Responsiveness of wheat and barley varieties to crown rot in southern NSW

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Key findings

- Winter cereal varieties differ in their levels of yield loss and responsiveness to crown rot and growers can use these rankings to improve production in the presence of this disease.
- Grain yield and responsiveness to crown rot appear strongly correlated in these experiments.
- Grain yield losses vary between seasons with up to a 25% reduction measured in southern NSW.

Introduction

Crown rot of winter cereals in southern New South Wales is caused by *Fusarium pseudograminearum* and *Fusarium culmorum*. This disease is known to cause large economic losses across Australia in winter cereal growing regions. The disease can persist in the stubble over many years, thus making its control in farming systems difficult and requiring a multifaceted approach. One way to avoid or minimise losses is to grow varieties that show higher levels of tolerance to the disease. However, tolerance is difficult to measure and may only provide marginal benefits. In this series of experiments, we have quantified the extent of yield loss displayed in a number of commonly grown winter cereal varieties in southern New South Wales across four years.

Tolerance to a disease can be defined as the ability of a variety to perform despite infection by disease. This is different to major gene resistance, which normally means that a variety is able to repel the infection of a pathogen and thus avoid disease. In the case of crown rot, tolerance in the field is difficult to distinguish from partial resistance. This is because accurate means of determining infection levels are labour intensive and expensive. None of the varieties included in these experiments are known to have major gene resistance, but do vary subtly in their susceptibility.

Methods

Nine experiments were conducted in southern New South Wales at Wagga Wagga and Cowra between 2011 and 2015. The experimental designs were fully randomised with four replicates per genotype and treatment. Sowing dates were delayed until the first week of June in all the years to maximise the opportunity for moisture stress during grain filling and expression of crown rot.

Inoculum was applied using two different methods. In the experiments conducted between 2011 and 2013, spores of *F. pseudograminearum* were sprayed directly onto the varieties' seed. In the experiments from 2014 to 2015, the inoculum was applied as sterile seed infected with the pathogen. Treatments consisted of a control where no inoculum was applied (minus_CR) and a disease treatment where inoculum was applied (plus_CR).

The following traits were measured on each plot; grain yield, grain protein, thousand grain weight, test weight and screenings. The across-sites analysis was conducted using mixed linear models in ASREML using the R package. The varieties' responsiveness was estimated using a paired comparison by multivariate analysis. A total of 27 entries (figures 3 and 4) were tested across the five years with 22 wheat (12 in 2011–2012, 16 in 2013, 13 in 2014–2015) and five barley varieties included in the years 2014–2015.

Results and discussion

The addition of crown rot inoculum reduced grain yield in six of the nine experiments conducted. The magnitude of the reduction in grain yield varied between experiments and ranged from 0–25% (Figure 1). Grain yield loss was higher in experiments conducted in the years 2011 and 2014 when spring rainfall was generally lower. This result is consistent with the findings from crown rot yield loss experiments conducted in other regions of Australia.

The importance of variety response to crown rot infection can be seen by examining the sources of variance in these experiments and how large the effects are in comparison with each other. Variety contributed a larger proportion of the variance than the interaction term variety by treatment (Figure 2). The size of this interaction term changes across the experiments and is not always significant where crown rot has reduced grain yield.

What we can say from this analysis, is that where crown rot is present, varieties do perform differently, but that within the varieties and environments tested, this effect was not consistent or large. Environmental conditions such as the amount and timing of spring rainfall heavily influences crown rot effects.

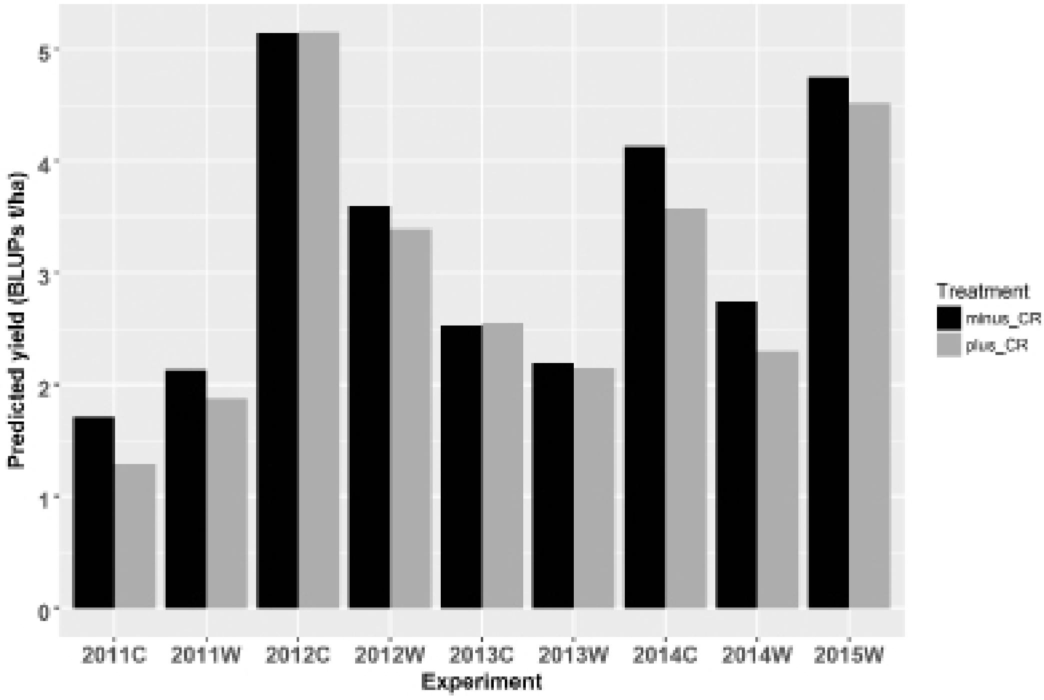

Figure 1. Predicted experiment mean grain yields of 22 wheat and five barley varieties grown at Wagga Wagga (W) and Cowra (C) in southern NSW between 2011 and 2015. The dark bars are the results for the control treatment (minus_CR) and the lighter bars are the results for the disease treatment (plus_CR).

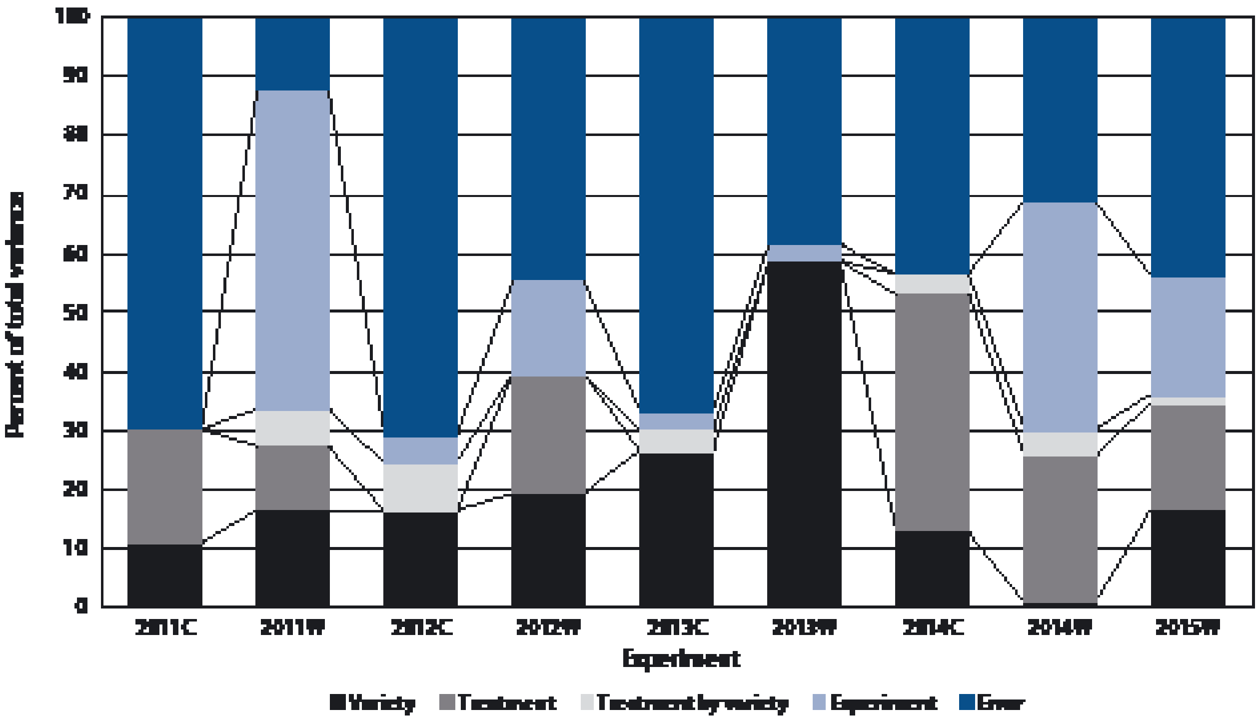

Figure 2. Variance components as a percentage of the total variance of grain yield for nine crown rot experiments grown at Wagga Wagga (W) and Cowra (C) in southern NSW between 2011 and 2015.

The grain yield response of individual varieties can first be examined by comparing them against each other in the presence of disease, compared with the absence of disease across all experiments (Figure 3). This comparison shows that there is a strong positive correlation between grain yield and grain yield in the presence of added crown rot. Barley varieties were higher yielding than the wheat varieties in these experiments in both presence and absence of crown rot infection. Growers could use this result to sow barley in paddocks where a known crown rot risk is high and non-host rotation crops are not an option.

Among the wheat varieties examined, Emu Rock[PBR] is clearly higher yielding than other varieties in both the presence and absence of crown rot infection. The next highest yielding varieties were Waagan[PBR] and LongReach Trojan[PBR]. The grain yield of some of the more popular varieties in southern NSW such as EGA Gregory[PBR], EGA Wedgetail[PBR], LongReach Spitfire[PBR] and LongReach Crusader[PBR] during 2011–2015 was lower in both the presence and absence of disease. This means grower profitability could have been improved over the past five years in paddocks that had high crown rot levels through better variety choice. This is an important finding considering a large portion of the cropping area of southern NSW is sown with a wheat-on-wheat rotation and has significant levels of crown rot inoculum present.

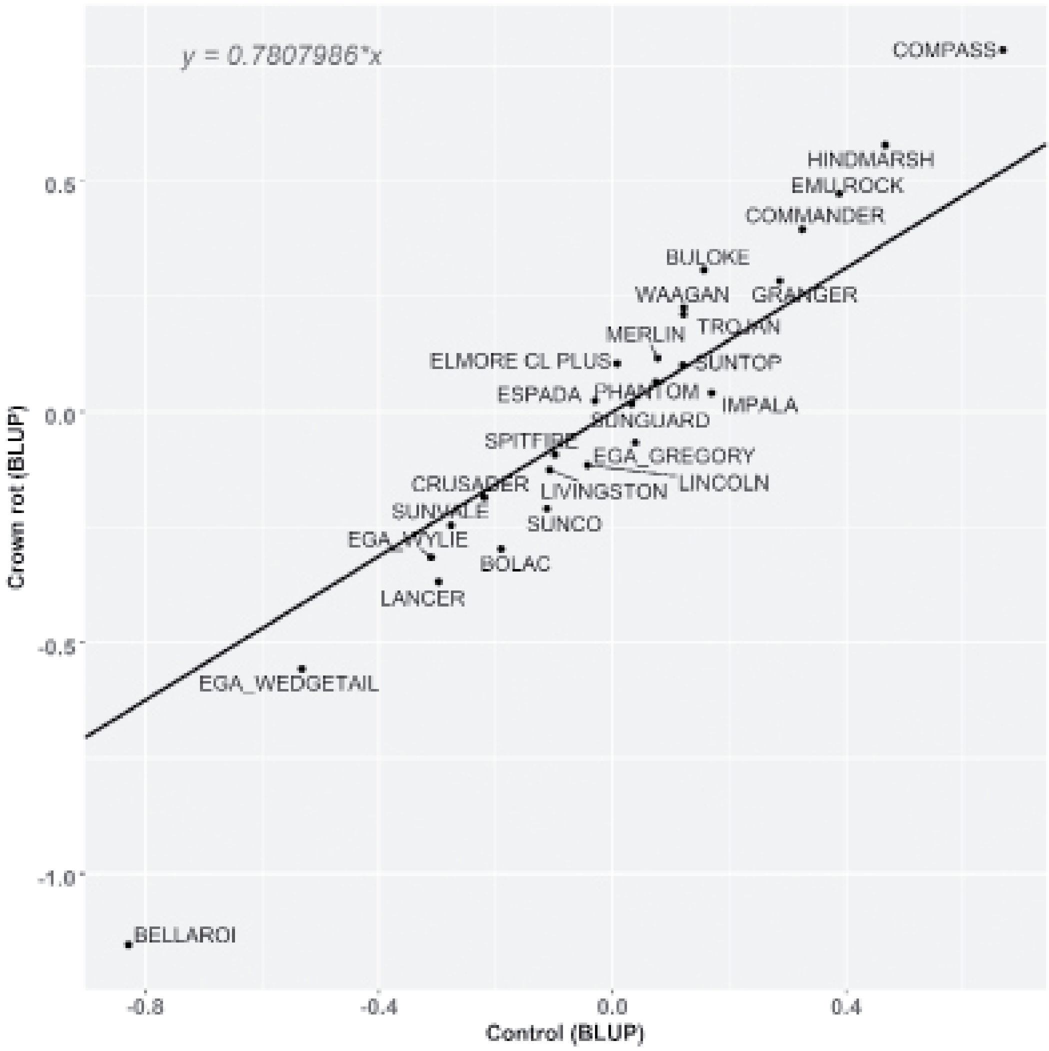

Figure 3. Grain yield BLUP of 22 wheat and five barley varieties in the presence and absence (control) of crown rot across nine experiments grown at Wagga Wagga and Cowra in southern NSW between 2011 and 2015.

Next we can look at the varieties' responsiveness to crown rot by removing the bias effect of overall grain yield performance. This measures how responsive a variety is to crown rot by calculating the distance above or below it from the regression line in Figure 3. By plotting the responsiveness value against grain yield in the absence of crown rot (Control BLUP), we can estimate if there are varieties that may not be high yielding, but have high levels of responsiveness where crown rot is present. For example, among the barley varieties, Buloke[PBR] has a higher level of responsiveness compared with Commander⁽ᵇ⁾, even though it was lower yielding in these experiments (Figure 4). For the wheats, Elmore CL PLUS⁽ᵇ⁾ is more responsive than LongReach Impala⁽ᵇ⁾, which can be seen more clearly in Figure 4. However, the ranking of the top varieties is relatively stable between the two methods of comparison.

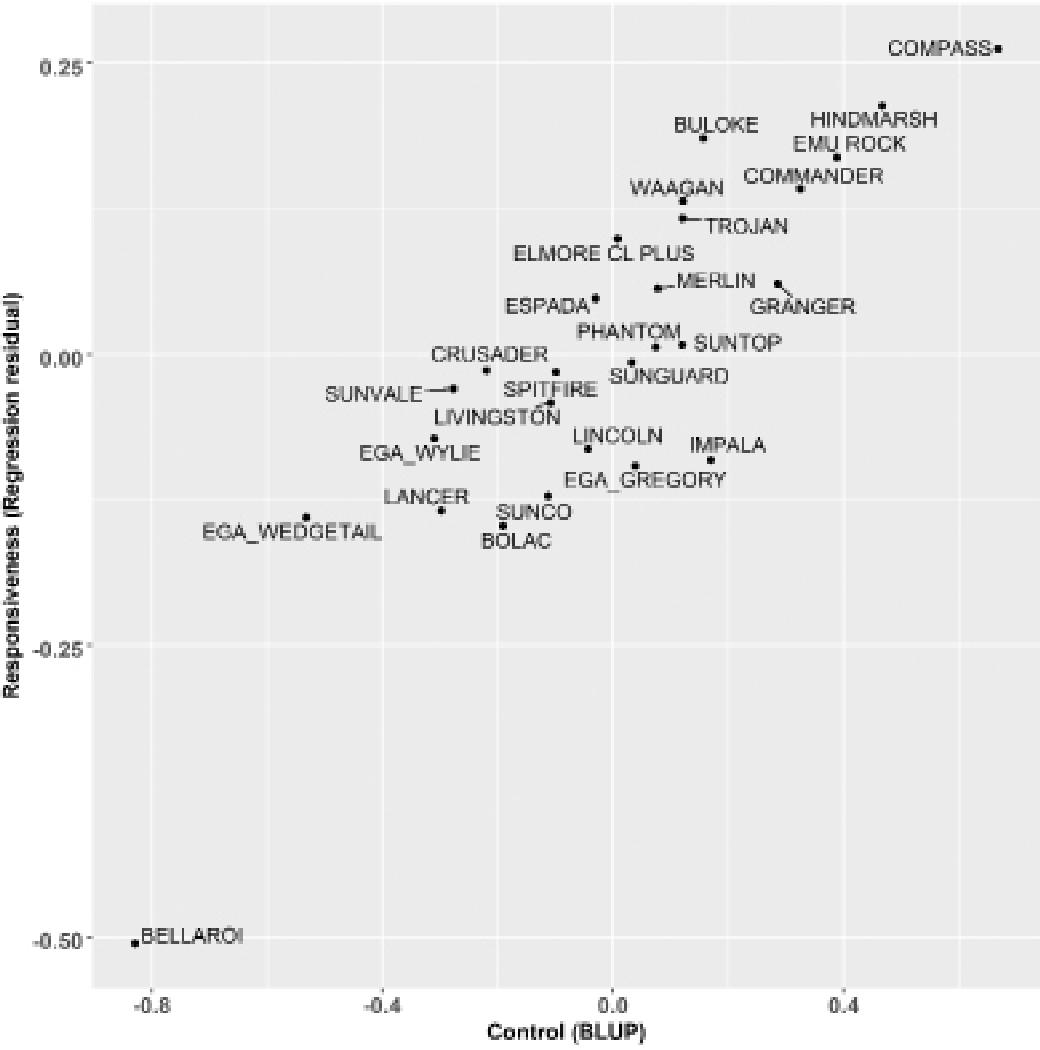

Figure 4. Responsiveness (Regression residual) and grain yield in the absence (control) of crown rot of wheat and barley varieties across nine experiments grown at Wagga Wagga and Cowra in southern NSW between 2011 and 2015. Varieties with responsiveness (regression residuals) of 0.00 and above have an increasingly positive responsiveness in the presence of crown rot inoculum.

There is an apparent strong correlation between the grain yield in the presence and absence of crown rot in southern NSW. One possible reason for this could be in the way varieties are developed through wide testing for grain yield across many sites and years, combined with a high incidence of crown rot within the farming system and in the experiments. This is likely to result in breeding material being regularly exposed to low to moderate levels of crown rot infection and selection of the highest yielding varieties will therefore remove the lower yielding lines in the presence of this disease. The genetic control of grain yield is under the influence of many genes and this is likely to be the case for responsiveness or tolerance to crown rot as well, which means that variety improvement through this approach is incremental and not simple. These experiments provide some evidence that there is a genetic basis to yield in the presence of this disease, or potential quantitative resistance, and that grain yield in crown rot managed experiments could be used as a cost effective measure of this trait in a genomic breeding strategy.

The effects of crown rot on quality traits have also been measured, but will not be discussed in detail in this paper. In summary, crown rot has a detrimental effect on grain quality. These effects were sometimes evident even when grain yield was not affected. For example, grain protein was reduced in six of the nine experiments in the presence of crown rot. Reductions in protein content ranged from 0–0.8%. This has obvious implications for growers' profitability in meeting grain specifications and through reduced nitrogen efficiency from applied nitrogen fertiliser.

Implications for growers

Winter cereal varieties in these experiments differ in their yield performance and responsiveness to crown rot infection. This can make a measurable difference to variety profitability when the disease is present. Growers choosing the highest yielding variety in their region of southern NSW are, in general terms, more likely to be choosing from more positively responsive material. Varieties we have identified with negative responsiveness such as EGA Wedgetail(b), should be sown in paddocks with lower crown rot risk to avoid yield loss. Equally, growers can select either barley or wheat varieties with a known higher yield in the presence of crown rot, to sow in cereal-on-cereal paddocks to maximise yield.

Acknowledgements

This experiment has been conducted under the 'National crown rot management program – Southern NSW component', DAN00175, 2014–18, with joint investment by GRDC and NSWDPI.

All technical components of conducting these experiments were carried out by Tony Goldthorpe, Brad Baxter and Michael McCaig (NSW DPI).