Root-lesion Nematodes: Cereal variety and Rotational Crop Impacts on Yield and Nematode numbers

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Key words

Root-lesion nematodes (RLN), *Pratylenchus thornei (Pt)*, tolerance, resistance and rotation

GRDC codes

NGA00003: GRDC Grower Solutions for Northern NSW and Southern Qld

DAN00143: Northern integrated disease management

DAQ000154: Northern integrated disease management

Take home messages

1. Know your enemy - soil test to determine whether RLN are an issue and which species are present

2. Select wheat varieties with **high tolerance ratings to minimise yield losses** in RLN infected paddocks

3. To manage RLN populations, it is important to **increase the frequency of RLN resistant crops** in the rotation

4. Multiple resistant crops in a rotation will be necessary for long term management of RLN populations

5. There are **consistent varietal differences in *Pt* resistance** within wheat and chickpea varieties

6. Avoid crops or varieties that allow the build-up of large populations of RLN in infected paddocks

7. Monitor the impact of your rotation

What are nematodes?

Nematodes (or roundworms) are one of the most abundant life-forms on earth. They are adapted to nearly all environments. In cropping situations they can range from being beneficial to detrimental to plant health.

The root-lesion nematodes (RLN) are a genus of microscopic plant parasitic nematode that are soil-borne, ~0.5 to 0.75 mm in length and will feed and reproduce inside roots of susceptible crops or plants. There are two common species of RLN in the northern grains region; *Pratylenchus thornei* (*Pt*) and *Pratylenchus neglectus (Pn)*. This paper will concentrate on *Pt* – often described as the cereal and legume root-lesion nematode.

Why the focus on *Pt*?

1. *Pt* are widespread in the northern grains region. Surveys conducted within Nth NSW and Sth Qld cropping areas consistently show *Pt* presence in ~60-70% of paddocks
2. *Pt* are frequently at concerning levels. Found at >2 *Pt*/g soil in ~30-40% of paddocks
3. Yield losses in wheat of up to 50% are not uncommon when *Pt* intolerant wheat varieties are grown in paddocks infested with *Pt*.
4. Yield losses in chickpeas of up to 20% have also been measured in DAFF QLD trials
5. There is no easy solution to RLN infestation. Variety and crop rotation are currently our major management tools

Figure 1 is a simplified chart that highlights the critical first step in the management of RLN is to **test your soil and determine whether or not you have an issue to manage**. NB where RLN are present, growers should focus on both 1) planting tolerant wheat varieties and 2) increasing the number of resistant crops/varieties in the rotation

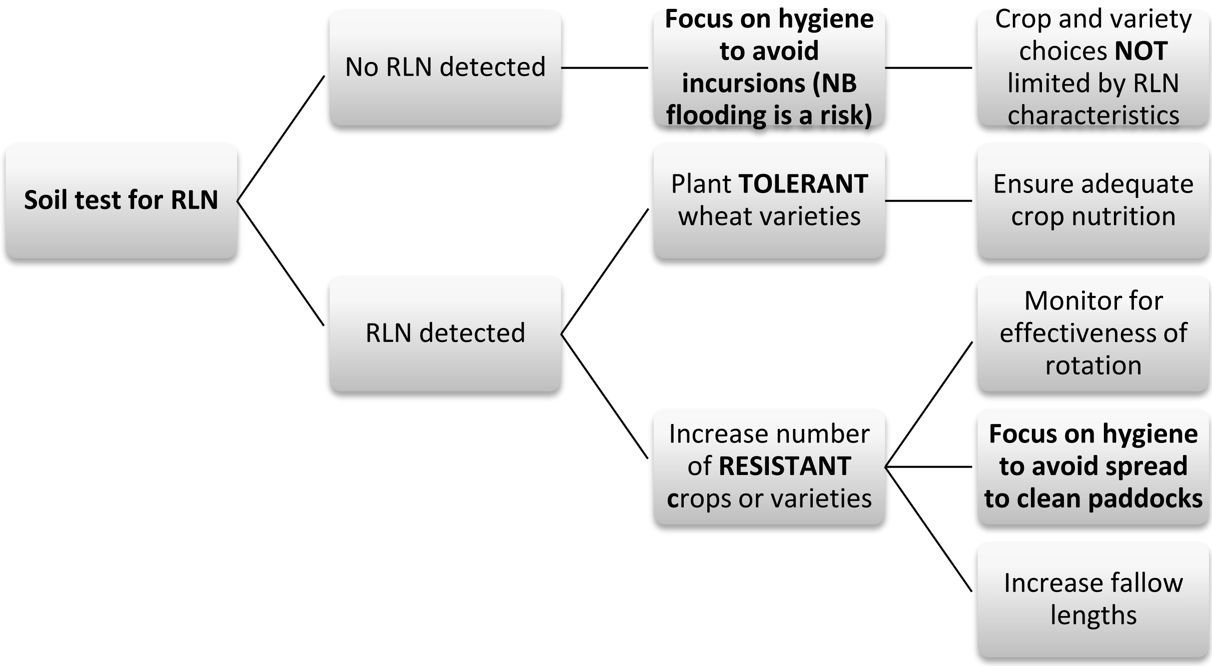


Figure 1: RLN management flow chart

Soil testing

The critical first step in the management of RLN is to test your soil and determine whether or not you even have the issue. Testing of soil samples is most commonly conducted via DNA analysis (commercially available as the PreDicta B test from SARDI) with sampling to depths of 0-15 or 0-30 cm.

Vertical distribution of *Pt* in soil is variable. Some paddocks have 'relatively' uniform populations down to 30 or 60 cm, some will have highest *Pt* counts in the 0-15 cm layer whilst other paddocks will have *Pt* populations increasing at deeper depths eg 30-60 cm. Although detailed knowledge of the distribution may be of some value, the majority of on-farm management decisions will be based on presence or absence of *Pt* with sampling at 0-15 or 0-30 cm depth providing that information.

What is seen in the paddock?

Although symptoms of RLN damage in wheat can be dramatic, they can be easily confused with nutritional deficiencies and/or moisture stress.

Damage from RLN results in brown root lesions but these are difficult to see and can also be caused by other organisms. Root systems are often compromised with reductions in root branching and quantities of root hairs together with a reduced ability to penetrate deeply into the soil profile. **RLN create an inefficient root system that impairs the ability of the plant to access nutrition and water**.

Visual damage above ground from RLN in wheat is non-specific. Lower leaf yellowing is often observed together with reduced tillering and a reduction in the amount of crop biomass. Symptoms are more likely to be observed later in the season, particularly when the crop is reliant on sub soil moisture. Clear symptoms are generally not seen in other crops.

In the early stages of RLN infection, localised patches of poor performing wheat may be observed. Soil testing of these patches may help to determine or eliminate RLN as a possible issue. In paddocks where previous wheat production has been more uniform, a random soil coring approach may be more suitable. Another useful indicator of RLN presence is low yield performance of RLN intolerant wheat varieties.

Management of RLN

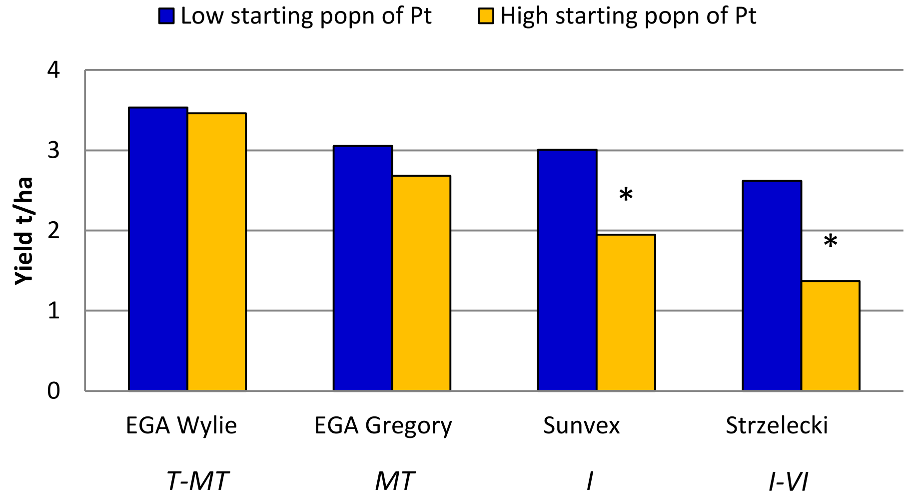
1. **Nematicides** (control in a drum): there are no registered nematicides for RLN in broadacre cropping in Australia. Screening of potential candidates continues to be conducted but RLN are a very difficult target with populations frequently deep in the soil profile.
2. **Nutrition**: damage from RLN reduces the ability of cereal roots to access nutrients and soil moisture and can induce nutrient deficiencies. Under fertilising is likely to exacerbate RLN yield impacts however over fertilising is still unlikely to compensate for a poor variety choice.
3. **Variety choice and crop rotation:** ***These are currently our most effective management tools for RLN****.* However the focus is on two different characteristics - ***Tolerance*** (ability of the variety to yield under RLN pressure) and ***Resistance*** (impact of the variety on the build-up of RLN populations). NB varieties and crops often have varied tolerance and resistance levels to *Pt* and *Pn*.
4. **Fallow:** RLN populations will generally decrease during a ‘clean’ fallow but the process is slow and expensive in lost ‘potential’ income. Additionally long fallows may decrease Mycorrhizal (VAM) levels and create more cropping issues than they solve.

Tolerance

Regional winter crop sowing guides detail the level of variety tolerance to both species of RLN. **Selection of wheat varieties on the basis of these published RLN tolerance rankings is critical to avoid significant yield losses, particularly in paddocks with large populations of *Pt***. Wheat breeding has successfully produced a range of varieties with moderate or higher levels of tolerance to *Pt* eg EGA Wylie, EGA Burke, EGA Eaglehawk and EGA Gregory together with the more recent releases of Lancer, Gauntlet, Sunguard and Suntop. These varieties will reduce the extent of yield loss due to *Pt*.

How valuable are wheat tolerance differences?

At a trial site near Yallaroi in 2012, a range of crops and varieties were grown where performance was evaluated in strips with contrasting starting levels of *Pt*. The 'low' starting population was ~2 *Pt*/g soil. This level is on the borderline between a low and medium risk rating for yield loss due to *Pt*. The 'high' starting population was ~19 *Pt*/g soil. This level is in the high risk category for yield loss due to *Pt*. Figure 2 shows the impact of *Pt* on the yield of varieties with a range of tolerance levels. A tolerant variety would be expected to achieve a similar yield under both *Pt* populations eg EGA Wylie. An intolerant variety would achieve much lower yields when grown under higher *Pt* pressure eg Sunvex and Strzelecki.



cv 9%, LSD 0.52

Figure 2: Comparison of wheat variety yield under 'low' and 'high' starting populations of *Pt* near Yallaroi 2012. (Trial RH1213)
* = significant yield difference in same variety between 'low' and 'high' *Pt* strips at p=0.05
Letters below variety names are the DAFF QLD 2013 published *Pt* tolerance rating; T=tolerant, MT=moderately tolerant, I=intolerant, VI=very intolerant

NB the level categorised as the 'low' starting Pt population was still equal to the current industry threshold. At this level significant yield losses (up to 20%) may occur in intolerant wheat varieties. Consequently the measured yield impact between 'low' and 'high' Pt in this trial is an underestimate of the full Pt affect.

The varieties rated as *Pt* intolerant (Strzelecki and Sunvex) suffered significant yield reductions of 35-48% in this trial when grown in the 'high' *Pt* population plots. Yield losses of ~1- 1.25 t/ha were recorded with direct economic costs >$250/ha. In contrast the two more tolerant varieties (EGA Wylie and EGA Gregory) did not suffer a significant yield reduction. The larger economic cost would have been in selecting an intolerant variety eg Strzelecki compared to a tolerant choice eg EGA Wylie. In this case a loss in potential yield of >2 t/ha would have been realised however not all of this difference could be attributed to nematode impact.

Key point: Choosing tolerant varieties will limit the yield and immediate economic impact from *Pt*, however some of these varieties may still allow high levels of nematode build-up. The second issue to be considered is the variety resistance/ susceptibility level.

Resistance

Resistance is the impact of the variety on RLN multiplication. Eradication of RLN from an individual paddock is highly unlikely so effective long term management is based on choosing options that limit

RLN multiplication. This involves using crop or variety choices that have useful levels of *Pt* resistance and avoiding varieties that consistently cause large increases in *Pt* numbers.

All the data presented has been from soil sampling depths of 0-30cm.

1. Resistance differences between winter crops

The primary method of managing RLN populations is to focus on increasing the number of resistant crops in the rotation. **Knowledge of the species of RLN present is critical as crops that are resistant to *Pt* may be susceptible to *Pn***. Key crops that are generally considered resistant or moderately resistant to *Pt* are sorghum, sunflower, maize, canola, canary seed, cotton and linseed. Wheat, barley, chickpeas, faba beans, mung beans and soybeans are generally susceptible - although the level of susceptibility may vary between varieties. Field peas (Maki, Yarrum and CRC Walana) were also evaluated. Field peas have previously been considered resistant however many newer varieties appear more susceptible. Figures 3 and 4 show the mean *Pt* population remaining after a range of winter crops were grown near Weemelah in 2011 (Fig 3) and Yallaroi in 2012 (Fig 4). Although all crops were sown in individual trials - to enable weed and pest control - the data gives some indication of the magnitude of *Pt* resistance differences between these crops.

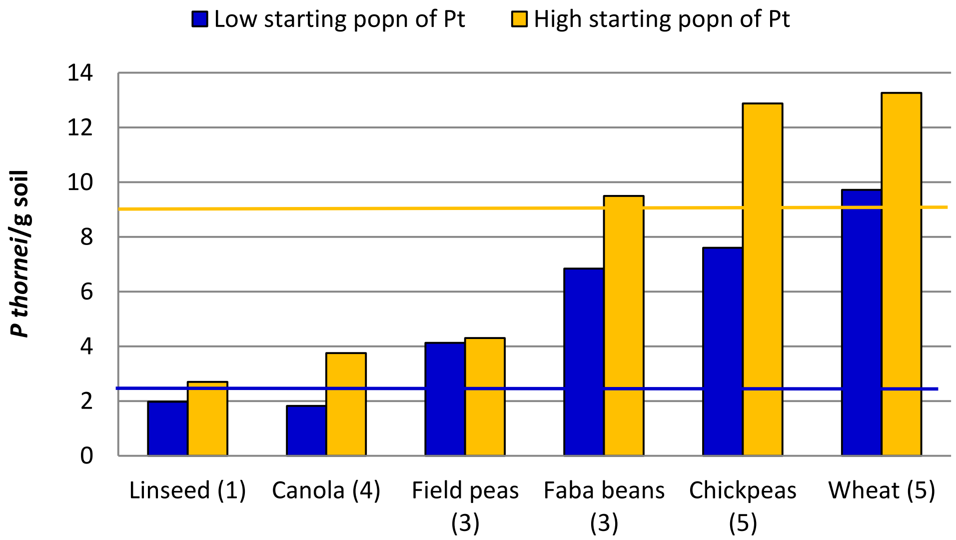


Figure 3: Comparison of *Pt* populations remaining in March /April 2012 following different winter crop species near Weemelah 2011 (Trials RH1101-1109)
(Number) indicates the number of varieties of each crop
The two horizontal lines indicate the respective ‘low’ and ‘high’ starting *Pt* levels in March 2011

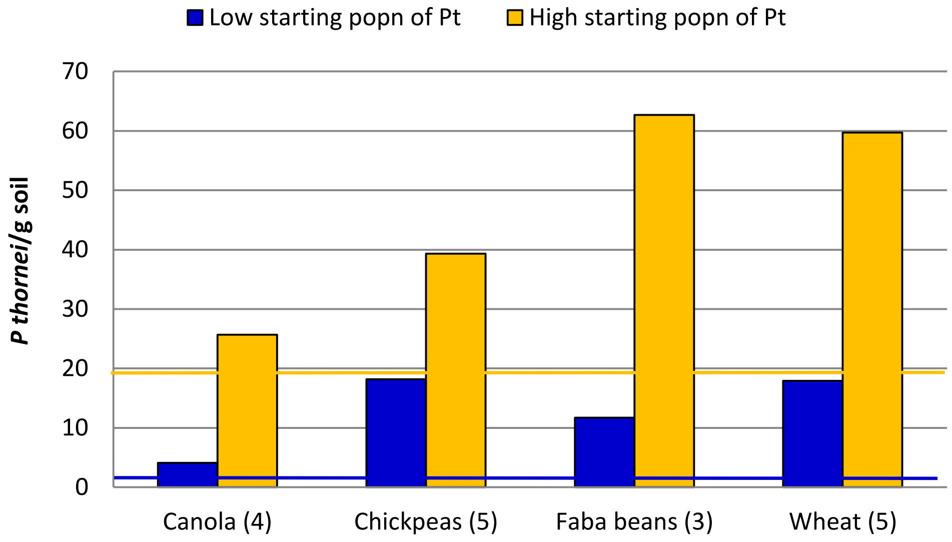


Figure 4: Comparison of *Pt* populations remaining in Jan 2013 following different winter crop species near Yallaroi 2012 (Trials RH1207-1213)
(Number) indicates the number of varieties of each crop
The two horizontal lines indicate the respective 'low' and 'high' starting *Pt* levels in Feb 2012

2. Resistance differences between summer crops

NGA have conducted nematode testing from a total of 16 replicated summer variety trials during 2012/13 and 2013/14 where *Pt* was present at planting. The majority of evaluations were in sorghum (9 trials) followed by dryland cotton (5 trials) and sunflower (2 trials). These crops are all rated as resistant or moderately resistant. The trials were evaluated primarily to compare varieties but provided some indication of the impact of a single resistant crop on *Pt* populations. Although the largest reductions of *Pt* populations were in sorghum trials, the general impact from a single resistant crop was disappointing. In 13 of the 16 trials, *Pt* populations were maintained or reduced by less than half. In the remaining 3 trials, the *Pt* population reduced by 50-75%. NB sorghum is a very useful rotation crop for the management of *Pt*, however it is susceptible to *Pratylenchus neglectus*.

Resistant crops/varieties are by definition, non-hosts to the specified disease. Although the nematode species will not multiply or increase to any significant degree when these crops are grown, the crop does not actively kill or suppress the nematode. The actual level of impact on the final nematode population is likely to be heavily influenced by a range of factors including rainfall, temperature and soil biology.

Key point: Management of *Pt* populations will not be achieved with a single resistant crop. Growers need to include as many resistant crops/varieties in their overall rotation as is practically and economically viable.

3. Resistance differences between commercial wheat varieties

Root-lesion nematode resistance ratings for wheat varieties have been published in variety guides for many years and these ratings should be used to assist in variety selection. There is a strong relationship between the resistance ratings produced by DAFF in glasshouse experiments and field assessment of resistance measured by high throughput DNA analysis. The large amount of field data generated in recent years has however helped to quantify the importance of variety differences in resistance rating. Figure 5 shows the relative variety impact on *Pt* populations as a % of the moderately resistant durum variety Hyperno, in trials conducted during 2009-2012.

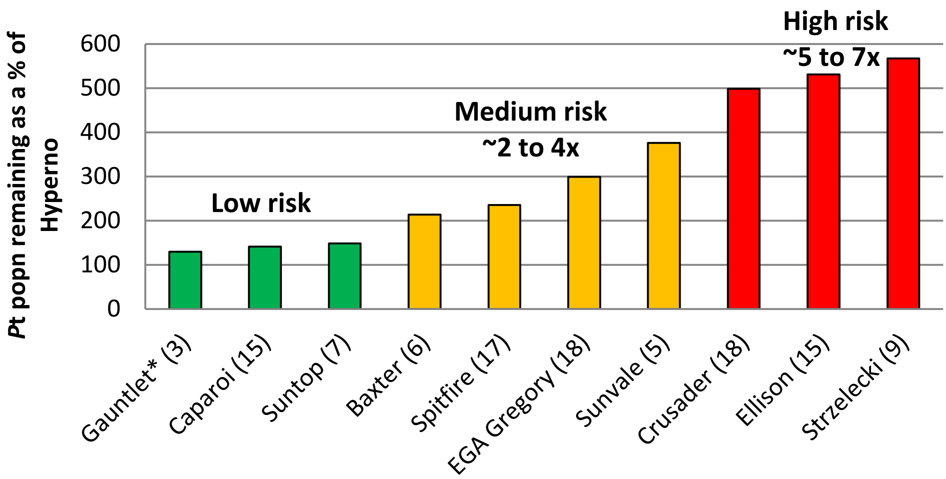


Figure 5: Comparison of *Pt* population remaining as a % of Hyperno, 2009-2012
(Number) indicates the number of field trials in which the variety was evaluated
Colours indicate risk of *Pt* build-up; green = low risk, amber = medium risk, red = high risk
* Gauntlet has only been evaluated in 3 field trials but has also performed well in pot resistance studies

Other common bread wheat varieties that are classed as high risk for *Pt* multiplication are Kennedy ,EGA Bounty, Elmore CL, Sunvex, Gazelle, Sunco, Janz, Impala and Lincoln

Key point: Bread wheats are generally *Pt* susceptible but there are large differences between varieties in the level of susceptibility. Growers with *Pt* infestations must avoid high risk or ‘sucker’ varieties that result in very high levels of *Pt* multiplication. NB although durum varieties generally restrict *Pt* multiplication compared to bread wheats, they are very susceptible to crown rot.

4. Resistance differences between desi chickpea varieties

Recent field data is also showing consistent differences in *Pt* resistance between commercial chickpea varieties. Figure 6 shows a summary of the performance of a range of chickpea varieties in 9 trials, during 2010-2013, conducted by DAFF QLD, NSW DPI or NGA.

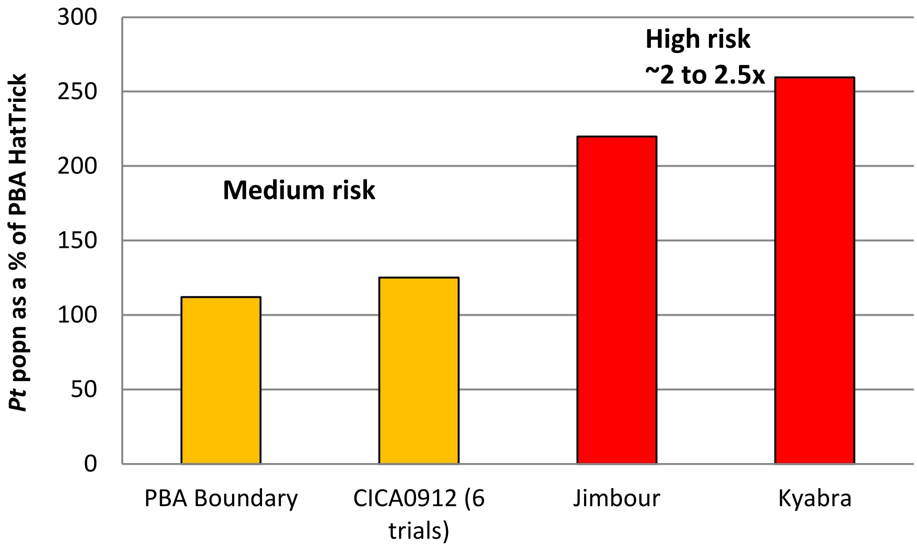


Figure 6: Comparison of *Pt* population remaining as a % of PBA HatTrickⒹ, 2010-2013
All varieties evaluated in all 9 trials except CICA0912 (only 6 trials)
Colours indicate risk of *Pt* build-up; green = low risk, amber = medium risk, red = high risk
All chickpea varieties evaluated to date appear to provide a medium to high risk of *Pt* build-up

Key point: Chickpeas are *Pt* susceptible but there are differences in the level of susceptibility. Mean *Pt* populations after Jimbour Ⓓ and KyabraⒹ have been generally double the level after PBA HatTrickⒹ or PBA BoundaryⒹ. Growers with *Pt* infestations should certainly avoid varieties that support higher populations of *Pt*.

5. **Variety resistance differences less evident in other crops**

Smaller data sets have been generated for commercial varieties of faba beans, field peas, canola, kabuli chickpeas, cotton and sunflower. Differences between varieties or hybrids in level of *Pt* resistance in these crops have been small or not significant to date. Figure 7 shows the mean results from 6 common sorghum hybrids that have been evaluated in a series of 9 individual trials. There was no indication of any consistent difference in *Pt* resistance between these, or any other, sorghum hybrids evaluated.

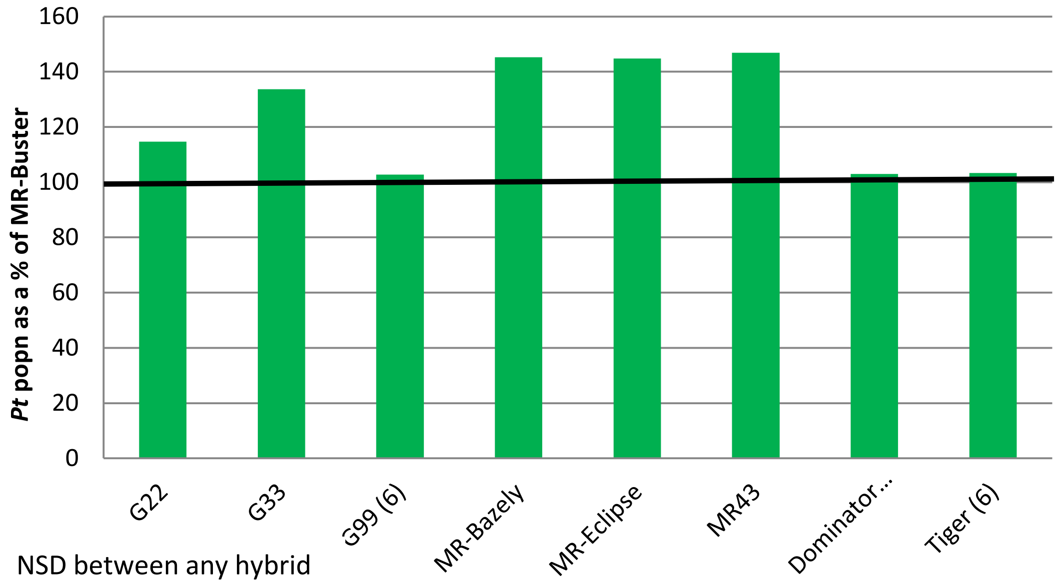


Figure 7: Comparison of *Pt* population remaining as a % of MR-Buster, summer 2012/13 and 2013/14
All sorghum hybrids evaluated to date appear to provide a low risk of *Pt* build-up

The table below is a summary of the resistance differences observed in field trials evaluated since 2009. These results support previous DAFF Qld findings.

Table 1: Comparison of crops for *Pt* build-up risk and frequency of significant variety differences

Crop	*Pt* build-up risk	Variety differences
Sorghum	Low	None observed
Cotton	Low	None observed
Sunflower*	Low	None observed
Linseed*	Low	-
Canola*	**Low** to Medium	None observed
Field peas*	Low to Medium	Low
Wheat - durum	Low to Medium	Moderate
Barley	Low to **Medium**	Moderate
Wheat - bread	Low, **Medium to High**	Large
Chickpea	Medium to High	Moderate
Faba beans	Medium to High	Low
Mung beans*	Medium to High ?	Moderate to Large ?

For crops with a range of build-up risk but a dominant category, the dominant category is in bold
eg barley; majority of varieties in the medium risk category but some low risk
bread wheat: varieties in all categories but most varieties are in the medium to high risk categories
*= data only from 1-2 field trial locations for these crops

Other factors involved – fallow effectiveness ?

Data generated from a number of NGA trials has enabled a comparison of the effectiveness of fallows in reducing *Pt* populations. Figures 8 and 9 appear to show two contrasting situations of fallow effectiveness. Figure 8 shows the *Pt* populations following common varieties of durum, bread wheat, canola, chickpeas and faba beans at Yallaroi in 2012. The blue columns show the *Pt* population in early January 2013 and the yellow shows the populations remaining 3 ½ months later. Across all crops there was a mean reduction in *Pt* population of ~50%. This large reduction was achieved in a late summer/autumn fallow with 350mm of rainfall during the period.

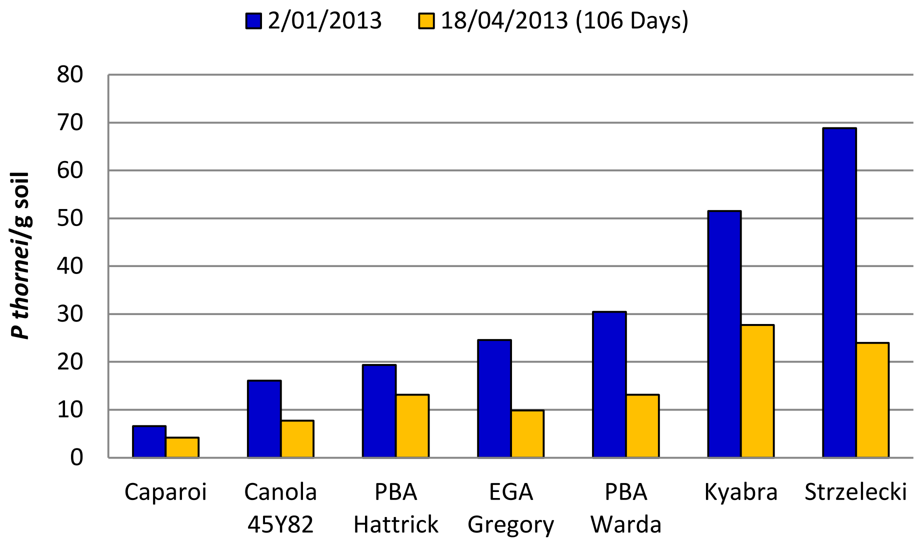


Figure 8: Differences in *Pt* populations following a range of crops assessed at two sampling times during the fallow, Yallaroi 2012

In contrast, Figure 9 shows data from two trials in winter 2013, where a 'fallow' treatment was created due to nil crop emergence from an in-furrow biological option being trialled as a seed treatment. The result may indicate some nematicidal activity from the biological option but is considered more likely to indicate the effectiveness of bare fallow. Rainfall was low in the growing season and then followed by a hot, dry summer. Both sites recorded ~80mm of rain in-crop together with ~190mm over a 5 to 6 month fallow. Under these predominantly dry conditions, *Pt* numbers were maintained despite the absence of a crop. Root-lesion nematodes can survive extreme dry periods by entering a dormancy phase called anhydrobiosis (dehydration). Interestingly *Pt* multiplication was still very high during the cropping phase despite the low in-crop rainfall.

Resistant crops act as non-hosts with the actual decline in *Pt* population driven by the 'fallow effectiveness' during that cropping phase and the fallow period pre and post cropping. In situations where the 'fallow effectiveness' is good, the resistant crop may appear very effective, where the 'fallow effectiveness' is poor eg under very dry conditions, the resistant crop may just maintain *Pt* populations. This may partly explain why there is a need for multiple resistant crops in the rotation to manage *Pt* populations and also reinforces the need to avoid growing varieties which consistently produce high levels of *Pt* multiplication. What drives 'fallow effectiveness' is probably poorly understood but it is likely to be a combination of soil moisture levels, temperatures and biological parameters.

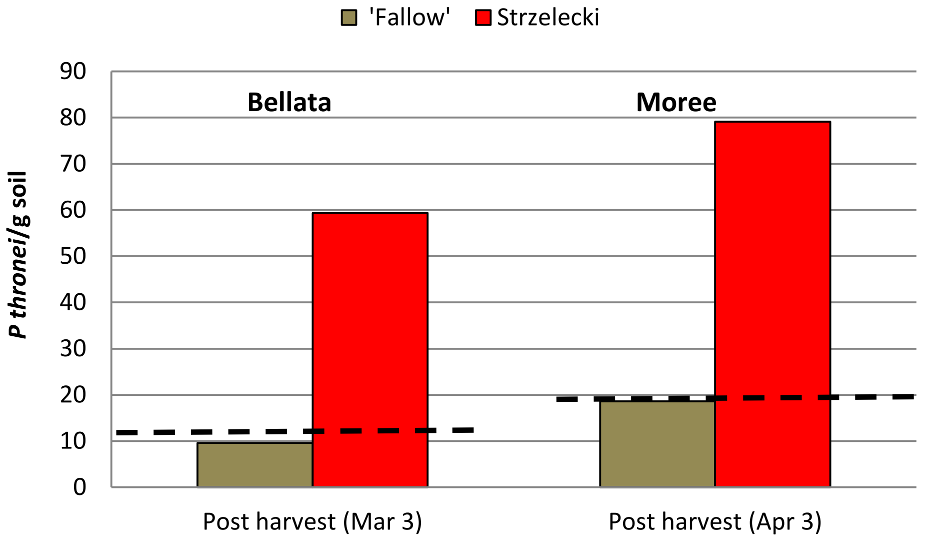


Figure 9: Differences in *Pt* populations following a fallow or Strzelecki⁽ᴰ⁾ compared to the population present near planting at two sites in 2013
The broken lines indicates the starting *Pt* populations at each site

Summary

RLN are key constraints of crop production in the northern grains region. The level of economic impact on intolerant wheat varieties is well understood but there have been concerning impacts also seen in chickpeas.

Once RLN are established in a paddock the key management tools are crop and variety choice. When wheat is grown, growers and advisors must focus on selecting tolerant varieties to avoid large yield losses. At the same time it is important to maximise the number of resistant crops/ varieties in the rotation and ensure that high risk or 'sucker' varieties are avoided. Unfortunately a single resistant crop is highly unlikely to be an effective management tool for RLN.

Acknowledgments

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⁽ᴰ⁾ Varieties displaying this symbol beside them are protected under the Plant Breeders Rights Act 1994

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