The effect of crop rotations on the incidence of crown rot in wheat

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Abstract

The crown rot fungus, *Fusarium pseudograminearum*, is a stubble-borne pathogen. Crop rotations are commonly used by farmers to manage the crown rot disease and inoculum survival. However, it is not clear if a preceding rotation crop of wheat, Indian mustard, canola or chickpea reduces the inoculum level and incidence of crown rot in wheat in northern NSW. Four rotation crop treatments with four replicates were established in a greenhouse, inoculated with crown rot fungus and grown for two months. Three wheat genotypes with differing levels of susceptibility were then sown into the same pots with the respective rotation crop residues. The severity of the crown rot disease was scored on six occasions throughout the growing season and the crop yield assessed. In addition, twenty field plots were sown to four rotation crops and a fallow with four replicates at Narrabri in northern NSW. The level of crown rot inoculum was measured at the beginning of the season, after sowing and again after 5 months of wheat growth. Genetic differences in tolerance to crown rot were observed among the three wheat genotypes. In the field, the canola, chickpea and Indian mustard rotation crops reduced the amount of stubble and crown rot inoculum significantly compared with the fallow treatment. *Brassica* and legume crop species may provide an effective crop rotation for the breakdown of crown rot inoculum throughout the growing season.

Key words

Crown rot, crop rotation, fallow, straw decomposition

Introduction

The crown rot disease, caused by the fungal pathogen *Fusarium pseudograminearum*, is a stubble-borne pathogen which detrimentally impacts wheat production in Australia and many other countries (Backhouse *et al*. 2004).Conservation agricultural systems if based on wheat monocultures facilitate the spread of the crown rot disease through no-till farming and the maintenance of ground cover, which often includes the retention of stubble from previous crops. Crown rot restricts wheat production in many areas and can cause losses of up to A$56 million per year in Australia (Kirkegaard *et al*. 2004). The crown rot inoculum can survive for up to two years on infected stubble (Chakraborty *et al*. 2006). This disease has the potential to reduce grain yields by up to 100%, depending on the environmental conditions and the cereal cultivar. As a result, crop rotations are the most common management tool used to combat the crown rot disease, as there are no fully resistant wheat varieties and no chemical control methods currently available (Chakraborty *et al*. 2006). However, whilst the impact of crown rot on cereal crops is widely documented, there is limited research on the effect of the preceding crop rotation on the incidence of crown rot in wheat and the breakdown of the crown rot inoculum. This research tests the hypothesis that the inoculum levels of crown rot will be reduced following chickpea, canola and Indian mustard rotation crops.

Materials and methods

Experiment 1 (Cobbitty)

Experiment 1 was a greenhouse pot experiment arranged in a factorial design with eight replicates conducted in a microclimate room at the University of Sydney Plant Breeding Institute at Cobbitty, NSW. Four rotation crops (Batavia and Suntop wheat, Indian mustard and Desi chickpea) were first planted in the pots followed by two bread wheat varieties and one durum variety: Bellaroi (a very susceptible durum cultivar), Batavia (susceptible bread wheat) and Suntop (moderately resistant bread wheat). The rotation crops were planted on 16 April 2014 and inoculated with crown rot two weeks after planting. Discs (5 mm diameter) of fungal mycelium were cut out of fungal cultures grown on potato dextrose agar and placed in the middle of eight seedlings in each pot, covered with wheat bran and watered. The rotation crops were left to grow for six weeks and harvested, leaving 3 cm of stubble. The following wheat crops were planted into the residual stubble on 19 June 2014. The plants in each pot were scoredsix times at fortnightly intervals using the 0 to

4 crown rot scoring system based on stem basal browning (Table 1). Heads were harvested on 3 September 2014.

Table 1. Description of the different crown rot scores used in experiment 1.

Score	Description
0	No lesions produced by the crown rot infection
1	First internode is partially lesioned
2	First internode is fully lesioned and there are partial or full lesions on the second internode
3	Partial or full lesions are present on more than two internodes
4	White head produced as a result of the crown rot infection

Experiment 2 (Narrabri)

Experiment 2 was a field experiment conducted on a field with high levels of crown rot inoculum (block D1B) at the I.A. Watson International Grains Research Centre, located 10 km north of Narrabri (30.3167oS, 149.7667oE and 212 m elevation). In 2013 this block was sown to a range of wheat varieties to encourage the build-up of crown rot inoculum. On 12 May2014, twenty plots (6 m x 2 m) were sown to Suntop wheat, Indian mustard, canola, chickpea or left fallow with four replicates in a randomised complete block layout. Narrabri has a subtropical semi-arid climate, with a mean average maximum temperature of 34oC and an average minimum temperature of 4oC, a summer dominant rainfall pattern with an average annual rainfall of 659 mm. The soil type in block D1B is a self-mulching, grey Vertosol. Samples of stubble and soil were collected twice; on 26 June and 1 September 2014. These samples were assessed using the PreDicta B soil test to detect soil borne pathogens using DNA analysis to give an indication of the amount of crown rot inoculum in the field. Five random samples were taken from each plot and sent to the South Australian Research and Development Institute (SARDI) for analysis. Stubble was sampled using a square metre quadrat in each plot, dried in a dehydrator (80°C for 12 h) and weighed. Eleven humidity and temperature data loggers were inserted into ten of the plots to measure relative humidity and temperature from 12 September 2014. Analyses of variance (ANOVA) and repeated measures analyses were conducted using Genstat 16th Edition.

Results and discussion

Experiment 1 (Cobbitty)

Bellaroi produced the highest crown rot scores with an average score of 3.6 at 94 days after planting (Fig. 1). Suntop produced the lowest average score of 2.5, while Batavia was rated moderately susceptible with an average score of 2.9(Fig. 1).The percentage of infected plants increased dramatically over the first three observations, reaching 100% infection across all treatments at the fourth observation (data not presented). This is consistent with the literature showing the relative susceptibility of Bellaroi durum and tolerance of Suntop to crown rot (Al-Fahdawi et al. 2014).

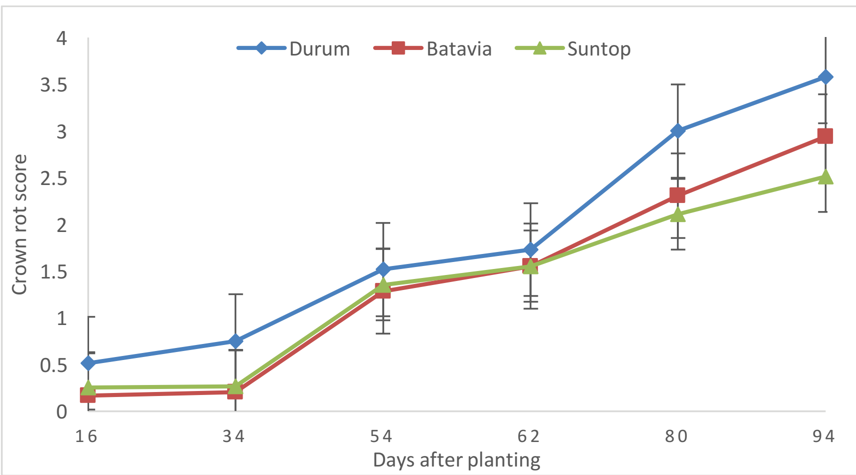

Fig. 1. Effect of wheat variety (Bellaroi, Batavia and Suntop) on the crown rot disease score (0-4). The LSD (p=0.05) were 0.28 at 80, and 0.23 at 94 days after planting, respectively. Error bars represent +/- one standard error of the mean.

The rotation crops produced no significant interaction with the following wheat genotype(*P=0.586*) under crown rot infection (data not presented).The inoculation applied to each pot fostered the growth of the *Fusarium pseudograminearum* and these high levels of inoculum may not have been broken down by the rotation crops within the 6 week period prior to the wheat sowing. This method could be improved by the removal of the wheat bran which was used to foster the growth of the fungus and contains the majority of the crown rot inoculum.

Rotation crops had a significant effect on the breakdown of crown rot inoculum, compared with fallow conditions in experiment 2 (Fig. 2). The percentage stubble reduction ($P<0.001$, 31%) and the percentage PreDicta B reduction ($P=0.043$, 36%) was greatest under the canola treatments and lowest under fallow (Fig. 2). The three rotation crops (canola, chickpea and Indian mustard) decreased the amount of stubble and crown rot inoculum compared with the fallow treatment.

Fig. 2. Effect of crop rotations (canola, chickpea, Indian mustard, Suntop and fallow) on the reduction of stubble levels (dotted) and PreDicta B (hashed) values. LSD (p=0.05) were 2.6 for stubble reduction and 15.6 for PreDicta B reduction. Error bars represent +/- one standard error of the mean.

The high relative humidity and stable temperatures (data not presented) under the various rotation crops possibly helped establish a microclimate conducive to the breakdown of previous wheat stubble and crown rot inoculum; an observation supported by other studies (Kirkegaard *et al*. 2004; Evans *et al*. 2010). Models have been developed to demonstrate stubble decomposition and the effect of the environment on decomposition (Lakhesar *et al*. 2010; Backhouse 2014). Most of these models assume that inoculum breakdown can be represented as an exponential decay function and incorporate indices to account for moisture availability and temperature, or thermal time (degree-days) adjusted for rainfall (Lakhesar *et al*. 2010). However, these models only consider moisture that comes from rain or dew and do not consider soil moisture or the moisture content of stubble. Further refinement of these models will provide improved predictions through the incorporation of rainfall, crop biomass, temperature fluctuation, available moisture other than rainfall and dew and the severity of the crown rot infections (Lakhesar *et al*. 2010; Backhouse 2014).

Chickpea has the ability to fix nitrogen through a symbiotic relationship with rhizobium bacteria. However the ability of legume crop species to fix nitrogen may not aid the suppression of the crown rot disease. Previous studies showed that the increased soil nitrogen produced by chickpea can exacerbate the severity of crown rot in the following wheat crop (Kirkegaard *et al*. 2004; Chakraborty *et al*. 2006). Chickpea also produces malic acid in the leaves, although this is unlikely to restrict grain production as the majority of the leaves were removed when the rotation crops were harvested (Chakraborty *et al*. 2006). Canola and Indian mustard produce glucosinolates which potentially have biofumigation effects on the soil environment (Gimsing and Kirkegaard 2009; Bohnic *et al*. 2012).The glucosinolates released into the soil may restrict the growth and production of the following wheat crop when crop residues do not have sufficient time to break down. In field conditions, the canola or Indian mustard crop would be produced one year and the wheat crop produced in the second year. This would allow the crop residues and glucosinolates to break down to non-inhibitory levels. *Brassica* crop species, such as canola and Indian mustard, are not susceptible to the crown rot pathogen and are therefore ideal for breaking the disease cycle (Halkier and Gershenzon 2006).

Conclusions

This study showed that crop rotations can reduce the incidence of crown rot in field grown wheat. Rotation crops encouraged stubble breakdown more than fallow, which led to a reduction in the amount of crown rot inoculum. *Brassica* and legume crop species may provide an effective crop rotation for the breakdown of crown rot inoculum throughout the growing season.

Acknowledgement

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