Effect of previous crops on crown rot infection and yield of wheat

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Abstract

The effect of previous crops on the incidence and severity of crown rot (Fusarium pseudograminearum) and yield of wheat was investigated in field studies in the Wimmera, Victoria and in northern NSW. The experiments sought evidence for enhanced suppression of crown rot following Brassica break crops compared to other non-host rotation crops as has been previously demonstrated for Take-all. Yield was lower after cereals than after broadleaf break crops and was higher after brassicas than after chickpea. In the crown rot susceptible durum wheat, the yield response to previous crops was closely associated with the levels of crown rot infection. In the tolerant bread wheat, the response to previous crops was similar to that of durum wheat despite lower disease levels and a weaker association with some of the disease measurements. No other explanation for the impacts of previous crops was obvious. The results indicate that Brassica break crops may be more effective than chickpeas in reducing crown rot infection of following crops and that tolerant wheat varieties can suffer yield penalties in the absence of visible symptoms such as white-heads.

Key Words

biofumigation, rotation, *Brassica*, canola, disease, *Fusarium*

Introduction

Crown rot of wheat caused by the pathogen *Fusarium pseudograminearum* (*Fp*) is a serious disease of cereals causing losses of up to $56Mpa in Australia (1). The prevalence of the disease has increased in recent years due to continuous cropping of wheat, the move towards conservation cropping and increased area of durum wheats that are highly susceptible to the pathogen. Despite the availability of some tolerant varieties, crown rot continues to cause significant yield loss. At present the key strategies for management of crown rot are to control grass hosts prior to cropping, rotate susceptible cereals with non-host break crops, burn infected stubble and to grow tolerant wheat varieties (2).

The area of canola (*Brassica napus*) expanded rapidly in southern Australia during the 1990's in part due to the significant break crop benefits it provides in reducing the level of root diseases in following wheat crops. Canola-quality Indian mustard (*B. juncea*) is also nearing release as a break crop for drier areas. Recent studies on take-all suggest that canola can reduce inoculum in soil to a greater extent than other non-host crops due to biocides (isothiocyanates - ITCs) released from decaying root residues in a process termed "biofumigation". Under certain circumstances this has led to reduced disease development and higher yield in subsequent wheat crops (3). *Fp* is also sensitive to ITCs (4), however there have been no field studies investigating the potential for enhanced suppression of crown rot as a result of biofumigation by *Brassica* break crops. The fact that inoculum carried on above ground stubble residues can initiate infection in a following cereal crop raises some questions about the effectiveness of soil-released ITCs in reducing the disease. However the longer survival of *Fp* inoculum in soil due to its greater saprophytic ability compared to take-all may make it a better potential target for the increased suppression offered by biofumigation. We conducted a series of 3-year field experiments to investigate the impact of previous crops on the levels of *Fp* inoculum, the incidence, severity and development of disease and yield of a following wheat crop.

Methods

The study included three 3-year crop sequence studies conducted at Longerenong in the Wimmera area of Victoria (1998 - 2000), and at Cryon (1997-1999) and Tamworth (1999 – 2001) in northern NSW. Each trial consisted of three phases: a first year to develop or locate sites with high and uniform levels of *Fp* inoculum, a second year in which a range of crops including host and non-host crops were included (Table 1), and a third year in which *Fp*-tolerant and sensitive wheat varieties were sown. These design features, including use of non-brassica break crops and brassicas differing in root glucosinolate levels (the ITC pre-cursors) in the second year, were used to provide evidence for enhanced suppression of crown rot due to biofumigation by *Brassica* break crops. All treatments at all sites were replicated four times. Plot sizes were 12 x 2, 20 x 4 and 20 x 2 m at Longerenong, Cryon and Tamworth respectively. The high inoculum site at Cryon was located after high incidence of crown rot in the previous year, while at Longerenong and Tamworth a susceptible durum wheat crop was sown with *Fp* inoculated seed. High and uniform levels of infection were achieved in all cases. Break crops were sown and managed in the second year using recommended district practice and with sufficient fertiliser to avoid nutrient deficiency limiting growth. In the third year, during the wheat phase, a range of disease assessments were made including pre-sowing *Fp* DNA levels, visual root disease assessments and colony isolations from roots and sub-crown internodes (SCI) at tillering, white-head counts and crown infection assessments at harvest. Biomass at tillering, anthesis and harvest, grain yield, yield components and grain protein were measured in the wheat using standard agronomic techniques as described elsewhere (3). Pre-sowing soil water and Min-N were also measured to 1.6m prior to the final wheat crop at Tamworth in 2001.

Table 1. Previous crop treatments used in the second year of the experiments.

Treatment	Description	Longerenong	Cryon	Tamworth
Wheat (durum)	Host (Susceptible)	Yallaroi	Wollaroi	Wollaroi
Wheat (bread)	Host (Susceptible)	-	Janz, Suneca	-
Wheat (bread)	Host (Tolerant)		Mulgara	Sunco, Mulgara
Barley	Host (Susceptible)	-	Skiff	Grimmett
Chickpea	Non-host	-	Gully	Gully
Linseed	Non-host	Glenelg	-	-
Canola 1	Low root GSL	Monty	Monty	Monty
Canola 2	Mod root GSL	-	Oscar	Oscar
Canola 3	High root GSL	Dunkeld	Karoo	Mystic
Mustard	Two root GSLs	-	JL2	99Y-1-1

Results

At Horsham, despite high levels of crown rot observed in the durum treatments in 1999 the levels detected at the site in 2000 were too low to detect significant treatment differences, even in the continuous durum plots. In addition, white-head development and yield measurements were confounded by a wet spring and a frost that significantly influenced grain development (data not shown). Interestingly, despite the generally low disease incidence in 2000 and the lack of statistical significance between treatments for individual disease parameters, the high GSL canola treatment (Dunkeld) consistently had the lowest disease score in all of the early assessments made (glasshouse soil bioassay, visual root assessment, colonies isolated from crown roots and SCI).

At Cryon and Tamworth significant levels of disease and the absence of other confounding factors in the final wheat year allowed an assessment of the impact of previous crop treatments on crown rot development and yield of wheat. At Cryon there was a significant effect of previous crop on the incidence of crown rot infection of wheat in the final year (Table 2). Infection was highest in the susceptible wheat variety following host crops, and lowest following non-host crops. There was slightly lower disease following canola than the high glucosinolate mustard or the chickpea treatments. The grain yield of the susceptible wheat variety was closely associated with the level of infection in the tillers ($r^2 = 0.6$) indicating that break-crops are effective in reducing the incidence of crown rot. There was not a good association between grain yield in the tolerant variety and the level of crown rot infection. Yield was highest following canola but did not differ between the 3 varieties that are pooled in the analysis. There was no difference in yield following the tolerant and susceptible wheat varieties although yield after barley was lower. There was no obvious association between the yield of previous crops (and likely water and N use) and yield of following wheat in 1999. Wheat after cereals had lower biomass throughout the season, lower HI, smaller grains and lower protein providing no evidence that the lower yield was associated with “haying-off” but more likely the result of disease.

Table 2. Effect of previous crop species (1998) on yield and crown rot infection in a susceptible durum wheat (Yallaroi) and tolerant bread wheat (Mulgara) at Cryon in 1999.

Previous Crop 1998	Yield(t/ha)	Yield (t/ha)		Crown Rot (% infected plants)	
		Yallaroi	Mulgara	Yallaroi	Mulgara
Canola (3 var.)	1.33	3.10	2.93	11	<1
Mustard	0.92	2.69	2.70	17	4
Chickpea	0.77	2.54	2.67	16	5
Wheat (Tol)	1.91	2.07	2.01	27	4
Wheat (Susc.)	1.90	2.04	2.14	21	3
Barley	3.78	1.88	1.99	51	10
LSD (P=0.05)					
Previous crop		0.15		4	
Variety		ns		5	
Previous crop x Variety		ns		6	

At Tamworth the overall yields were higher than those at Cryon and there was a significant difference in yield between the two wheat varieties, however there were similarities in the general response of wheat to previous crops (Table 3). Yield was highest after mustard, intermediate after canola and chickpea and lowest after the cereals, and in general, these yield trends were related to the level of crown rot measured at harvest in both wheat varieties. Interestingly wheat yielded more after mustard compared to canola, and after susceptible wheat varieties compared to tolerant varieties. This could not be explained by differences in the level of crown rot assessed on these treatments at harvest. The trends in yield were expressed early as differences in biomass at tillering that persisted at anthesis and final harvest. The HI and seed size of wheat after canola and chickpea were similar and higher than those after cereals. Measurements of soil water and N at sowing showed relatively small differences between treatments that did not relate to crop performance.

Table 3. Effect of previous crop species (2000) on yield and crown rot infection in a susceptible durum wheat (Yallaroi) and tolerant bread wheat (Sunco) at Tamworth 2001.

Previous Crop 2000	Yield(t/ha)	Yield (t/ha) Yallaroi	Yield (t/ha) Sunco	Crown Rot (% infected plants) Yallaroi	Crown Rot (% infected plants) Sunco
Mustard	1.71	5.85	4.87	41	29
Canola (3 var.)	2.14	5.59	4.59	44	32
Chickpea	1.76	5.43	4.72	62	33
Wheat (Tol)	3.29	4.74	3.79	73	64
Wheat (Susc.)	3.26	5.17	4.04	70	74
Barley	3.42	5.06	4.07	81	47
LSD (P=0.05)					
Previous crop		0.10		7	
Variety		0.10		7	
Rotation x Variety		ns		ns	

At Tamworth several other assessments of disease were made and these are shown in Table 4. The levels of *Fp* DNA in the soil prior to sowing were lower in break crops than cereals, higher for wheat than barley and higher following susceptible wheat varieties than tolerant wheat varieties. The incidence of crowns infected by *Fp* at tillering revealed lower levels after brassicas than chickpeas and highest levels in cereals, with lower overall levels in the tolerant variety. These trends were generally reflected in white-head counts in the durum although, as expected, white-head incidence was very low in the tolerant variety.

Table 4. Effect of previous crops (2000) on *Fusarium* inoculum levels and disease development in a susceptible (Yallaroi) and tolerant (Sunco) wheat variety at Tamworth in 2001.

Previous Crop 2000	DNA(pg/g) (Sowing)	Crown Rot (% infected plants) Yallaroi	Crown Rot (% infected plants) Sunco	Whiteheads (%) Yallaroi	Whiteheads (%) Sun
Mustard	251	44	16	6	<1
Canola (3 var.)	284	44	28	8	<1
Chickpea	272	64	36	10	<1
Wheat (Tol)	1784	76	60	13	1
Wheat (Susc.)	2763	72	60	11	4
Barley	1153	60	56	6	1
LSD (P=0.05)					
Previous crop	190	10		1	
Variety	-	10		1	
Rotation x Variety	-	ns		2	

Conclusions

The results of these experiments demonstrate that provided adequate nutrition and good management *Brassica* crops provide an effective break crop option for reducing crown-rot infection in following cereals, and were generally more effective than chickpeas. The small but significant advantage of the brassicas over chickpeas was not related to N, water or other diseases but appears to be related to reduced levels of crown rot following the brassicas. There was no consistent advantage of high root GSL brassicas over low GSL varieties although in the susceptible durum wheat, disease was always lowest after a high GSL type, but varied for the intermediate GSL canola variety and mustard (data not shown). This inconsistency is not surprising given that cultivars changed between experiments (Table 1). Although the evidence for biofumigation in these experiments remains inconclusive, the results of these field trials would support further investigation as to the reason for reduced disease and higher yield after the brassicas compared with chickpea. One possibility is more rapid rate of wheat stubble breakdown under dense canola canopies compared with the more open chickpea canopies leading to reduced inoculum carry-over. Other soil microbial changes associated with different break crop species may also influence *Fp* survival.

The results also provide other interesting insights into the use of tolerant varieties for managing crown rot. The fact that “tolerant” varieties appear to be infected by crown rot and have similar yield responses to “susceptible” varieties despite the lack of severe symptom development (white-heads) has been reported elsewhere (2), and indicates that tolerance alone is an insufficient strategy for disease control. It is also interesting that a preceding tolerant wheat crop resulted in similar or greater disease levels developing in the subsequent wheat crop as a preceding susceptible wheat crop, indicating that tolerant cereals are not effective at decreasing levels of crown rot inoculum.

References

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