Effect of heat stress on canola yield: A novel method of imposing heat stress in the field environment

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Key findings

- A preliminary experiment in 2017 showed that extra heat can be applied to canola plots successfully using specially designed heat chambers.
- Heat stress of four days, applied seven days after flowering started, significantly reduced the grain yield of the flowers opening during that period.
- Four days of heat stress significantly reduced harvest index and thousand seed weight at the plot level, however, grain yield and biomass yield was not affected due to recovery during cooler nights.
- Further research is needed to extend the duration and intensity of heat stress to show differences, and for rigorous validation across different varieties.

Introduction

Past research indicates that canola is particularly susceptible to temperatures above 28 °C during flowering. The frequency of extreme climatic events is predicted to increase, which would pose a serious risk to winter season crops. There is limited research on canola heat stress; most research has been undertaken in controlled temperature growth chambers where flowers are exposed to a constant high temperature at the same growth stage. However, in the field environment all the plants are not exposed to the same heat intensity – canola's indeterminate growth habit means that flowers can miss a heat stress event. Secondly, heat stress research has focused on using different sowing dates, which are then generally confounded by differences in the insidious effects of temperature, water stress; and vapour pressure deficits. Therefore, there is the need to develop a reliable method of imposing heat stress in the field environment. The aim of this experiment was to test a novel method of imposing heat stress in the field and determine the effect of heat stress on canola grain yield and its interaction with water availability.

Site details

The experiment was conducted at Wagga Wagga Agricultural Institute located at 35.01379°S latitude and 147.1940°E longitude. Soil at the experiment site was a red–brown chromosol with pH_{Ca} 5.3 and soil nitrogen 75 kg/ha at the time of sowing. The experiment was sown on 4 May 2017 with the variety Nuseed® Diamond. To establish the different water regimes, four irrigations (40, 20, 20 and 40 mm) were applied to wet plots using drip lines from August to October. All crop husbandry operations were carried out as per best management practices for canola.

Heat chambers

Six chambers (2.5L × 1.8W × 1.2H m) were constructed with Suntuf Sunlite® twin wall polycarbonate clear sheets fitted to a metal frame (Figure 1). The heating was provided by two standard 1200 W fan heaters in each chamber, with the power in the field being supplied by a 6 KVA generator. The heaters drew fresh air from outside the plots. A ceiling fan was used to ensure that heated air was evenly distributed through the chamber. A commercially available thermostat was used with extended thermocouples to control the heaters. Temperature and humidity inside the chamber were monitored at one minute intervals using a TinyTag Plus2 temperature and humidity logger placed inside a small radiation screen.

Heat treatment

A randomised complete block design with two heat treatments (control vs heat stress 31 °C), seven timings of heat stress (start of flowering until end of flowering), two water regimes (wet vs dry) and three replications was used. When 50% of the plot reached first flowering with one open flower, heat treatments (31 °C) were applied for four days. Each chamber enclosed six rows of plot for a length of 2.5 m. The chambers were placed on the plots at 11.30 am and the heaters were switched on at 12.00 pm. The chambers were then heated to 31 °C – the time taken to achieve this temperature depended on the ambient conditions. The temperature inside the chambers oscillated between 28 °C and 34 °C with an average of 31 °C. The heaters were turned off at 3.30 pm and the chambers removed from the plots at 4.00 pm.

Measurements

Before applying heat stress, the most recent fully opened flower on the main, secondary and tertiary branches on 10 random plants were tagged using coloured duct tape (Figure 2). After removing the heat stress, the process was repeated to mark the periods of heat stress. The same 10 sample plants were tagged (using different coloured tape) for each heat stress application in control plots. This tagged band was used to assess the grain yield from the flowers opening during that heat stress period. Seed yield, biomass, seed size (thousand seed weight) and harvest index (HI) were assessed from a 1.5 m^2 sample from each plot. The experiment was hand-harvested on 9 November 2017.

Figure 1. Heat chambers in a canola plot at Wagga Wagga Agricultural Institute in 2017.

Figure 2. Tagged plants in control plots at Wagga Wagga Agricultural Institute in 2017.

Results

Grain yield from heat stress periods

The yield from the tagged band (flowers opened during heat stress period) from heat stressed plants was less than the control plants for each timing of heat stress application (Table 1), but usually only at the *P*<0.01 level (with the exception of the treatment applied 14 days after start of flowering [DAF]).

Table 1. Grain yield (g) of tagged band (flowers opening during heat stress period averaged across 10 plant samples) for four heat stress timings (7, 14, 21 and 28 days after flowering [DAF]) under heat stress and control, averaged across wet and dry plots.

	Timing of heat stress (days after flowering [DAF])			
	7 DAF	**14 DAF**	**21 DAF**	**28 DAF**
Heat stress	0.063	0.867	0.744	1.192
Control	0.187	1.164	1.025	1.793
S.E.D.	0.08	0.32	0.28	0.56
P (0.05)	0.037	0.108	0.094	0.084

Plot grain yield and yield components

Heat stress did not affect grain yield or biomass at the plot level, however, heat stress did affect HI and grain size. Harvest index significantly decreased when stress was applied at 7 DAF and 28 DAF; however, grain size increased at the same heat stress applications (Figure 3). There was an overall increase in both grain yield and biomass yield of 19% with irrigation, but there was no interaction between heat stress timing and irrigation.

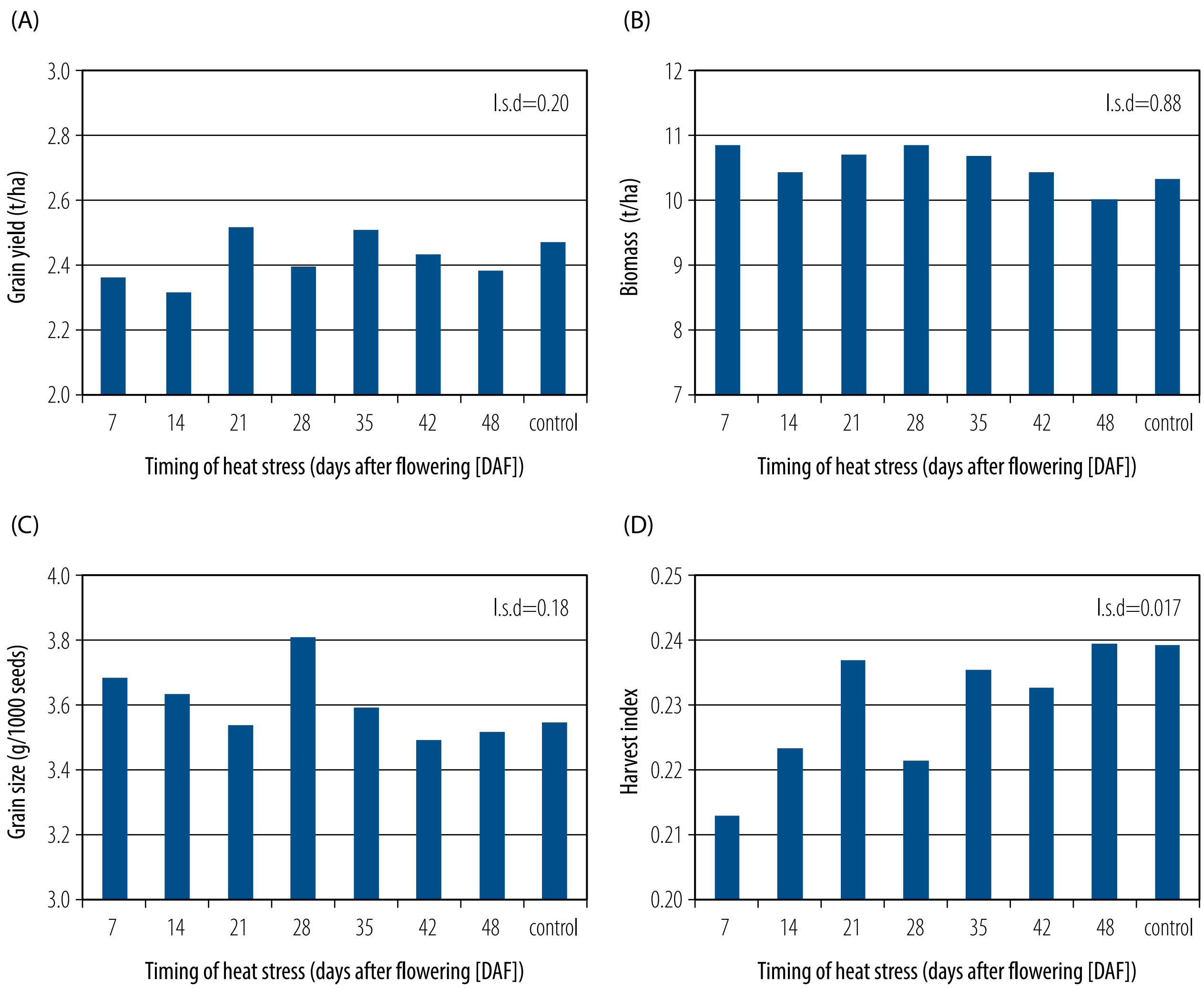

Figure 3. Effect of timing of heat stress (days after flowering [DAF]) on (A) grain yield, (B) biomass, (C) grain size and (D) harvest index (HI).

Conclusions

This preliminary experiment to develop a methodology to impose heat stress in the field environment was successful in establishing heat chambers and imposing heat stress of 31 °C for four days with minimal confounding effects. Preliminary statistical analysis shows heat stress imposed seven days after the start of flowering significantly reduced grain yield obtained from the flowers opening during that period. However it appears there was some recovery from cooler nights, therefore there is need to improve the methodology by increasing the duration and severity of heat stress in future experiments.

This is the first report on heat stress effect in canola at the plot level in the field environment. Developing a novel method of heat tolerance research will set a clear path for heat stress physiology research that will benefit canola growers, particularly in northern and western growing regions.

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