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Crown rot yield loss response curves – Macalister 2015

Clayton Forknall[1], Steven Simpfendorfer[2] and Alison Kelly[1]
[1]DAFQ, Toowoomba
[2]NSW DPI, Tamworth

Key findings

- Yield loss response curves are an additional tool to help growers in varietal selection decisions to maximise returns where disease is present.
- Variations occurred in the yield response of varieties to crown rot, along with their resistance to this disease.
- The variety Suntop⊕, although displaying crown rot symptoms similar to that of a susceptible variety, demonstrated a greater ability to maintain yield where disease was present than other varieties that are considered tolerant.
- The selection of varieties based purely on current resistance categories may be overlooking genetics with improved tolerance, such as the variety Suntop⊕.

Introduction

Production losses due to disease are a major financial constraint to producing cereal crops in Australia, with annual losses in wheat alone estimated at $913 million (Murray & Brennan, 2009; 2010).

Given the demonstrated constraint that disease poses to the grains industry, the Grains Research and Development Corporation (GRDC) funded the yield response curves (YRC) project (DAW00245) with the aim to better understand and quantify potential production losses incurred from foliar, crown and root diseases by developing response curves. Response curves relate a measure of productivity, namely grain yield, to a measure of disease. They are being constructed for a range of varieties differing in resistance levels, across a number of locations and years, for an array of priority pathogens identified to affect the grains industry, both at a regional and national level.

One such pathogen is crown rot, caused predominantly by the fungus *Fusarium pseudograminearum* (*Fp*). Crown rot has been identified as affecting winter cereal crops across Australia, with an estimated cost to growers of $97 million annually (Murray & Brennan, 2009). As such, a module of the YRC project, led by the New South Wales Department of Primary Industries, has been dedicated to constructing response curves to explore the impact of crown rot on production losses.

Crown rot infection is characterised by a honey-brown discolouration at the base of infected tillers. Yield loss is related to the expression of whiteheads, which are induced by water and/or temperature stress during flowering and grain-filling. These prematurely ripened spikes contain either no grain or shrivelled grain depending on the timing of stress relative to crop development. All winter cereal crops host the crown rot fungus.

This paper summarises the results from a single experiment conducted near Macalister in Queensland in 2015, presenting response curves for the five wheat varieties considered in the experiment, along with exploring the types of information that can be gathered from the response curves for each variety.

Site details

Location	'Curraweena', Macalister, Qld
Co-operator	Rob Taylor
Sowing date	1 June 2015
Plant population	Target 100 plants/m^2
Fertiliser	250 kg/ha Urea and 40 kg/ha Granulock® 12Z at sowing
Starting Nitrogen	170 kg N/ha to 0.6 m

Rainfall	The growing season rainfall was 121 mm
PreDicta B	5.5 *Pratylenchus thornei*/g soil (medium risk) at sowing (0–30 cm)
Trial design	Randomised complete block design with variety as the main block and inoculum level as the sub-plots; three replications.
Harvest date	2 November 2015

Treatments

Varieties (5)	Four bread wheat varieties (Sunguard⁽ᵈ⁾, Suntop⁽ᵈ⁾, EGA Gregory⁽ᵈ⁾ and LRPB Lincoln⁽ᵈ⁾) and one durum variety (Caparoi⁽ᵈ⁾).
Inoculum rates (6)	Crown rot inoculum, based on sterilised durum grain colonised by at least five different isolates of Fp, was added at sowing at rates of 0, 0.25, 0.5, 1.0, 2.0 and 4.0 g/m of row.

Analysis

The data was analysed using random regression techniques to estimate the yield potential (intercept) and yield response (slope) of each variety in the experiment. Yield potential provides an estimate of a variety's ability to yield in the absence of disease, while the yield response demonstrates the rate at which yield is lost per unit increase in disease pressure.

Results

Varieties differed in both their yield potential where crown rot was absent and yield response, due to crown rot infection (Figure 1). Although named 'curves' the relationship between grain yield and crown rot index was found to be linear in this case.

Using the response curves presented in Figure 1, each variety can be compared for a series of traits. For example, under the highest disease pressure, Suntop⁽ᵈ⁾ still had a 17% (0.7 t/ha) yield loss when compared with the no applied inoculum treatment, while Sunguard⁽ᵈ⁾ lost 12% (0.5 t/ha).

Yield potential

The intercept of the response curve for each variety gives an estimate of the yield potential, or the ability of a variety to yield where crown rot is absent. In this case, it can be seen that Suntop⁽ᵈ⁾ had the greatest yield potential in the Macalister environment in 2015, yielding approximately 4.2 t/ha with no crown rot present. On the other hand, LRPB Lincoln⁽ᵈ⁾ has the lowest yield potential in this environment (approximately 2.5 t/ha). However, the yield potential of LRPB Lincoln⁽ᵈ⁾ in this experiment was severely compromised by the presence of the root lesion nematode, *Pratylenchus thornei* (*Pt*), which was identified as present in medium numbers (5.5 *Pt*/g soil 0–30 cm) using a PreDicta B test before sowing.

Also evident from the response curves is the low background level of crown rot inoculum present at the experimental location, with little disease present in those treatments where no crown rot inoculum was applied. The selection of experimental locations plays a substantial role in the success of these experiments, as high levels of background inoculum and the subsequent infection of plants without the addition of inoculum, prevent the accurate estimation of the yield potential of varieties.

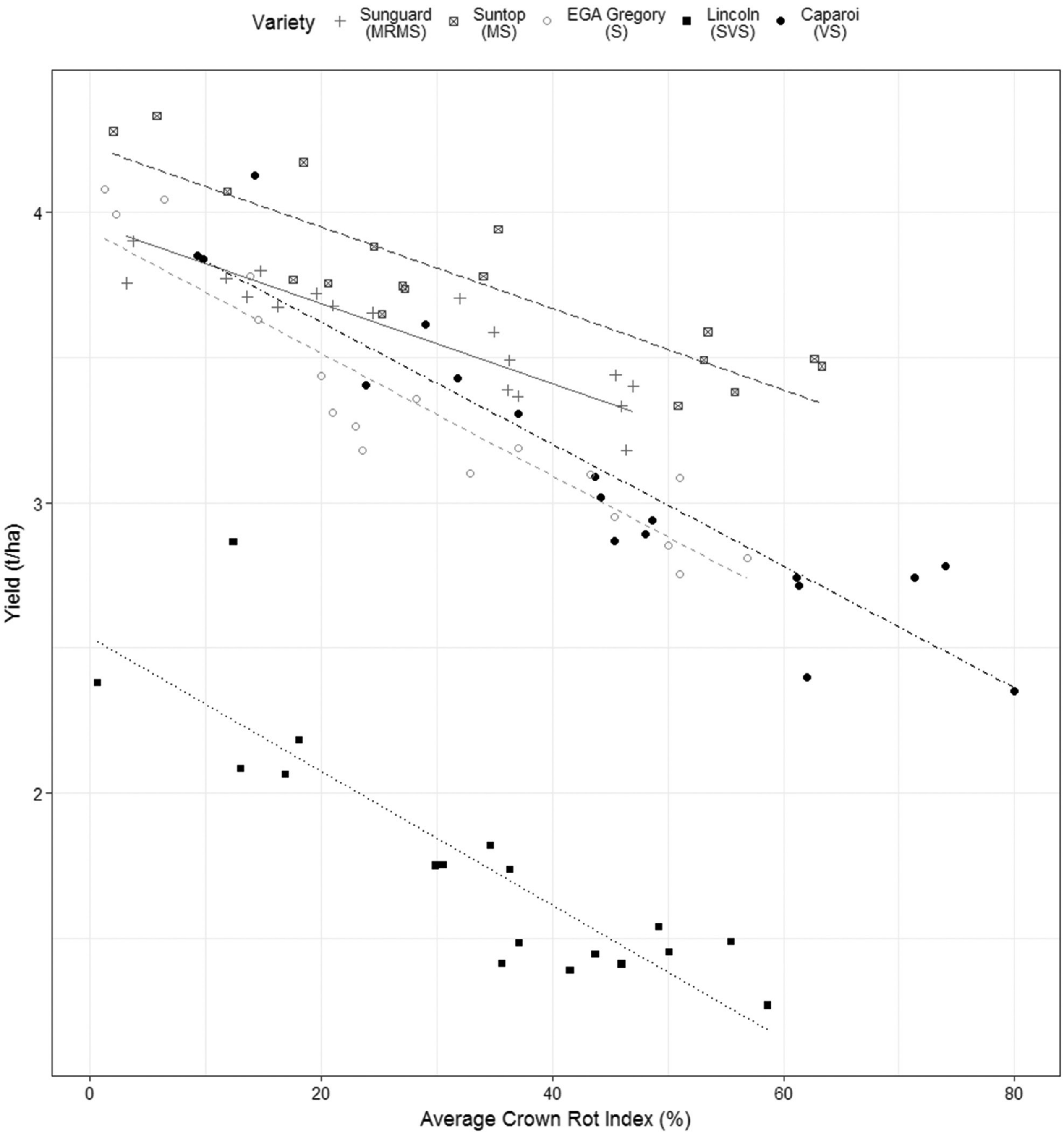

Figure 1. Response curves describing the response in yield of five wheat varieties to crown rot at an experiment near Macalister in 2015. Variety resistance categories provided beneath variety names.

Resistance

The resistance of varieties to disease can also be assessed using response curves. In the case of crown rot, this is achieved through comparing the maximum crown rot index values measured. A variety displaying a greater maximum index is more susceptible to the disease. Using the response curves in Figure 1, Caparoi⸸ displayed the highest crown rot index value (approx. 80%), followed by Suntop⸸ (approx. 63%). Conversely, Sunguard⸸ exhibited the least amount of disease symptoms (maximum value approx. 47%). Comparing the variety rankings according to maximum crown rot index with the resistance categories assigned by the National Variety Testing (NVT) system reveals a high degree of similarity in terms of varietal resistance to crown rot, except for Suntop⸸. Suntop⸸ is rated as a moderately susceptible (MS) variety, however, in this experiment it displayed a maximum crown rot index value second only to the very susceptible (VS) durum wheat, Caparoi⸸. This abnormal behaviour of Suntop⸸ has also been seen in other experiments conducted across the northern grains region (data not shown).

Yield response and tolerance

The yield response of each variety to crown rot is provided by the slope of the response curves; the greater the slope, the more yield is lost per unit increase in crown rot pressure. From a comparison of the responses in Figure 1, the varieties Suntop$^{\phi}$ and Sunguard$^{\phi}$ are seen to have near equivalent yield responses to the disease, losing approximately 0.01 t/ha per unit increase in the crown rot index. In the case of EGA Gregory$^{\phi}$, LRPB Lincoln$^{\phi}$ and Caparoi$^{\phi}$, the rate of change in yield was doubled, with the varieties losing approximately 0.02 t/ha per unit increase in the crown rot index.

Of particular note is the response of Suntop$^{\phi}$. In this case, and at numerous other experiments conducted across the northern grains region (data not shown), the level of disease expressed by Suntop$^{\phi}$ is not indicative of the yield losses incurred by the variety. Given the extent of symptoms exhibited, greater yield loss would be expected. This ability to maintain yield in the presence of disease implies the variety has some level of improved tolerance to crown rot.

Yield performance – maximising profitability

The response curves presented in Figure 1 can also be used to determine the point at which growing one variety becomes more profitable than another under crown rot pressure. This comparison involves not only the yields observed, but also the price of grain offered for the different crop types and quality categories. With the higher price recently offered for durum wheat grain relative to bread wheat grain, growers can use the response curves to determine the cross-over point in terms of crown rot pressure where it is still more profitable to produce durum wheat (e.g. Caparoi$^{\phi}$), even though it has poorer resistance and tolerance levels relative to some bread wheat varieties (Sunguard$^{\phi}$ and Suntop$^{\phi}$).

Conclusions

Response curves provide an additional tool that growers can use to select a variety to maximise returns where disease is present. Response curves describing the impact of crown rot on yield were presented in this paper, however, the same approach is being applied by the YRC project to describe yield and grain quality responses to root lesion nematodes, along with foliar diseases of wheat and barley on a national level.

When considering variety selection under crown rot conditions, the response curves presented in Figure 1 pose a number of potential options to growers:

1. Consider chasing the superior yield performance of a variety with a high yield potential that demonstrates improved tolerance to the disease (Suntop$^{\phi}$), but could result in more inoculum remaining in the system for future rotations, or
2. Grow a more resistant variety (e.g. MR–MS) that could result in less inoculum in the system (Sunguard$^{\phi}$); however, incurring a penalty in terms of lower yield potential.
3. Only target production of varieties with reduced tolerance to crown rot (Caparoi$^{\phi}$ and EGA Gregory$^{\phi}$) in paddocks that are known to have low inoculum levels (e.g. PreDicta B testing or paddock history).
4. The response curves can be used to determine the point at which it is more profitable to grow one variety or crop type over another under crown rot pressure (e.g. durum wheat vs bread wheat).

Grain quality (protein and screenings) was also measured in this experiment, but the data is not presented here. They are also an important consideration in the above scenarios, especially given that screenings can be exacerbated where crown rot infection is present in some varieties.

This experiment also demonstrates the effect that other soil-borne pathogens can have on varieties' performance. In this case, the root lesion nematode, *Pratylenchus thornei* (*Pt*), severely compromised the performance of LRPB Lincoln$^{\phi}$, a variety known to be intolerant of and susceptible to *Pt*. Therefore, when making varietal selection decisions, it is important to select varieties with resistance or tolerance against the target diseases, but also to balance the risk associated with other potential pathogens in the system. PreDicta B offers a useful service to identify and quantify the risks associated with measured levels of inoculum of soil-borne pathogens, such as crown rot and *Pt*, in the cropping system.

Finally, it should be emphasised that variety selection is not the sole solution to crown rot. Even though varieties in this experiment demonstrated improved levels of resistance (Sunguard⦹) or tolerance (Suntop⦹ and Sunguard⦹), which improved their yield performance where crown rot infection was present, significant yield losses still occurred compared with when no crown rot inoculum was applied. Under the highest disease pressure, Suntop⦹ still had a 17% (0.7 t/ha) yield loss when compared with the no applied inoculum treatment, while Sunguard⦹ lost 12% (0.5 t/ha). An integrated approach to managing crown rot is still required to minimise losses from this disease, with selecting varieties with improved tolerance and resistance only one component of an integrated disease management system.

References

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