of these various disease constraints. In 2013, NSW DPI conducted a series of 11 trials across central/northern NSW extending into southern Qld to examine the impact of crown rot and RLN on the yield of two durum and ten bread wheat varieties.

What did we do?
Eleven trials were sown between the 15 May and the 4 July in 2013. The six ranges at each site were soil cored separately at sowing to establish background levels of crown rot and RLN using PreDicta B (Table 1). Two durum and 10 bread wheat varieties (Table 2) were established at each site with the sowing rate adjusted to target 100 plants/m² based on seed weight and germination. LRPB Crusader and SUN663A were not included in the Garah and Rowena trials. Each variety had either
added or no added crown rot (CR) inoculum as durum grain colonised by *Fp* in the seed furrow at sowing. The only site where frost damage was noted in 2013 was with the quicker maturing varieties LRPB Dart(†) and Jandaroi(†) at Coonamble.

What did we find?

The average yield of the 12 cereal varieties at each of the 11 trial sites in the presence of no added CR or added CR varied across the sites (Table 1). Tamworth was the only site where the addition of CR inoculum at sowing did not result in a significant reduction in yield. This was a function of moderate levels of CR inoculum already present across the site and comparatively low yields. Data is therefore presented as an average of the added CR and no added CR treatments for this site.

The impact of added CR on yield was highest at Rowena and Macalister with 53% and 57% yield loss, respectively and considerably lower at Spring Ridge (15%) and Trangie (14%) (Table 1). However, determining yield loss by comparing inoculated and uninoculated plots across sites potentially underestimates the full impact of crown rot on yield at some sites. PreDicta B coring at sowing indicated that 6 of the 11 sites had medium to high levels of CR inoculum already present across the trial area (Table 1). Comparisons would underestimate losses at these sites as there is no way to account for yield loss that is attributed to the background infection levels in the no added CR plots.

Yield outcomes are also a function of the interaction of each variety with CR, RLN populations which varied across the sites (Table 1), starting soil water, in-crop rainfall and maturity relative to moisture/temperature stress during the flowering and grain-fill period.

Table 1. Field sites, sowing dates, background risk levels of root lesion nematodes (RLN) and crown rot at sowing and average site yield without and with added crown rot inoculum in 2013

<table>
<thead>
<tr>
<th>Site</th>
<th>Sowing date</th>
<th>Background levels</th>
<th>Av. site mean yield (t/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>RLN</td>
<td>Crown rot</td>
</tr>
<tr>
<td>Bithramere</td>
<td>7 June</td>
<td>Medium <em>Pn</em></td>
<td>High</td>
</tr>
<tr>
<td>Tamworth</td>
<td>4 July</td>
<td>Nil</td>
<td>Medium</td>
</tr>
<tr>
<td>Spring Ridge</td>
<td>23 June</td>
<td>Nil</td>
<td>Medium</td>
</tr>
<tr>
<td>Terry Hie Hie</td>
<td>29 May</td>
<td>Nil</td>
<td>Low</td>
</tr>
<tr>
<td>Narrabri</td>
<td>17 May</td>
<td>Medium <em>Pt</em></td>
<td>Medium</td>
</tr>
<tr>
<td>Coonamble</td>
<td>15 May</td>
<td>Nil</td>
<td>Medium</td>
</tr>
<tr>
<td>Trangie</td>
<td>28 May</td>
<td>Low <em>Pn</em></td>
<td>Nil</td>
</tr>
<tr>
<td>Rowena</td>
<td>30 May</td>
<td>Low <em>Pt</em></td>
<td>Nil</td>
</tr>
<tr>
<td>Garah</td>
<td>31 May</td>
<td>Low <em>Pt</em></td>
<td>Low</td>
</tr>
<tr>
<td>Macalister</td>
<td>5 June</td>
<td>Low <em>Pt</em></td>
<td>Low</td>
</tr>
<tr>
<td>Westmar</td>
<td>31 May</td>
<td>Nil</td>
<td>Medium</td>
</tr>
</tbody>
</table>

The average yield loss (difference between no added CR and added CR treatments) across the 11 sites was roughly in line with the reported crown rot resistance ratings (Table 2). The very susceptible and susceptible varieties averaged between 30-39% yield loss while the moderately resistant-moderately susceptible variety Sunguard(†) had roughly half the level of yield loss (17%). LRPB Spitfire(†) and QT14381, which are both MS, averaged the same level of yield loss as Sunguard(†) even though they have a lower resistance rating. Suntop(†) which is also rated MS to crown rot averaged a higher level of yield loss (25%) than the other MS rated varieties. As outlined earlier these numbers are likely to be an underestimate of the impact of crown rot due to background inoculum levels at over half of the sites. Comparing varieties in terms of percentage yield loss can also be potentially misleading for growers and advisers as it masks the actual yields obtained in the presence of crown rot.
Table 2. Crown rot resistance, Pratylenchus thornei (Pt) tolerance and P. neglectus (Pn) rating of 12 cereal varieties across 11 sites in 2013 and relative yield loss from the addition of CR inoculum.

*indicates provisional rating

<table>
<thead>
<tr>
<th>Variety</th>
<th>Crown rot</th>
<th>Pt tolerance</th>
<th>Pn tolerance</th>
<th>Av. % yield loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>Caparoi</td>
<td>VS</td>
<td>MI</td>
<td>MI-I</td>
<td>39</td>
</tr>
<tr>
<td>Jandaroi</td>
<td>VS</td>
<td>MI-I</td>
<td>MI</td>
<td>30</td>
</tr>
<tr>
<td>EGA Gregory</td>
<td>S</td>
<td>MT</td>
<td>MI</td>
<td>30</td>
</tr>
<tr>
<td>Strzelecki</td>
<td>S</td>
<td>I-VI</td>
<td>MI</td>
<td>30</td>
</tr>
<tr>
<td>Suntop</td>
<td>MS</td>
<td>MT</td>
<td>MI*</td>
<td>25</td>
</tr>
<tr>
<td>LRPB Dart</td>
<td>MS-S</td>
<td>MI</td>
<td>MI-I*</td>
<td>23</td>
</tr>
<tr>
<td>SUN663A</td>
<td>MS-S*</td>
<td>MT*</td>
<td>-</td>
<td>23</td>
</tr>
<tr>
<td>LRPB Lancer</td>
<td>MS-S*</td>
<td>MT-MI*</td>
<td>-</td>
<td>21</td>
</tr>
<tr>
<td>LRPB Crusader</td>
<td>MS-S</td>
<td>MI-I</td>
<td>MI-I</td>
<td>19</td>
</tr>
<tr>
<td>LRPB Spitfire</td>
<td>MS</td>
<td>MT-MI</td>
<td>MI</td>
<td>17</td>
</tr>
<tr>
<td>QT14381</td>
<td>MS*</td>
<td>MT*</td>
<td>-</td>
<td>17</td>
</tr>
<tr>
<td>Sunguard</td>
<td>MR-MS</td>
<td>MT</td>
<td>MI</td>
<td>17</td>
</tr>
</tbody>
</table>

Under high crown rot pressure (added CR) only the two durum varieties (Caparoi and Jandaroi) and the bread wheat variety Strzelecki were lower yielding than EGA Gregory when averaged across sites (Table 3). The remaining bread wheat varieties all appear to have improved tolerance to crown rot compared to EGA Gregory with yield benefits in added CR treatments of between +0.26 t/ha (LRPB Dart) up to +0.63 t/ha (LRPB Spitfire).

Table 3. Average yield (t/ha) of varieties with no added CR and added CR at sowing, protein level obtained and yield difference (%) compared with EGA Gregory in no added CR plots at sites with either nil to low or medium to high background levels of crown rot

<table>
<thead>
<tr>
<th>Variety</th>
<th>Av. site yield (t/ha)</th>
<th>Yield (% EGA Gregory)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No added CR</td>
<td>Added CR</td>
</tr>
<tr>
<td>Caparoi</td>
<td>2.72</td>
<td>1.66</td>
</tr>
<tr>
<td>Jandaroi</td>
<td>2.63</td>
<td>1.83</td>
</tr>
<tr>
<td>EGA Gregory</td>
<td>3.18</td>
<td>2.21</td>
</tr>
<tr>
<td>Strzelecki</td>
<td>2.97</td>
<td>2.08</td>
</tr>
<tr>
<td>Suntop</td>
<td>3.49</td>
<td>2.63</td>
</tr>
<tr>
<td>LRPB Dart</td>
<td>3.19</td>
<td>2.47</td>
</tr>
<tr>
<td>SUN663A</td>
<td>3.41</td>
<td>2.64</td>
</tr>
<tr>
<td>LRPB Lancer</td>
<td>3.43</td>
<td>2.72</td>
</tr>
<tr>
<td>LRPB Crusader</td>
<td>3.41</td>
<td>2.78</td>
</tr>
<tr>
<td>LRPB Spitfire</td>
<td>3.42</td>
<td>2.84</td>
</tr>
<tr>
<td>QT14381</td>
<td>3.42</td>
<td>2.83</td>
</tr>
<tr>
<td>Sunguard</td>
<td>3.40</td>
<td>2.82</td>
</tr>
</tbody>
</table>

Under lower crown rot levels (no added CR) the two durum varieties and Strzelecki were again lower yielding than EGA Gregory, while LRPB Dart had an equivalent average yield across sites (Table 3). The remaining bread wheat varieties were between +0.22 t/ha (Sunguard) to +0.31 t/ha (Suntop) higher yielding than EGA Gregory. This probably reflects the medium to high background crown rot levels in just over half of the sites and supports the improved crown rot tolerance of these newer varieties as evident in the added CR treatments.

Protein levels were fairly high across sites in 2013 ranging from a variety average of 11.9% (Spring Ridge) to 14.3% (Bithramere). Jandaroi had the highest protein concentration at 14.2% while EGA
Gregory averaged the lowest protein concentration at 12.2%. LRPB Spitfire was the highest bread wheat variety at 13.9% which was 1.7% higher than that achieved by EGA Gregory when averaged across sites (Table 3).

Further examining the relative yield of varieties compared to EGA Gregory across the no added CR treatments highlights the value of determining the background levels of crown rot in trial sites (e.g. using PreDicta B). This treatment is essentially equivalent to GRDC funded National Variety Trial (NVT) sites with plots located in grower paddocks where both background crown rot and/or RLN levels may be present at varying levels. The Coonamble, Macalister and Westmar trials were actually co-located with cereal NVT sites in 2013. There were five sites with nil to low background levels of crown rot and six sites with medium to high starting levels (Table 1). Suntop, LRPB Lancer, LRPB Spitfire and Sunguard had similar yields to EGA Gregory at sites with nil/low background levels of crown rot but were between 17% (Suntop) to 12% (Sunguard) higher yielding than EGA Gregory at sites with medium/high background levels of crown rot (Table 3). This highlights the potential impact that targeting the production of EGA Gregory specifically to paddocks with lower levels of crown rot risk based on PreDicta B testing could have on the profitability of growing this popular variety. Growers and advisors should also take into account the background levels at trial sites, if known, before interpreting their local NVT results.

Determining the relative impact of crown rot versus RLN on yield from these current trials is difficult as the varieties with reduced tolerance to Pt (Caparoi, Jandaroi, Strzelecki, LRPB Dart and LRPB Crusader) also have lower resistance to crown. The varieties also do not vary greatly in their tolerance to Pn. Furthermore, only two sites had medium levels of RLN with Bithramere having Pn and Narrabri Pt. The remaining sites had low or no RLN populations which limits the ability to infer nematode impacts. However, Narrabri in 2013 which had medium risk of both Pt and crown rot highlights the benefit of growing varieties with improved tolerance to Pt (e.g EGA Gregory 3.09 t/ha) or combined tolerance to Pt and resistance to crown rot (e.g. Suntop 3.87 t/ha) compared to varieties with poor levels of resistance/tolerance to both pathogens (e.g. Strzelecki 2.45 t/ha).

Conclusions
Determining the relative tolerance of varieties to crown rot is complex as it can be significantly influenced by background inoculum levels, RLN populations, differential variety tolerance to Pn versus Pt and varietal interaction with the expression of crown rot. Other soil-borne pathogens such as Bipolaris sorokiniana, which causes common root rot, also need to be accounted for in the interaction between crown rot and varieties. Starting soil water, in-crop rainfall, relative biomass production, sowing date and resulting variety phenology in respect to moisture and/or temperature stress during grain-fill can all differentially influence the expression of crown rot in different varieties. The research reported above needs to be conducted over a number of seasons and locations with full measurement of these influencing factors to fully understand the relative tolerance of varieties to crown rot under varying conditions. A more detailed interpretation of individual site results will be available in the autumn 2014 Northern Grains Region Trial Results book, published annually by NSW DPI.

Summary
The 2013 season was very conducive to the expression of crown rot in the northern region with little rainfall in spring and hot grain-fill temperatures. EGA Gregory remains the dominant wheat variety across the region due to its high yield potential and flexibility in sowing time. However, under high crown rot pressure (i.e. added CR treatments) Suntop was 0.42 t/ha, LRPB Lancer 0.51 t/ha, Sunguard 0.61 t/ha and LRPB Spitfire 0.63 t/ha higher yielding than EGA Gregory when averaged across the 11 sites in 2013. This reflects the improved levels of tolerance to crown rot and Pt in recently released varieties in the region, which can significantly impact on profitability in the presence of these disease constraints.
Due to its increased susceptibility to crown rot, growers should consider targeting EGA Gregory production to paddocks with low risk of crown rot development based on testing such as Predicta B. Otherwise, growers should consider switching to one of these newer varieties, which have a measurable yield improvement in the presence of crown rot. Growers still need to be aware that significant yield loss can occur in these more tolerant varieties under high infection levels, particularly when plants suffer serious moisture/temperature stressed during grain-fill. Macalister and Rowena were sites that experienced the greatest yield loss from crown rot in 2013. Under high infection levels, the best variety at Macalister was LRPB Spitfire which still suffered 34% yield loss while Sunguard was the best at Rowena but still suffered 41% yield loss from crown rot. That is, some of these newer varieties have a measurable improvement in their tolerance to crown rot but these current levels are still not a complete solution to crown rot.

Acknowledgments

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Varieties displaying this symbol beside them are protected under the Plant Breeders Rights Act 1994.
1. Grow varieties with adequate resistance to stem, stripe and leaf rust.
2. Phase out very susceptible (VS) or susceptible (S) varieties.
3. Remove volunteer plants, called the green bridge, at least four weeks before sowing.
4. Know the seedling and adult rust resistance or susceptibility of varieties sown.
5. Monitor crops – early disease detection and management is best.
6. Identify chemical options, taking into account maximum residue limits and withholding periods.
7. Play your part in national rust management and report infections to your State agriculture department.
8. Send suspected rust infections to the Australian Cereal Rust Survey, Private Bag 4011, Narellan NSW 2567.

If you find rust, be proactive and tell other growers.

The Rust Bust is an initiative of the Australian Cereal Rust Control Program Consultative Committee, with support from the Grains Research and Development Corporation.
Radial® is an optimised high performance broad spectrum fungicide for use in wheat and barley. With up to 6 weeks preventative disease control Radial® optimises the performance of your crop.

**Product Overview**

RADIAL® is a broad spectrum foliar fungicide for use in wheat and barley, combining market leading strobilurin and triazole active ingredients.  
- **Contains 75 g/L epoxiconazole and 75 g/L azoxystrobin**
- Highly effective EC formulation optimised for Australian diseases and conditions
- **Excellent crop safety** - extensively tested on multiple varieties and situations
- **Extended protectant activity**
- **Highly compatible** with commonly used insecticides and fungicides
- Dual modes of action for resistance management

**Mode of Action**

RADIAL® is a combination of an (dimethylation-inhibitor) and strobilurin (Quinone outside inhibitors - Qols) group of fungicides and incorporates the strength of both these key fungicide groups.  

The triazole active ingredient (epoxiconazole) acts to inhibit ergosterol production, an essential component of the membranes of a wide range of fungi. Epoxiconazole has a strong inhibitory effect on fungal hyphae and mycelia and has the ability to interrupt fungal growth in plant tissue.

Azoxystrobin inhibits the respiration of fungi by binding to the mitochondrial cytochrome and blocking electron transfer. When applied prior to disease infection, azoxystrobin provides excellent protectant activity and has long residual activity. RADIAL® is a robust fungicide combination with activity across multiple stages of the disease lifecycle as illustrated in the below diagram.

---

**Features**

<table>
<thead>
<tr>
<th>Features</th>
<th>Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mixture of highly effective strobilurin and DMI active ingredients</td>
<td>Two modes of action for resistance management.</td>
</tr>
<tr>
<td>EC formulation</td>
<td>Unrestricted SC and SE formulations the active ingredient is fully dissolved.</td>
</tr>
<tr>
<td>Excellent preventative control</td>
<td>Ability to protect the plant for longer periods.</td>
</tr>
<tr>
<td>Highly compatible</td>
<td>Less need to perform multiple applications.</td>
</tr>
</tbody>
</table>

**Standard Recommendations**

- **Wheat**
  - Leaf Rust, Yellow Spot, Septoria nodorum Blast, Stem Rust, Stripe Rust and Powdery Mildew: 420 to 840 mL/ha.
  - Apply when conditions favour disease development and prior to incidence of high levels of disease in the crop. Aim to apply between stem elongation and complete ear emergence (Z22-39).
- **Barley**
  - Leaf Rust, Leaf Scald, Net Form of Net Blotch and Powdery Mildew: 420 to 840 mL/ha.
  - Apply when conditions favour disease development and prior to the incidence of high levels of disease in the crop. Aim to apply from jointing (Z30).

**Go to the distance on broadleaf weeds with Triathlon™’s unique triple mode of action.**  
With excellent control of Wild Radish and other hard to control broadleaf weeds in wheat and barley. Also providing residual action to control later germinating weeds.

**Product Overview**

TRIATHLON® is a unique broad spectrum herbicide for early broadleaf weed control in winter cereals, incorporating 3 herbicide modes of action (HMA). When applied early in the crop TRIATHLON® is an effective management tool for a range of broadleaf weeds as well as hard to control Wild Radish. TRIATHLON® also provides residual activity to help control later germinating weeds.

- Optimised formulation for Australian conditions and weeds
- Excellent activity on Wild Radish, including multiple herbicide resistant biotypes
- Excellent crop safety - extensively tested on multiple varieties and situations
- Additional benefit of residual control of up to 4 weeks
- **Compatible with a wide range of products**
- **Excellent rotational option for pyrinate/late based products on Wild Radish**

**Available for 2014 season – registration expected April 2014.**

**Mode of Action**

TRIATHLON® is a member of the nitrilamide, nitrile and phenoxy groups of herbicides and acts by inhibiting cytochrome P450 (PDS inhibitors), inhibiting photosynthesis at photosystem II (PS II inhibitors) and disrupting plant cell growth.

TRIATHLON®’s primary activity is on emerged broadleaf weeds through foliar uptake, however, a level of pre-emergent residual weed control can be achieved that allows TRIATHLON® to control newly germinating weeds for up to 4 weeks following an application.

For herbicide resistance management TRIATHLON® is a Group E Group C and Group I herbicide and where possible should be used in rotation with herbicides from alternative HMA groups.

**Standard Recommendations**

**Crops:** For use in wheat, barley, tricale and cereal rye.
**Rates:** 250mL to 1000 mL/ha are recommended depending on target weed and weed size.
**Weeds:** Registered to control or suppress 47 broadleaf weeds including, Wild Radish, Canola, Volunteer Canola, Fumitory and Hedge Mustard.

**Application:**
- **Boom Sprayer:** A minimum of 50 L/ha of water should be used, however, for optimum results water rates of 70-100 L/ha are recommended. Increase the water volume if weed infestation is heavy or crop cover is dense. Complete coverage of weeds is essential.
- **Aircraft:** (NSW, VIC, SA only) Apply in a minimum of 30 L/ha of water. Effective weed control will only be achieved where good coverage of leaf surface is achieved.
Rust issues for 2014

Steven Simpfendorfer, NSW DPI

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- 3 modes of action giving broad spectrum of protection
- Robust Rhizoctonia performance
- Pythium Root Rot control
- Enhanced vigour through good root health for better crop performance
- Yield advantage in comparison with standard seed treatments in high and low yield environments

<table>
<thead>
<tr>
<th>Product benefit</th>
<th>Product features</th>
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<th>Evergol Prime</th>
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<tr>
<td></td>
<td>Net Blotch</td>
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</table>

WHAT HAPPENS BELOW THE GROUND IS JUST AS IMPORTANT AS WHAT HAPPENS ABOVE.

Association of seed treatments and yield in comparison with untreated in a low yielding environment – Mallee, Vic 2010

* Yield Advantage* vs untreated 17%

**Significant (P<0.05) yield advantage vs untreated.** (Mallee Vic, Peracto 2010)
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