Root-lesion nematode management – the cost of getting it wrong!

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Key words

Pratylenchus thornei, yield, quality, wheat, chickpeas, faba beans and canola

GRDC code

NGA00003: GRDC Grower Solutions for Northern NSW and Southern Qld

DAN00143: Northern integrated disease management

CES00055: Crop sequences to manage soil pathogens and reduce the yield gap of northern grain production.

Take home messages

1. Wheat variety selection, based on *Pratylenchus thornei* (*Pt)* tolerance rankings, is a critical tool to reduce yield and economic loss when wheat is grown in the presence of *Pt*

2. Size does matter: increased populations of *Pt* significantly reduced yield and economic returns in *Pt* intolerant wheat varieties

3. *Pt* reduced leaf area index, yield, grain quality and nitrogen recovery in wheat with significant impact in *Pt* intolerant varieties

4. Wheat variety yields reduced by up to 59% (~1.8t/ha) between 'low' and 'high' *Pt* populations

5. Crown rot severity increased under higher populations of *Pt*

6. Economic cost of *Pt* in key wheat varieties was between ~$300-500/ha

7. No apparent impact in canola and no significant impact measured in faba beans

8. Trend to reduced yield in chickpeas by ~15-20% (0.35-0.4t/ha), economic cost of ~$175-200/ha

9. Size does matter: final populations of *Pt* in ALL crops were still significantly higher in strips where *Pt* were increased the previous year

10. Significant differences in *Pt* resistance were measured in varieties of all crops except canola

11. Wheat variety choice in 2012 resulted in up to a ~10 fold difference in final *Pt* population

12. Two successive years of 'very susceptible' varieties resulted in a ~10-20 fold increase in final *Pt* population compared to two moderately resistant selections

13. Canola resulted in the lowest final *Pt* populations of the broadleaf crops

The root-lesion nematode - *Pratylenchus thornei (Pt),* is one of the key 'diseases' affecting winter cereal production in the northern region. *Pt* is a major constraint due to: their large impact on yield when intolerant varieties are grown, broad geographic distribution with *Pt* populations frequently at above threshold levels and the susceptibility (*Pt* hosting) of key rotation crops such as chickpeas.

Successful *Pt* management will involve a range of practices including on-farm hygiene and soil testing to identify problem paddocks. However crop and variety choice are likely to be the major tools used for management. Wheat varieties are well characterised in terms of *tolerance* (yield impact suffered during the year of crop production) and *resistance* (impact from variety on the multiplication or build-up of *Pt*). Both characteristics are important for long term management.

This paper reports on trial work conducted in 2012 at a site near Yallaroi in northern NSW. The trials were designed to improve our understanding of the differences in tolerance between a range of winter crops and varieties followed by an assessment of the impact of these options on subsequent *Pt* densities (*resistance*). The approach used alternating strips of 'low' and 'high' *Pt* population which allowed evaluation of the impact of increased *Pt* numbers on variety performance.

Primary Aims

1. Evaluate the impact from *Pratylenchus thornei* (*Pt)* on the **yield and economic returns** from a range of winter crops and varieties
2. Examine the impact from different winter crops and varieties on the **multiplication of *Pt***

Trial site preparation 2011

Soil testing was conducted from a paddock in the Yallaroi area where *Pt* had previously been found at above threshold levels (>2000 *Pt*/kg soil). Samples were analysed by the DNA method (PreDicta B) and showed a mean population of ~8,900 *Pt*/kg soil in samples taken from 0-15cm depth. *Pratylenchus neglectus* (another root-lesion nematode species) was not detected in any sample. The previous crop was chickpea.

The aim in 2011 was to create 'strips' of alternating *Pt* populations to allow multi-crop evaluation in 2012. Four commercial scale strips of either Sunvex wheat or EGA Bellaroi durum were planted in June 2011 with each strip ~200m long x 12 wide. Sunvex was used to maximise the increase in *Pt* population and EGA Bellaroi was selected to reduce the multiplication. Sunvex is rated as S (susceptible) and EGA Bellaroi is rated as MR-MS (moderately resistant to moderately susceptible) for *Pt* resistance or multiplication. All eight strips were grown to maturity and harvested as per the surrounding commercial wheat crop.

Differences in *Pt* populations

Figure 1 shows the *Pt* counts from detailed transects, sampled at 0-30cm in early February 2012. Three transects were sampled across all strips, at roughly 50m intervals, to examine *Pt* population uniformity. There was a highly significant difference in *Pt* counts between the two varieties with no significant difference in counts between transects or interaction between variety and transect. The *Pt* populations were relatively uniform across the site.

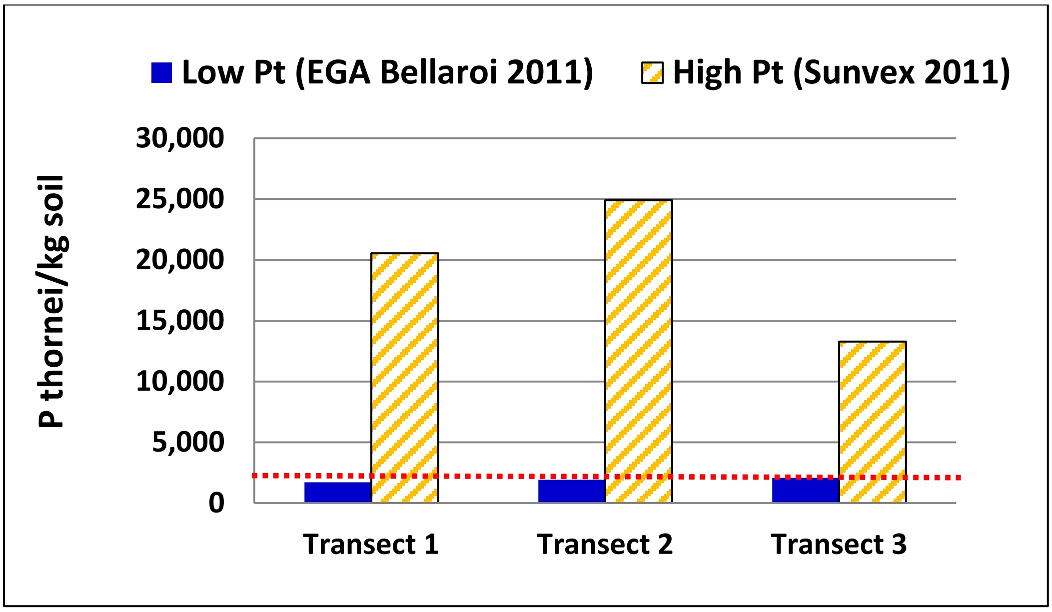

Figure 1: Back transformed means of DNA assay of *Pt* populations (February 2012)

The red dotted line indicates the industry guideline threshold of 2,000 *Pt*/kg soil, a population level that is likely to cause significant yield loss in intolerant wheat varieties.

Key points:

- **DNA analysis showed the Sunvex (‘high’ *Pt*) strips had *Pt* populations ~10 times larger than those following EGA Bellaroi (‘low’ *Pt*) strips. This highlights the impact of one poor variety choice.**
- **Importantly, the *Pt* population in the EGA Bellaroi (‘low’ *Pt*) strips were still at or close to the industry threshold of 2,000 Pt/kg soil.**

Trial activity 2012

A total of 19 commercial varieties of four key crops were evaluated in individual split plot trials with a primary focus on measuring the direct nematode impact on yield and economic returns. In addition three crop nutrition trials were evaluated at this site together with a CSIRO trial aimed at generating data to enable modelling of nematode impacts in cereals. Seed size and % germination were assessed for all seed lots with sowing rates adjusted to plant an equivalent number of viable seeds for each crop. Urea was spread over all cereal trial areas at 195kg/ha on the 21/5/12 and incorporated by planting on the same day. All nematode focussed trials received DAP + Zinc at 80kg/ha at planting. Commercial crop protection products (and chipping) were used to manage weeds, foliar diseases and insect pressure.

There were four replicates in all trials. Plots were sown at ~12m length x 5 rows on 32cm row spacing. Strips sown to Sunvex in 2011 were described as having ‘high’ *Pt* pressure and the strips sown to EGA Bellaroi were described as having ‘low’ *Pt* pressure.

Individual trial details are shown in Table 1. Trials RH1208-10 were conducted as standard split plot trials comparing variety performance in the ‘low’ and ‘high’ *Pt* strips. In trial RH1213, all varieties were evaluated with and without additional crown rot inoculum (2g/m row) at sowing in an attempt to partition the impact from *Pt* and crown rot.

Table 1: Details of key individual nematode trials conducted in 2012

Trial #	Crop	Number of varieties	Target plant stand/m^2	Planting date	Additional factor	Harvest date
RH1208	Canola	4	25	9/05/2012	-	8/11/12
RH1209	Faba bean	3	20		-	
RH1210	Chickpea	5	25	21/05/2012	-	26/11/12
RH1213	Wheat	7	90		Crown rot inoculum	13/11/12

2012 season

The trial site was established on a full profile of soil moisture but only received ~60% of average in-crop rain (~156mm May-November inclusive). The trial experienced late season moisture stress with only ~32mm received during August-October. Crop yields were better than expected given the poor finishing conditions.

Crop establishment

Plant establishment was acceptable from both sowing dates. The majority of broadleaf varieties were close to their target plant stand with only the juncea canola (Xceed™ Oasis CL) having significantly lower plant stands than the comparison canola varieties (~7/m^2 compared to ~22/m^2). Mean wheat establishment was ~70/m^2 compared to a target of 90/m^2. There were significant differences in plant stand between wheat varieties but all varieties were within a range from ~60/m^2 to ~90/m^2.

NDVI and Leaf Area Index assessment

NDVI (Normalised Difference Vegetation Index) readings were taken on August 13 and September 27 using a handheld GreenSeeker. NDVI is an assessment of the reflectance of the crop or variety. **Higher NDVI scores within the same variety usually indicate increased green leaf area which may also relate to biomass differences**. The first NDVI reading was taken when the cereals were in early stem elongation and the second during head emergence. A leaf area index (LAI) assessment was conducted on all cereal plots using a ceptometer in late August. This measures light interception above and below the canopy. Results from both the NDVI assessment, conducted in mid-August, and the LAI assessment showed similar patterns between varieties and between *Pt* strips. LAI measurements were only taken in wheat plots. Table 2 summarises the significant differences.

Table 2: Patterns of significant differences in NDVI or LAI between 'low' and 'high' *Pt* strips by crop

Trial #	Crop	NDVI 13/8/12	Leaf Area Index 27/8/12	NDVI 27/9/12
RH1208	Canola	No	-	No
RH1209	Faba bean	No	-	No
RH1210	Chickpea	No	-	No
RH1213	Wheat	**Yes**	**Yes**	No

The NDVI and LAI assessment in August both showed reduced leaf area and 'greenness' in the 'high' *Pt* strips. Strzelecki (31% reduction) and Sunvex (18% reduction) both recorded significantly reduced NDVI levels. There was a significant reduction in leaf area of ~26% in the 'high' *Pt* strips across all varieties in the LAI assessment with the largest levels of reduction in Strzelecki (48% reduction) and Sunvex (42% reduction).

Key points:

- **NDVI and LAI readings were reduced when averaged across all wheat varieties in 'high' *Pt* strips during August but differences were not significant by the 27/9/12 (similar patterns in CSIRO trial)**
- **Level of impact greater in intolerant varieties eg Strzelecki and Sunvex**
- **No significant difference in NDVI readings within canola or faba bean varieties**

Yield

The primary focus was the yield difference within each variety between 'low' and 'high' *Pt* strips. NB yield differences **between** varieties would be due to a very wide range of factors that included *Pt* tolerance/ intolerance.

The cereal trial showed the largest impact from the 'high' *Pt* strips. There was a significant overall reduction in yield between the 'low' and 'high' *Pt* strips but with clear differences in variety reaction (*tolerance*).

Canola appeared the most tolerant crop with no indication of any difference in yield between 'low' and 'high' *Pt* strips. There was also no consistent impact on yield in the faba bean varieties. The chickpea trials were the least uniform but there was a clear trend in both trials to yield losses of ~15-20% in the 'high' *Pt* strips.

Figures 2-5 show the variety yields in each individual trial.

Crop yields

NB varieties ranked in order of mean yield in the 'high' Pt strips

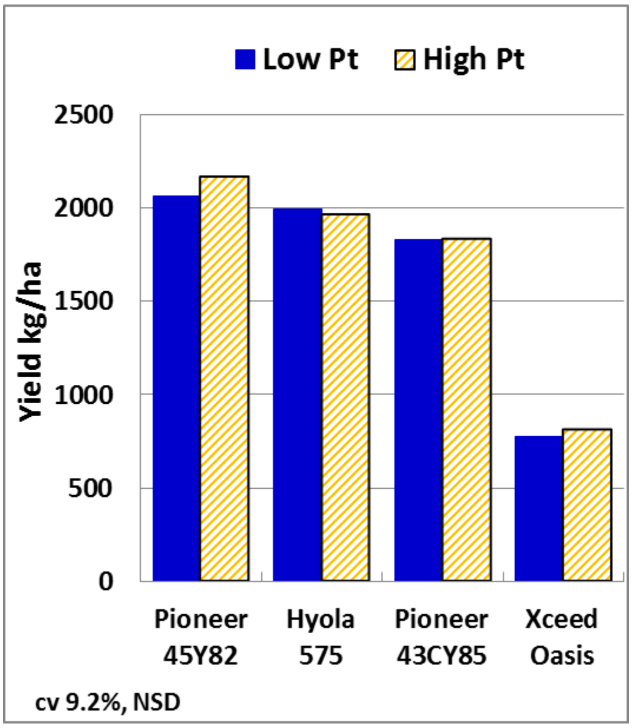

Figure 2: Canola yield (RH1208)

NB Very poor establishment for Xceed Oasis

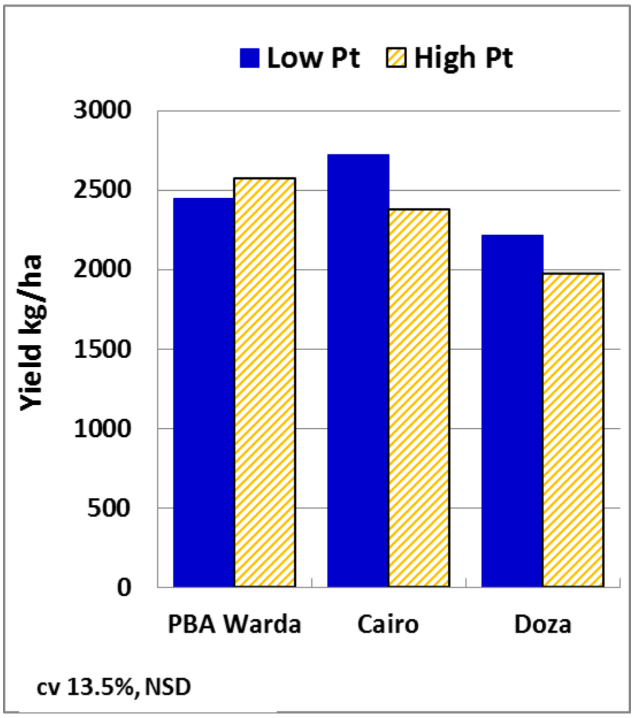

Figure 3: Faba bean yield (RH1209)

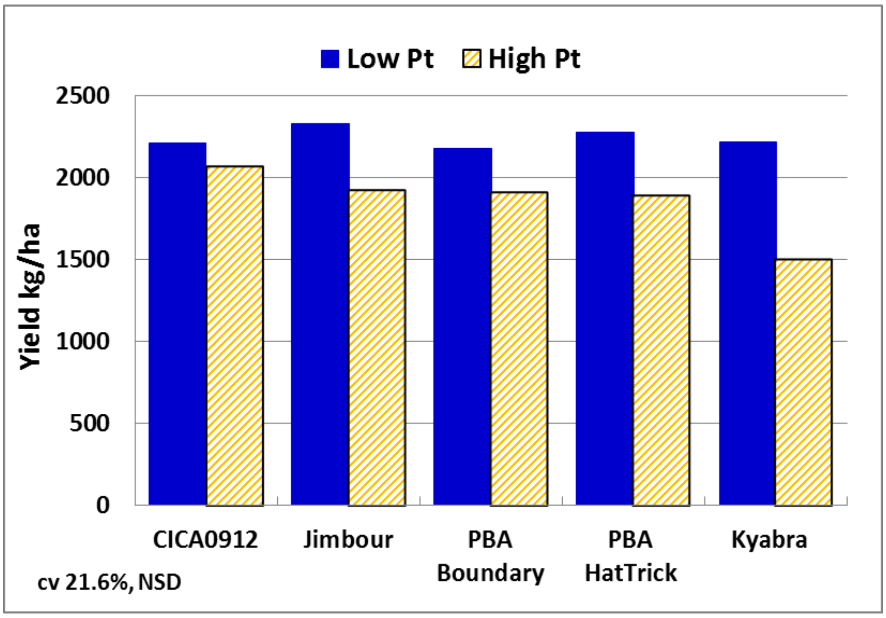

Figure 4: Chickpea yield (RH1210)
NB Trend to reduced yield in 'high' *Pt* strips across all chickpea varieties, significant at p=0.10
Similar trend apparent in PBA HatTrick nutrition trial.

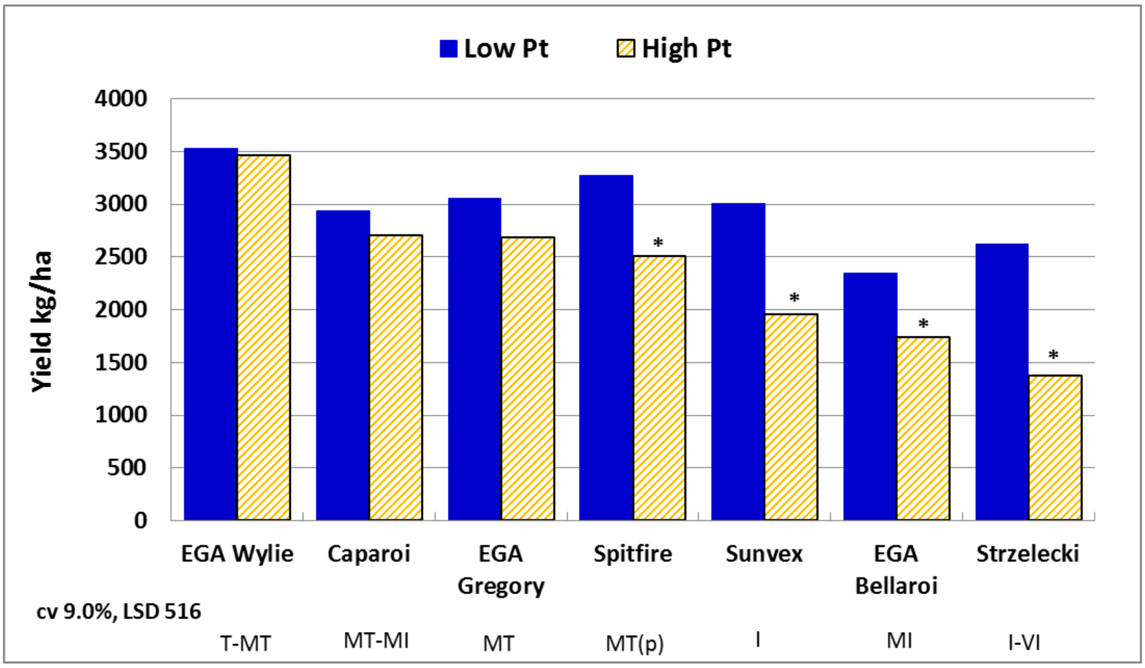

Figure 5: Wheat yield (RH1213)
* = significant yield difference in same variety between 'low' and 'high' *Pt* strips at p=0.05
Codes below variety names are the DAFF QLD published *Pt* tolerance rating; T=tolerant, MT=moderately tolerant, MI=moderately intolerant, VI=very intolerant , (p)=provisional, based on one trial

Key points:

- **Wheat was the most intolerant crop with large varietal differences**
- ***Pt* intolerant wheat varieties recorded significant yield losses**
- **Clear trend to yield losses of 15-20% in chickpeas**
- **No indication of impact in canola and no clear yield impact in faba beans**

Grain quality – canola

Test weight: averaged 64-65 kg/hL for all varieties with no indication of any impact from 'high' *Pt* strips.

Screenings: all varieties had screenings <1% with no indication of any impact from 'high' *Pt* strips.

Protein: no indication of any impact from *Pt* with canola protein levels ~21-23%.

Oil: no indication of any impact from *Pt* with canola oil levels ~45-46%. There was a significant increase in juncea canola oil content in the 'high' *Pt* strips.

Key point:

- **Little indication of any impact from changing *Pt* population on canola grain quality**

Grain quality - wheat

Test weight: Generally high - only Strzelecki and EGA Bellaroi averaged less than 74 kg/hL.

Screenings: Levels were low to moderate (all varieties in range from 2-9%). Significant increases in screenings in 'high' *Pt* strips for Strzelecki (2.5% higher) and Spitfire (3% higher).

Protein: Very low to low. Significant increase in protein in 'high' *Pt* strip for Strzelecki and for all varieties in the CSIRO trial.

Grain weight: Variety grain weights ranged from 30-38 g/ 1000 grains. Significant reductions in grain weight in 'high' *Pt* strips for Strzelecki and Spitfire (~3-3.5 g/1000 grains lower).

Key points:

- **Increased screenings and reduced grain weight were the most affected quality trait**
- **Significant impacts however only seen in 'less *Pt* tolerant' varieties**
- **Bread wheat receival classification varied from ASW to GP due to low protein and increased screenings for some varieties**
- **All durum classification was FED1 due to a combination of low protein and/or low test weight**

Total nitrogen recovery in wheat grain

Although absolute protein levels were increased for all wheat varieties in the 'high' *Pt* strips, differences in total nitrogen recovery were apparent. Total nitrogen recovery in grain was determined as yield x grain protein x 0.175. Total available nitrogen at the site was ~158 kg N/ha (~30kg N in early March soil test, 25 kg mineralisation credit, 90 kg N applied as Urea IBS and 13 kg N applied as Starter DAP). Figure 6 shows the nitrogen recovery patterns in the cereal trial.

Nitrogen use efficiency was calculated as the mean nitrogen recovery of the variety/ total available nitrogen. EGA Wylie had the highest efficiency at ~37%, Strzelecki had the lowest efficiency at ~20%.

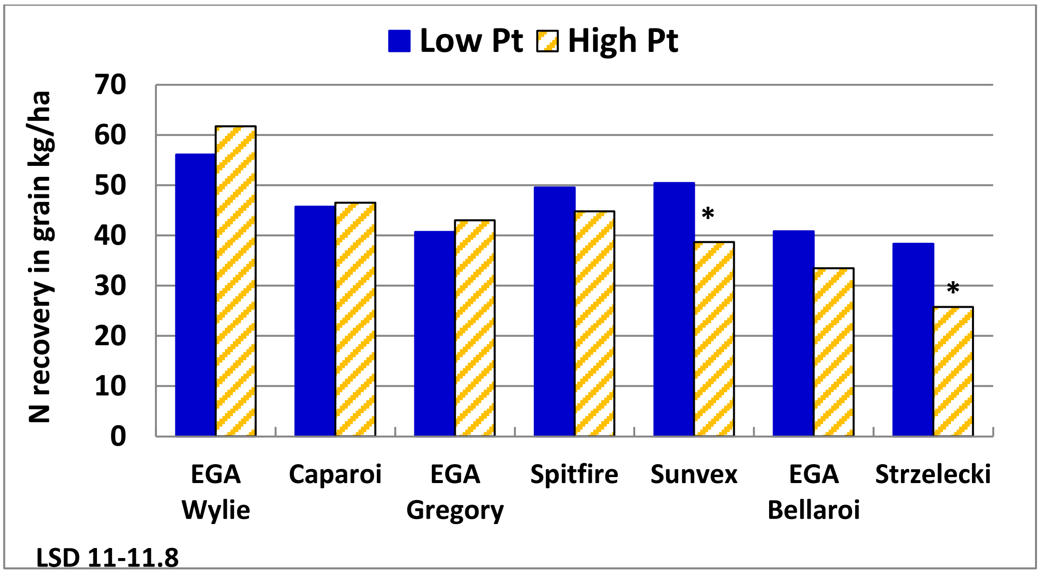

Figure 6: Wheat N recovery (RH1213)
* = significant difference in N recovery in same variety between 'low' and 'high' *Pt* strips at p=0.05

Key points:

- **Total nitrogen recovery reduced in varieties 'less tolerant' to *Pt***
- **Nitrogen recovery maintained in 'tolerant' varieties.**
- **Nitrogen use efficiency reduced in varieties 'less tolerant' to *Pt***

Interaction of *Pt* and Crown rot

In the wheat trial RH1213, all varieties were evaluated with and without the addition of crown rot inoculum at planting. Earlier NGA research in collaboration with NSW DPI indicated that the impact from crown rot may be increased when combined with *Pt* presence.

Figure 7 shows the yields for each variety. There was little impact from the addition of crown rot inoculum alone in this situation. The most likely explanation is due to the very high level of natural infection from the 2011 cereal stubble. Stubble samples in March 2012 had shown significant levels of crown rot inoculum with increased levels in the EGA Bellaroi⦸ stubble (i.e. the 'low' *Pt* strips)

Stubble samples were pulled from each wheat plot after harvest and sent to NSW DPI, Tamworth for assessment of incidence levels (based on plating) and disease severity which was a combination of a visual assessment of the % tillers with basal browning and the extent or height of browning up the stem. All varieties recorded very high levels of incidence of the crown rot pathogen - *Fusarium pseudograminearum (Fp).* Figure 8 highlights that there was no significant difference in *Fp* incidence between the *Pt* strips i.e. crown rot incidence was generally uniform across the strips with marginally higher levels in the 'low' *Pt* strips, following EGA Bellaroi⦸. Figure 9 shows the crown rot severity ratings. Despite no difference in incidence between the 'low' and 'high' *Pt* strips, there was a significant increase in crown rot severity across all varieties in the 'high' *Pt* strips. Varieties with lower crown rot tolerance appeared to be more impacted. It is expected that the 'high' *Pt* strips were limiting root growth and access to moisture (and nutrition). The reduction in the ability to extract available soil moisture appears to be driving increased crown rot severity.

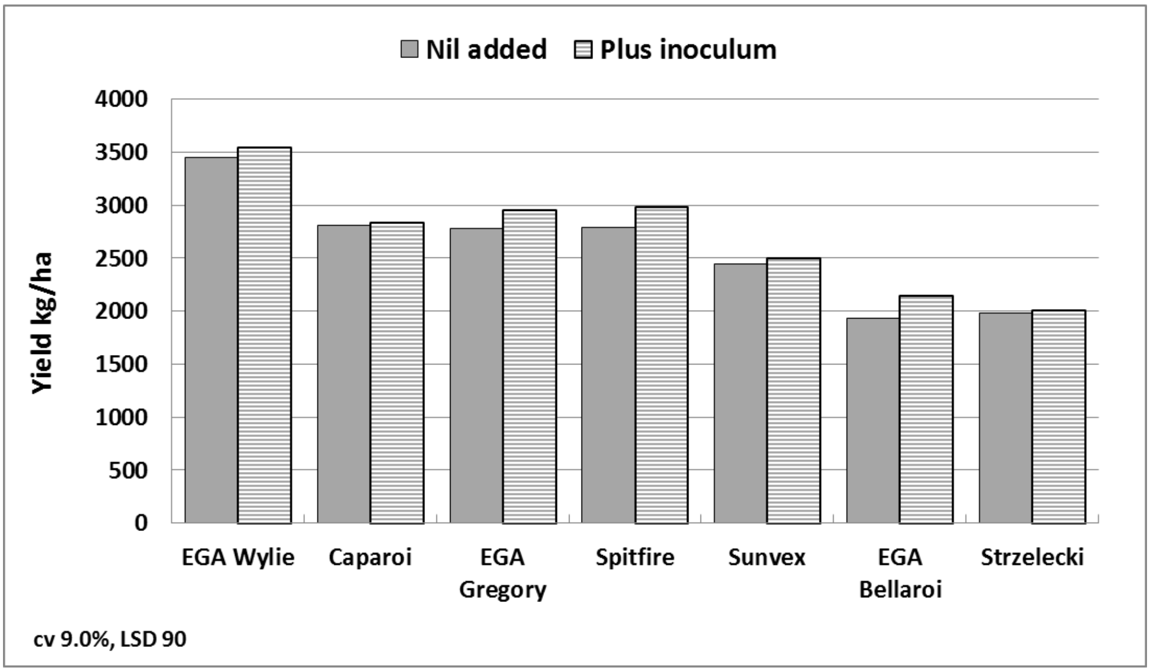

Figure 7: Wheat yield with additional crown rot inoculum (RH1213)
NB Averaged across all varieties there was a significant increase in yield in the plus inoculum plots

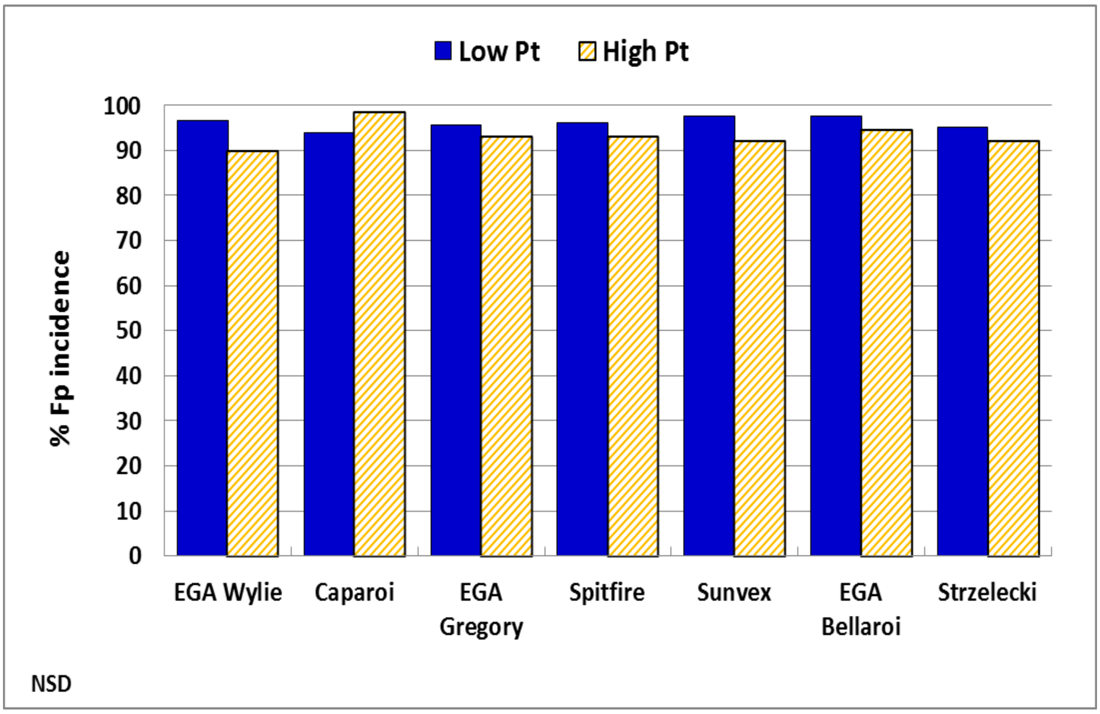

Figure 8: Wheat *Fusarium pseudograminearum* incidence (RH1213)

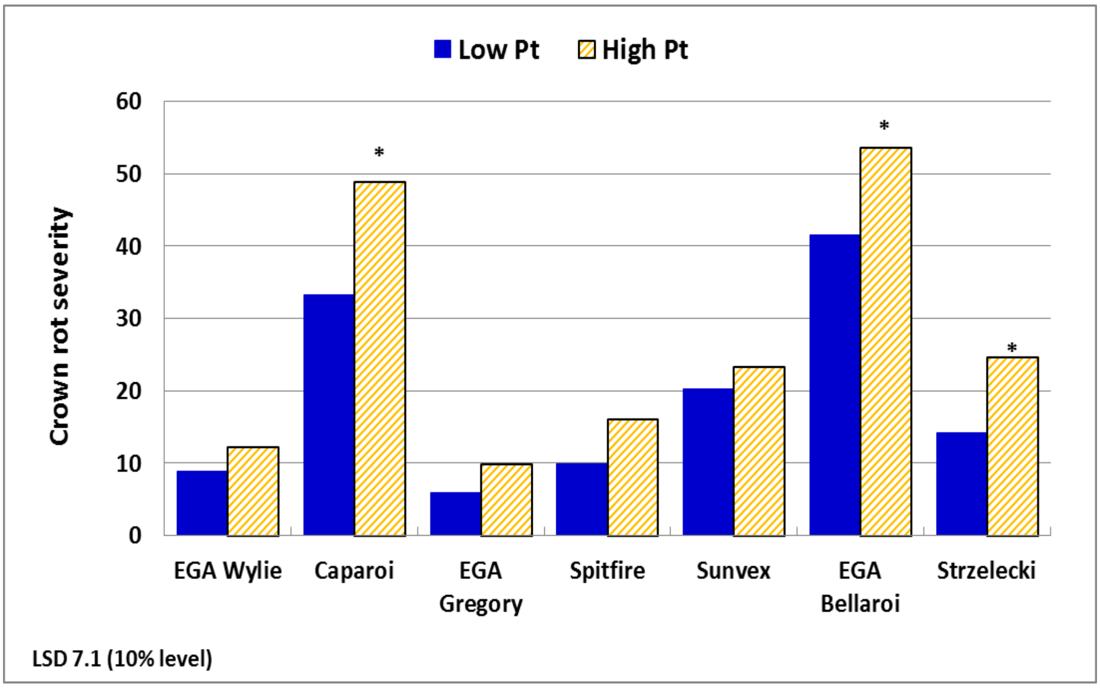

Figure 9: Wheat crown rot severity (RH1213)
* = significant increase in crown rot severity between 'low' and 'high' *Pt* strips at p=0.10

Key points:

- **High levels of natural infection across trial site**
- **Negligible impact from addition of extra crown rot inoculum**
- **Crown rot severity increased in the presence of higher populations of *Pt***

Economic impact

There are at least two ways to look at the economic impact from *Pt* in this trial;

1. Loss in production from 'low' to 'high' *Pt* strips within each variety
2. Loss in production compared to the most *Pt* tolerant variety in either 'low' or 'high' *Pt* strips eg EGA Wylie⒫

The first approach is the most scientifically accurate as it looks at the impact of increasing *Pt* population on individual variety performance. However our 'low' Pt strips already had *Pt* populations at the threshold level. Consequently the yield impacts reported are a CONSERVATIVE estimate of the actual losses caused by *Pt* at this site.

NB the problem with the second approach is that it does NOT just evaluate the impact of *Pt* but will take into account other factors such as crown rot tolerance, variety yield potential etc. Variety economic loss compared to EGA Wylie⒫ is likely to be a combination of *Pt* tolerance but also crown rot tolerance, although the results from this site suggest *Pt* is likely to have been a dominant factor.

Table 3: Economic loss in $/ha from *Pt* in wheat varieties

Variety	Grain receival grade	Due to increasing *Pt* pressure WITHIN same variety	Compared to EGA Wylie in 'low' *Pt* (*EGA Wylie gross return $837/ha)*	Compared to EGA Wylie in 'high' *Pt* (*EGA Wylie gross return $820/ha)*
EGA Wylie	ASW1	**nsd**	-	-
Caparoi	FED1	**nsd**	-184 *	-220 *
EGA Gregory	GP1	**nsd**	-144 *	-211 *
Spitfire	ASW1/GP1	**-206 ***	-62 *	-251 *
Sunvex	ASW1	**-251 ***	-125 *	-359 *
EGA Bellaroi	FED1	**-134 ***	-317 *	-434 *
Strzelecki	GP1	**-284 ***	-243 *	-510 *

* = significant yield reduction between 'low' and 'high' *Pt* strips at p=0.05 or compared to EGA Wylie

Grain prices (delivered Moree): ASW1 $237, AGP1 $227 and FED1 $222
Spitfire quality downgraded in 'high' *Pt* strips due to significant increase in screenings
Total cereal fertiliser and crop protection cost was ~$276/ha

There were no significant differences in yield within canola or faba bean varieties so no economic data is presented. In chickpeas there was a trend to reduced yield in 'high' *Pt* strips, significant at p=0.10. The mean impact across all chickpea varieties was ~380 kg/ha. At a grain price of $480/t, the impact from 'high' *Pt* strips was ~$180/ha.

Table 4: Mean crop economic performance in 'high' *Pt* strips compared to EGA Wylie

Variety	Total fertiliser and crop protection cost $/ha	Mean net benefit in 'high' *Pt* $/ha
Canola	345	$642/ha
Faba bean	222	$470/ha
Chickpea	252	$642/ha
EGA Wylie	276	$553/ha

Grain prices: Canola $495, Chickpeas $480, Faba beans $300, ASW1 $237

Key points:

- **Yield losses of ~$130-280/ha occurred in 'less *Pt* tolerant' wheat varieties due to increasing populations of *Pt.***
- **This figure is conservative as it measures the loss above threshold rather than from a nil *Pt* population**
- **Spitfire performance was unusual. It had high yield in the 'low' *Pt* strips but significantly reduced yield and grain quality in the 'high' *Pt* strips**
- **All wheat varieties were significantly lower in yield than EGA Wylie in both 'low' and 'high' Pt situations when combined with very high incidence levels of crown rot**
- **Economic impact of a poor cereal variety choice was ~$400-500/ha**

Multiplication of nematodes (crop or variety resistance)

Layout 2012 (not to scale)

North ↗

RH1207	RH1208	RH1209	RH1210	RH1211	RH1212	RH1213	CSIRO modelling
Canola nutrition	Canola	Faba beans	Chickpeas	Chickpea nutrition	Wheat nutrition	Wheat x crown rot	

← 156m →

All soil cores were taken on January 2, 2013. Sampling was not conducted in nutrition trials or where crown rot inoculum was added at planting in trial RH1213. All sampling was at 0-30cm depth with four random cores taken between the three central crop rows.

Figures 10-13 show the **mean number of *Pt* remaining by variety** across both 'low' *Pt* and 'high' *Pt* strips. NB although the transects of the trial site appeared uniform for starting population of *Pt*, no statistical comparison of final *Pt* populations is possible between crops as they were all in separate trials.

Canola

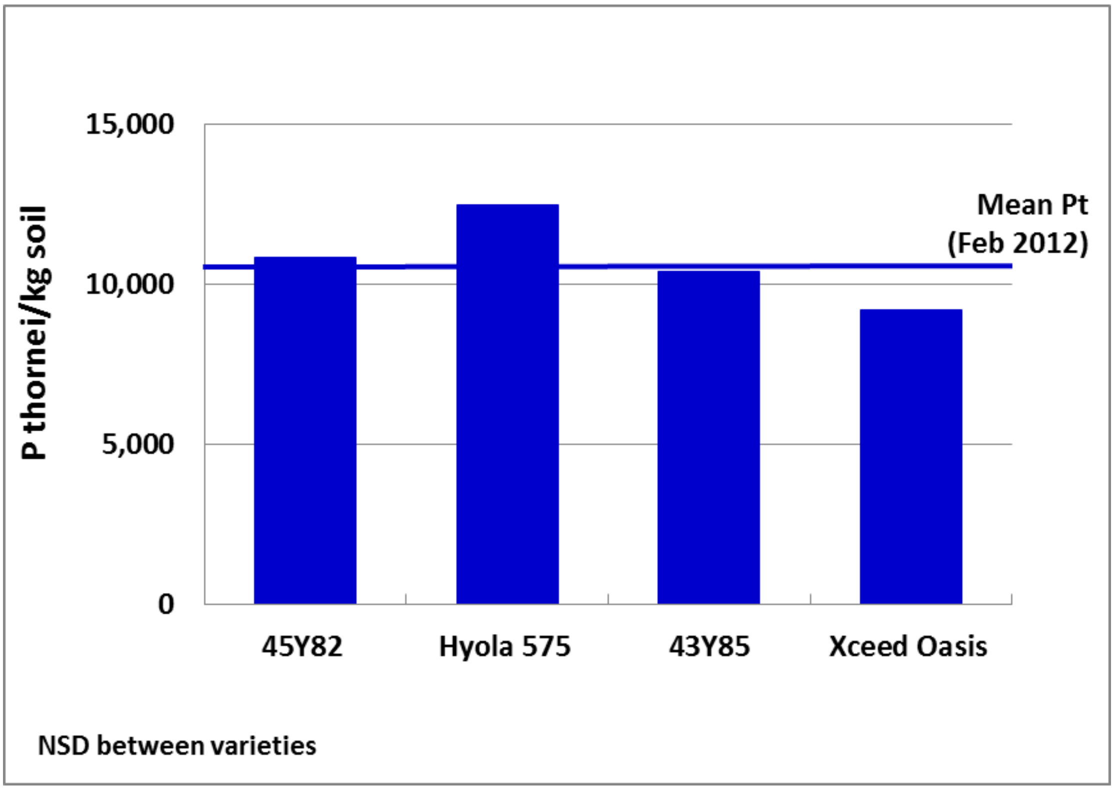

Figure 10: Canola and *B juncea* (Xceed Oasis) impact on final *Pt* population (RH1208)
The blue horizontal line indicates the **mean starting *Pt* population**

Faba bean

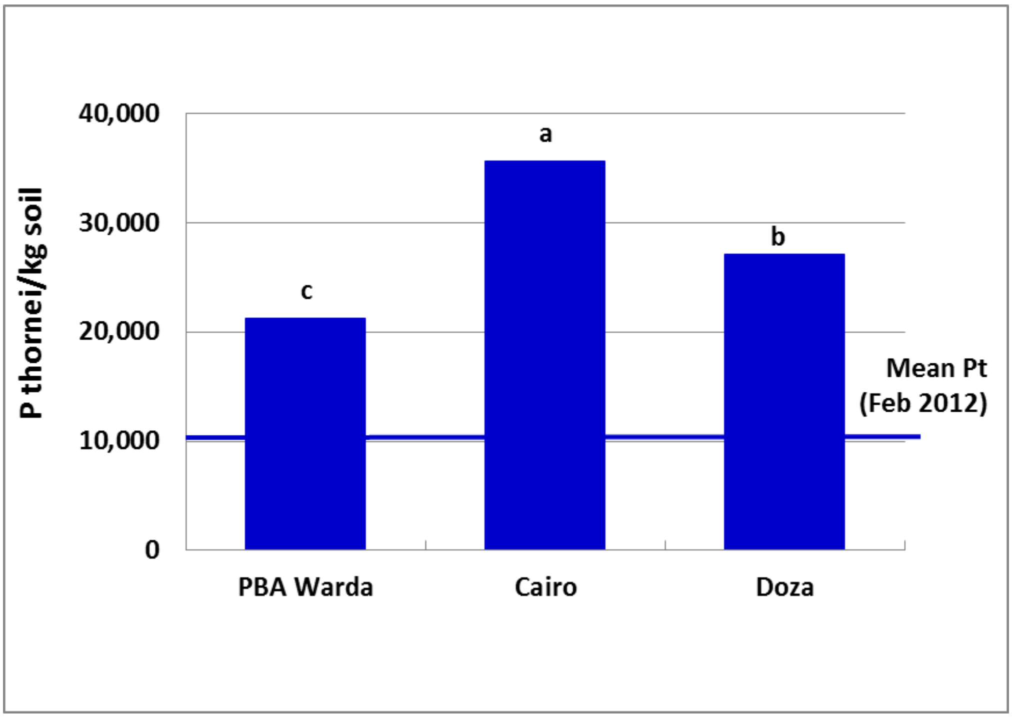

Figure 11: Faba bean impact on final *Pt* population (RH1209)
Varieties sharing the same letter are not significantly different at p=0.05
The blue horizontal line indicates the **mean starting *Pt* population**

Chickpea

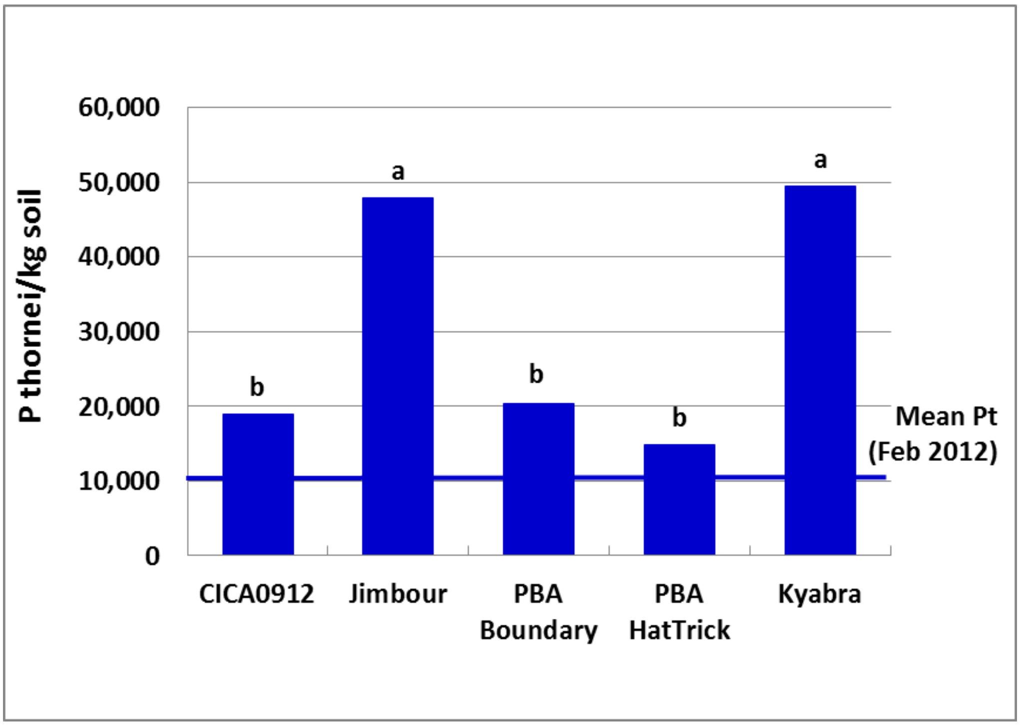

Figure 12: Chickpea impact on final *Pt* population (RH1210)
Varieties sharing the same letter are not significantly different at p=0.05
The blue horizontal line indicates the **mean starting *Pt* population**

Wheat

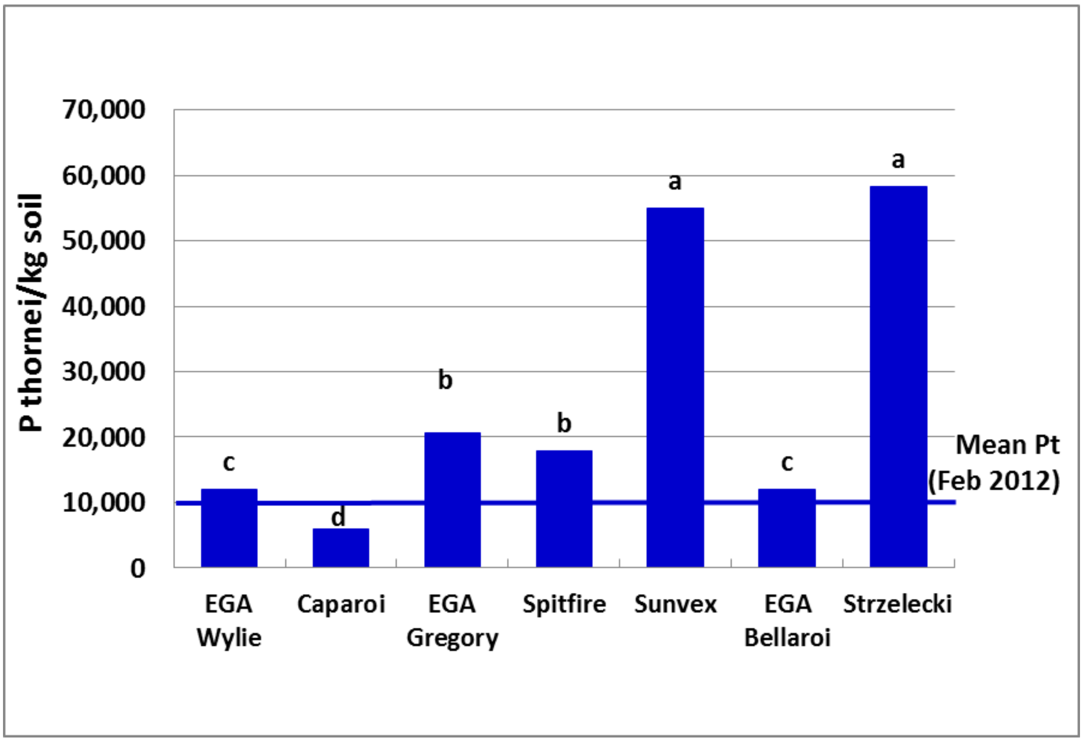

Figure 13: Wheat impact on final *Pt* population (RH1213)
Varieties sharing the same letter are not significantly different at p=0.05
The blue horizontal line indicates the **mean starting *Pt* population**

Key points:

- **Canola** showed moderate levels of resistance with no apparent varietal difference
- **Faba beans** appeared more susceptible than canola with significant differences between all three varieties. On average, faba beans had ~2-3 times the final *Pt* population found in canola
- **Chickpeas** appeared more susceptible than canola with significantly higher *Pt* populations after Jimbour and Kyabra. On average, chickpeas had ~3 times the final *Pt* population found in canola
- Significant differences in final *Pt* populations between **bread wheat varieties**. Strzelecki and Sunvex resulted in final *Pt* populations ~4-5 times larger than following EGA Wylie
- Both **durum** varieties (Caparoi and EGA Bellaroi) displayed at least **moderate levels of resistance**

Impact of initial *Pt* population or previous crop

Figure 14 shows the mean final *Pt* populations by crop in both the 'low' and 'high' *Pt* strips. NB no statistical comparison is possible of final *Pt* populations **between broadleaf and cereal crops** as they were in separate trials.

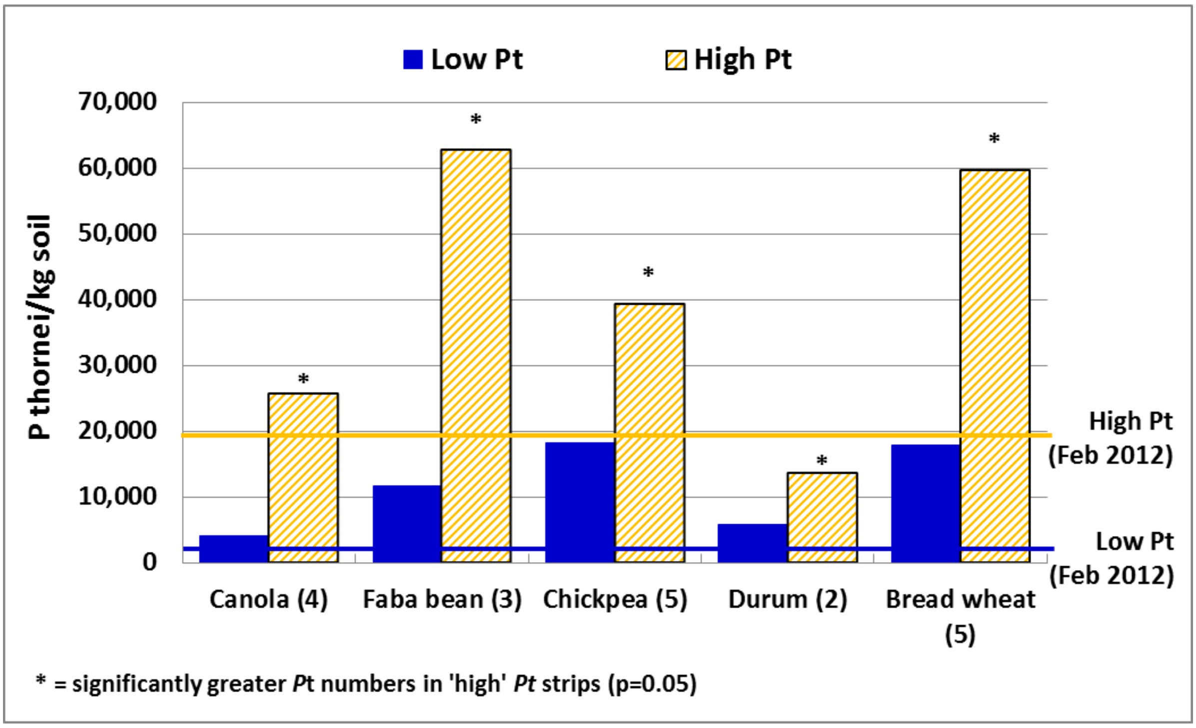

Figure 14: Impact by crop of initial *Pt* population on final *Pt* counts
Blue and yellow horizontal lines indicate starting *Pt* populations in 'low' and 'high' *Pt* strips respectively
Figure in brackets after crop name is the number of varieties evaluated

Key points:

- In all crops, **final *Pt* populations were still significantly higher in the 'high' *Pt* starting population strips**
- In canola and faba beans there was a ~5-6 fold difference in final *Pt* counts between the low and high *Pt* strips
- In chickpeas, durum and bread wheat there was a ~2-3 fold difference in final *Pt* counts between the 'low' and 'high' *Pt* strips
- All crops resulted in increased *Pt* counts in the 'low' *Pt* strips with the lowest final counts in canola and durum varieties
- All crops, except the durum varieties, resulted in increased *Pt* counts in the 'high' *Pt* strips. Both durum varieties resulted in reduced counts in the 'high' *Pt* strips with the canola varieties recording the smallest increases in *Pt* population

This data highlights that management of *Pt* is a long term process. This site was selected in March 2011 with a *Pt* population of ~9,000/kg soil. Growing a moderately resistant crop in 2011 (EGA Bellaroi⚐) reduced the number to ~1,900/kg soil. Following a second moderately resistant crop in 2012 (canola or durum varieties) still resulted in a final *Pt* population of ~4,500/kg soil or ~50% of the initial population in 2011 (it is not known why the durum was apparently more 'effective' in 2011 than in 2012).

Growing susceptible varieties in both 2011 and 2012 resulted in final *Pt* populations of ~50,000-100,000/kg soil**. In this trial, the impact of two poor crop or variety choices resulted in a ~10-20 fold difference in the final *Pt* population.**

Very susceptible crops or varieties need to be avoided when Pt is present to avoid population 'blow-outs' and the prolonged period for population decline, even when Pt resistant crops are sown.

The future in wheat varieties?

One of the entries in the modelling trial was QT8447 a pre-breeding wheat line developed by DAFF for both good tolerance (yields well in presence of *Pt*) and resistance (reduces *Pt* multiplication in the roots). This strategy is important for long term management as we need to include more crops or varieties in the rotation which help to reduce the ongoing population and impact of this nematode. QT8447 performed very well and was significantly higher yielding than EGA Wylie⦸ in the 'high' *Pt* strips. It also provided significantly higher N recovery than any other variety in the 'high' *Pt* strips.

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- ⦸ Varieties displaying this symbol beside them are protected under the Plant Breeders Rights Act 1994

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