Fusarium crown rot of wheat - impact on plant available soil water usage

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Abstract

Expression of crown rot, caused by *Fusarium pseudograminearum*, is related to moisture and or evaporative stress during grain filling. The impact of the disease on plant soil water use is however, not well understood so we investigated it in the durum variety Caparoi at Walgett in 2012 and both Garah and Rowena in 2013. Neutron probe access tubes were installed in replicated inoculated and uninoculated plots to 1.8 m in each season. Soil moisture was measured in depth intervals at GS30, GS39, GS61, GS80 and GS92. Stress occurred relatively late at Walgett in 2012 due in part to a full starting moisture profile and average early season rainfall and temperatures. Stress occurred earlier at both sites in 2013 with infection impacting on soil water use from GS39 onwards. Crown rot infection prevented extraction of a total of 24 mm of PAW at Garah and 49 mm of PAW at Rowena by harvest. Crown rot infection reduced yield from 3.78 t/ha down to 3.11 t/ha (17.8% yield loss) at Walgett in 2012 with screenings increasing from 6.4% up to 13.2%. At Garah in 2013, crown rot reduced yield by 55.3% (2.20 t/ha down to 0.98 t/ha) with hectolitre weight decreasing from 82.6 kg/hL to 75.5 kg/hL. At Rowena in 2013, crown rot reduced yield by 64.3% (3.32 t/ha down to 1.18 t/ha) with screenings rising from 6.6% up to 19.5%. Crown rot restricts the plants ability to extract PAW which significantly impacts on yield and grain quality.

Key words

Plant available water (PAW), durum, crown rot, yield, grain quality.

Introduction

Crown rot, caused predominantly by the fungus *Fusarium pseudograminearum (Fp)*, is considered the most important disease of durum wheat (*Triticum turgidum*) in the northern grains region of Australia (Kneipp 2008), and is also a major constraint to both bread wheat and barley production. Yield losses attributed to crown rot can exceed 60% in susceptible crops such as durum wheat particularly if moisture stress occurs during grain filling (Daniel and Simpfendorfer 2008). Crown rot infection is characterised by a honey-brown discolouration at the base of infected tillers. It is believed to be initiated by moisture stress and results in the proliferation of hyphal growth in the base of infected tillers, restricting water movement through the plant. Yield loss is related to the expression of 'whiteheads' during flowering and grain fill, these prematurely ripened spikes contain either no grain or shrivelled grain depending on the timing of stress relative to crop development. This study investigated the effect of crown rot infection on soil water use in the durum cultivar (*cv*.) Caparoi and its impact on yield and grain quality parameters.

Method

Trials were conducted at a total of three sites in northern NSW over two years, these included Walgett in 2012, and Garah and Rowena in 2013. All trials were replicated, and had uninoculated versus inoculated (2 g inoculum/m row) treatments at sowing using sterilised durum grain colonised by five isolates of *Fp* as described by Dodman and Wildermuth (1987). The trial included a bread wheat (*cv.* Spitfire), a durum (*cv.* Caparoi) and a barley variety (*cv.* Commander), planted at 80 or 160 plants/m^2 across three row spacing's of 300, 400 and 500 mm. Neutron probe access tubes were installed in all replicated inoculated and uninoculated plots to 1.8 m in each season. Soil moisture was measured in 0-30, 30-60, 60-90, 90-120 and 120-150 cm depth intervals at stem elongation (~GS30), flag leaf fully emerged (~GS39), flowering (~GS61), grain filling (~GS80) and physiological maturity (~GS92). The upper and lower soil water limits were characterised at each location through a 'wet-up' and 'rain exclusion' site adjacent to the trial area. This data was used to determine the Plant Available Water (PAW) at incremental depths down the soil profile for each plot at the different growth stages. Only the total average soil water usage, yield and grain quality parameters for the durum variety Caparoi with plus or minus added *Fp* are presented in this paper to simplify interpretation. The trial data was analysed as a regular grid spatial mixed model in Genstat 17th edition.

Results

In 2012 at Walgett, due to a good starting soil moisture profile, average March to September rainfall, and generally average to below average in crop monthly maximum temperatures, moisture stress occurred relatively late in the season. Due to the late onset of moisture stress, there was no significant difference in water extraction in terms of PAW remaining in the profile of infected versus uninfected durum plots averaged across all treatments (Figure 2a). The presence of crown rot infection did not cause a significant *(P*<0.05*)* yield loss in barley and only a slight reduction of ~3.7% for bread wheat, when averaged across all treatments (data not shown). In contrast, the durum *cv.* Caparoi experienced a yield loss of 17.8% in the presence of *Fp* infection with yield decreasing from 3.78 t/ha to 3.11 t/ha (Figure 1a). Importantly, screenings (grain below the 2.0 mm screen) increased from 6.4% to 13.2% (Table 1), which would have resulted in a downgrading from *ADR3* to Feed grade and therefore both a yield and grain quality penalty was associated with crown rot infection even in a season with relatively moderate and late season moisture/temperature stress.

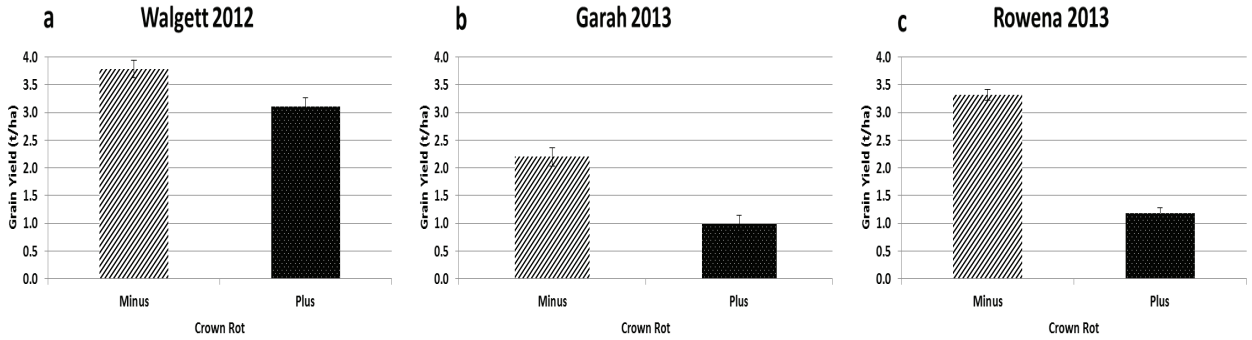

Figure 1. Grain yield (t/ha) for the durum wheat *cv.* Caparoi plus and minus *Fp* infection, average across row spacing and plant populations at Walgett in 2012 (a), Garah in 2013 (b), and Rowena (c) in 2013. Bars represent lsd (*P*=0.05).

In contrast to the 2012 Walgett trial, moisture stress occurred in early August (~GS39) at both Garah (Figure 2b) and Rowena (Figure 2c) in 2013. Monthly rainfall at Garah and Rowena was below average in July, August and October 2013 with the mean maximum temperatures for July to October above average and or equivalent to the long-term highest mean monthly maximum temperatures. The difference in water extraction at Garah in terms of PAW remaining in the soil profile of *Fp* infected versus uninoculated plots was 10.3 mm at GS39 increasing to 24 mm at physiological maturity ~GS92 (Figure 2b). At Rowena the difference in unextracted PAW between plus and minus *Fp* infected plots was 23 mm at GS39, increasing to 49 mm at physiological maturity. These results demonstrate the potential for crown rot infection to restrict the ability of crops to extract PAW, which has a significant impact on grain yield and quality.

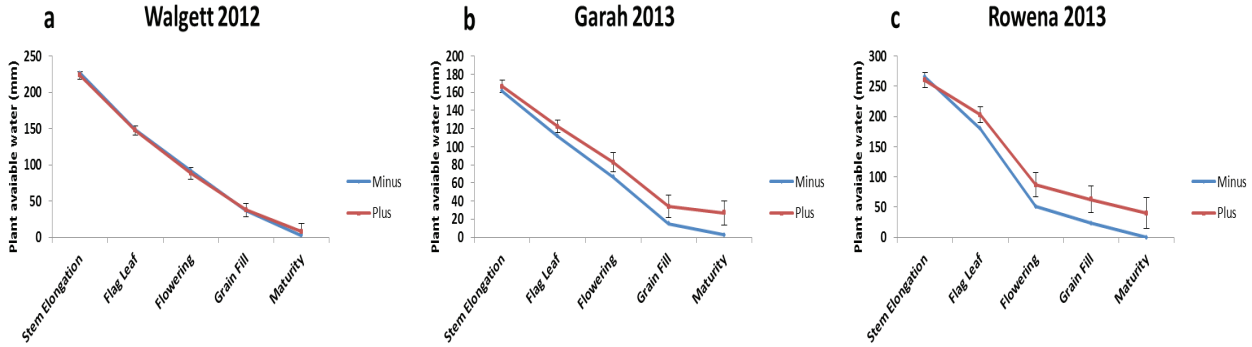

Figure 2. Impact of crown rot (plus and minus *Fp* infection) on soil water use of the durum wheat *cv.* Caparoi (0-150 cm) - Walgett 2012 (a), Garah 2013 (b), Rowena 2013 (c). Bars represent lsd (*P*=0.05).

Crown rot infection reduced yield by 55.3% (2.20 t/ha down to 0.98 t/ha) at Garah, and by 64.3% (3.32 t/ha down to 1.18 t/ha) at Rowena in 2013 (Figure 1b and c). Apart from grain yield, crown rot also impacted on grain quality parameters. Test weights at Garah decreased by 7.11 kg/hL, from 82.61 for uninfected plots to 75.54 kg/hL in *Fp* infected plots (Table 1). Similarly, screenings increased from 6.62% to 19.54% for *Fp*

infected plots at Rowena with Thousand Grain Weight (TWG) also decreasing in the presence of *Fp* infection (Table 1). It was also noted that grain protein concentration decreased at both Garah and Rowena in *Fp* infected treatments indicating that crown rot infection also appears to impact on the extraction, translocation and/or redistribution of nitrogen (N) within the plant.

Table 1. Grain quality parameters measured at each location for the durum *cv.* Caparoi plus and minus *Fp* infection.

Location	Grain Quality	Minus	Plus	lsd (*P*=0.05)
Walgett 2012	Protein (%)	11.76	12.65	0.27
	Screening (%)	6.36	13.21	0.16
	Test weight (kg/hL)	83.25	78.62	0.48
	TGW (g)	32.77	27.49	0.76
Garah 2013	Protein (%)	13.86	13.55	0.23
	Test weight (kg/hL)	82.61	75.54	1.13
Rowena 2013	Protein (%)	14.11	12.81	0.19
	Screening (%)	6.62	19.54	1.23
	TGW (g)	28.76	23.66	1.11

Conclusions

Yield loss associated with crown rot infection, is largely related to the expression of whiteheads, which is influenced by moisture and/or temperature stress during flowering and grain filling (Chakraborty *et al.* 2006). Crown rot infection was shown to restrict the plants ability to extract PAW, its impact on grain yield and quality, being dependant on the timing of stress relative to crop development. Results showed that even with only relatively moderate late seasonal moisture/temperature stress, such as experienced at Walgett in 2012, that the durum *cv.* Caparoi still experienced a yield loss of 17.8% in the presence of *Fp* infection, with screening levels also increasing from 6.36% to 13.21%. At Garah and Rowena, with stress occurring earlier in the season from GS39 onwards the presence of *Fp* infection resulted in a significant decrease in the extraction of PAW. This resulted in significant reductions in both yield and grain quality. Yield decreased by 55.3% at Garah and by 64.3% at Rowena, grain quality parameters (screenings/test weight) were also impacted, resulting in quality downgrades. These results reinforce the susceptibility of durum to crown rot infection and highlight the need to avoid planting, where there is an increased potential risk of infection and or increased likelihood of early onset of moisture stress particularly during anthesis and grain fill.

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