Wheat varieties differ in response to natural heat events during the early reproductive stage

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Key findings

» The most intense of three heat events averaged 35.5 °C and reduced grain numbers per spikelet by 21%.

» Significant genetic variation was observed for floret sterility induced by natural heat events. The variety Halberd was identified as most heat tolerant and Westonia as most sensitive.

» The results indicate a genetic variation that could be exploited to improve wheat crop resilience under heat stress.

Introduction

Substantial genetic variation has been demonstrated for wheat response to heat stress at post-flowering stages (Emebiri et al. 2015). However, relatively few studies have compared varieties exposed to stress at an early reproductive stage when the potential grain number is determined (Fischer 2011). Genetic variation for tolerance at this early reproductive stage is desirable, because it is the loss in grain number, rather than a reduction in grain size, that largely accounts for crop yield reduction when abiotic stress occurs (Dolferus et al. 2011). In studies under controlled-environment conditions, tolerance differences were observed between wheat varieties, but no field study has been reported.

This study determined whether genetic differences in tolerance can be identified in field-grown wheat exposed to natural heat events at the early reproductive stage of development.

Treatments

The experiment was conducted at the Wagga Wagga Agricultural Institute in the 2015 winter cropping season.

Eight wheat varieties ranging in maturity were grown under a birdcage (Figure 1) in single-row plots. Planting was repeated every two weeks from 20 June to 29 September using a randomised complete block design. The consecutive planting was to ensure tillers at the sensitive stage of gametogenesis were available to be tagged from each genotype at the time of a heat event. Each planting was independently watered using a dripper system to limit drought stress. A heat event was defined as a block of ≥2 days of maximum temperature >30 °C.

Immediately after each heat event, a minimum of 30 tillers per genotype with a 0–3 cm auricle interval length (the distance between the bases of the flag leaf and next leaf down) were tagged to represent tillers exposed to heat stress at the sensitive stage. For controls, a minimum of 15 tillers per genotype from the same plots with an average auricle interval length of >9 cm were also tagged to represent those that were past the sensitive stage.

There were three heat events during the experiment period during which tillers were tagged. The first occurred on 4–6 October with an average maximum temperature of 32.7 °C, the second on 15–16 October with an average maximum temperature of 31.6 °C and the third on 18–20 November with an average maximum temperature of 35.5 °C. At maturity, the tagged heads were harvested for floret fertility scoring (grains per spikelet in the basal two florets of each spikelet).

Figure 1. Floret fertility heat tolerance experiment under the birdcage.

Results

Data was obtained from scoring five spikes per genotype per heat event. Scoring the remaining tagged tillers is not yet complete.

The first two heat events had little or no impact on grain number per spikelet, but the damage from the third event, with a maximum temperature averaging 35.5 °C (Figure 2), was significant (P = 0.001) and reduced grain number per spikelet by 21%. Genotypes also differed significantly (P = 0.05) in their responses to this heat event for grain number per spikelet.

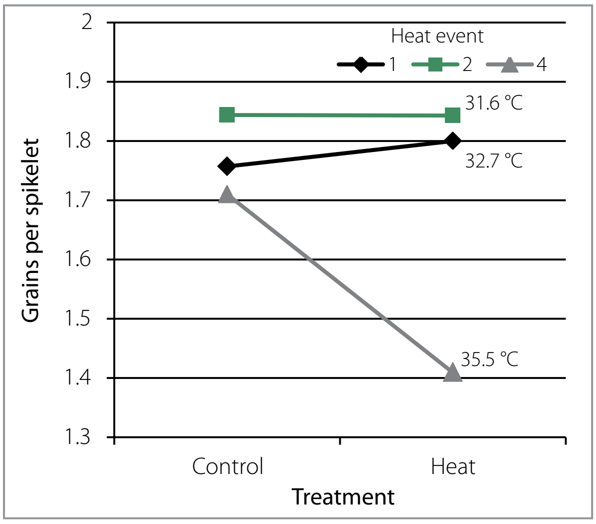

Figure 2. Changes in grain number per spikelet in wheat following exposure at the sensitive tiller stage (heat), or past the sensitive stage (control), to three natural heat events in a field experiment at Wagga Wagga, NSW during the 2015 season.

The wheat variety Halberd was most tolerant (Figure 3), showing virtually no reduction in grains per spikelet. By contrast, Westonia showed a 35.4% reduction in grains per spikelet, indicating it was sensitive to the natural heat event.

Summary

Confirmation of differences in tolerance between the varieties will require analysis of the complete tagged tiller set from the 2015 experiment and repeat experiments. If confirmed, this will be the first description of differences in wheat varietal responses to natural heat events at the early reproductive stage. This would indicate genetic variation that could be exploited to improve wheat crop resilience under heat stress.

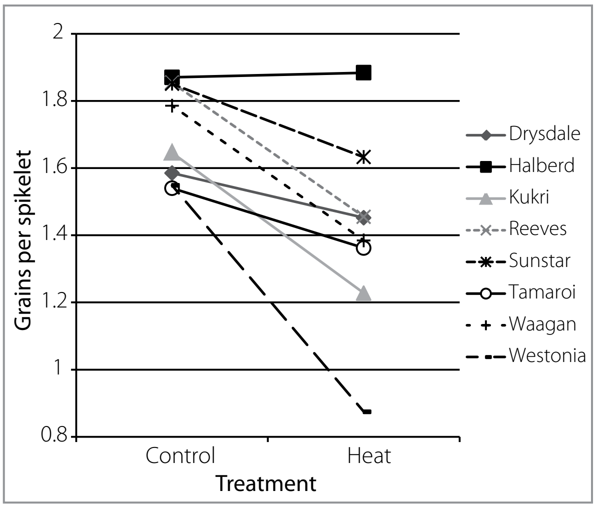

Figure 3. Floret fertility of wheat varieties exposed to a natural heat event at the sensitive tiller stage (heat), or past the sensitive stage (control), in field experiments at Wagga Wagga Agricultural Institute, NSW during the 2015 season.

References

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