Wheat grain yield response to elevated temperature and nitrogen

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Key findings

- Elevated temperature reduced yield by 0.3 – 0.4 t/ha per degree (°C) higher during pre- and post-flowering.
- The effect of temperature was offset by grain number per m^2.
- Higher N rates may partially mitigate the effect of elevated temperature.

Why do the trial?

Efficient management practices together with crop breeding are required to improve grain yields. Growers often take considerable risk with making N fertiliser decisions given the variability in uptake and response from season to season. Increasingly growers are utilising early sowing opportunities to take advantage of early season breaks and the ability to spread their seeding window. Shifting seeding date also modifies the thermal regime the crop experiences at critical stages.

Both sowing time and variety selection modify crop growth and N requirements. The interaction between N availability and temperature is largely unknown. The objective of this trial was to study the effect of elevated temperature, sowing time, variety, and N rate on wheat yield.

How was it done?

Plot size	1.75 m x 6.0 m	**Fertiliser**	Urea
Seeding dates	26 May, 9 June &		@ 0 kg N/ha, 2-4 leaf & GS31
	23 June 2017		@ 100 kg N/ha, 2-4 leaf & GS31

The field trial at Hart combined three sowing times, two wheat varieties, two temperature regimes during critical stages (heated and control) and two N rates. Sowing times spanned from late May to late June. Varieties were Mace (AGT) and Spitfire (LongReach). Temperature regimes consisted of unheated controls (actual field temperature), and plots heated with open-top passive heating cubes (1.5 m wide, 1.5 m length and 1.5 height) (Photo 1). The timing of heating was from booting (GS40) to 10 days after flowering (in first and second sowing time) and from 10 days after flowering till maturity (third sowing time). N treatments consisted of unfertilised control, and 100 kg N/ha applied as urea split between early tillering and just before stem elongation.

Photo 1. Open-top passive heating system before flowering (left) and during grain filling (right).

Results and discussion

Temperature regimes

The temperature in the heated treatments closely followed the temperature of untreated controls, providing a realistic system for comparison (Figure 1). On average, the heating system increased the average temperature by 1.4 °C for the first and second sowing times, and 1.7 °C during the late stages of the third sowing time. The increase in average temperature was due to consistently higher maximum temperatures with little change in minimum temperatures.

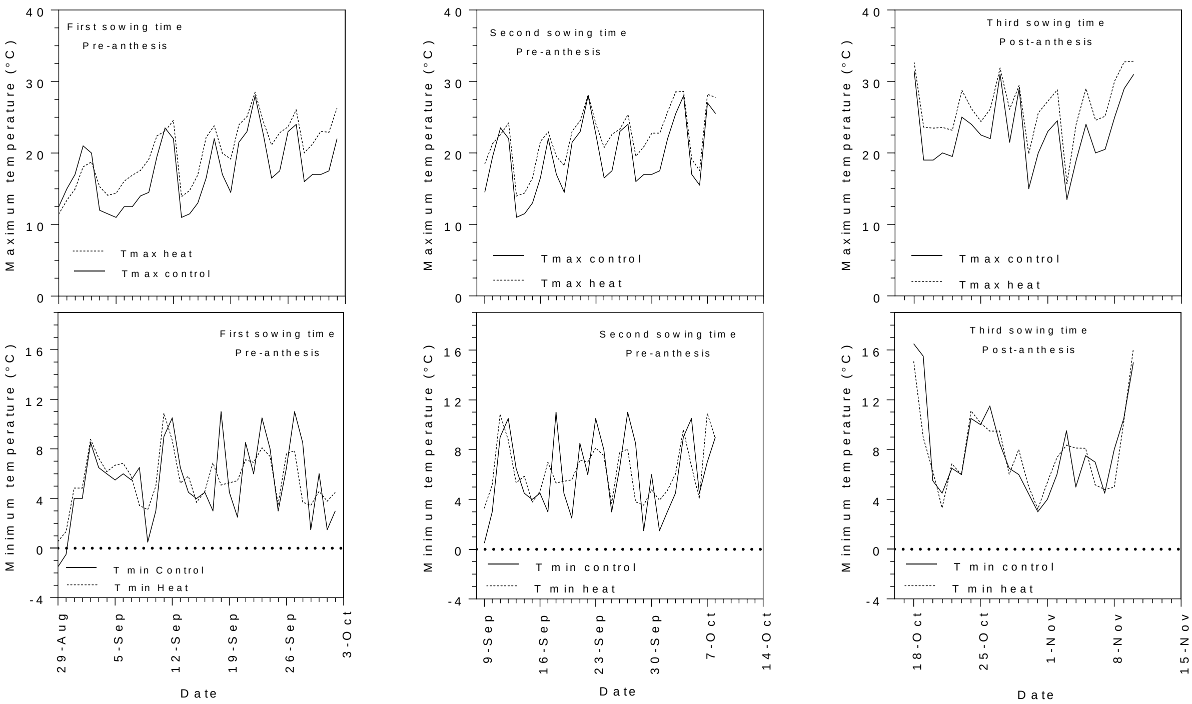

Figure 1. Minimum (T min) and maximum (T max) temperatures during the heating period for the three sowing times.

Temperature effects before flowering

Grain yield was affected by temperature, sowing time and N. The varieties Mace and Spitfire did not differ in grain yield in this trial. The effect of N fertiliser depended on the sowing time with a significant increase in yield (1.4 t/ha) in the first sowing and no effect on the second time. Delaying sowing reduced grain yield of fertilised crops but not for the unfertilised controls. Increasing the temperatures before flowering reduced grain yield in unfertilised crops but not in fertilised crops (Figure 2). The reasons for this response are unknown and will be the subject of further research.

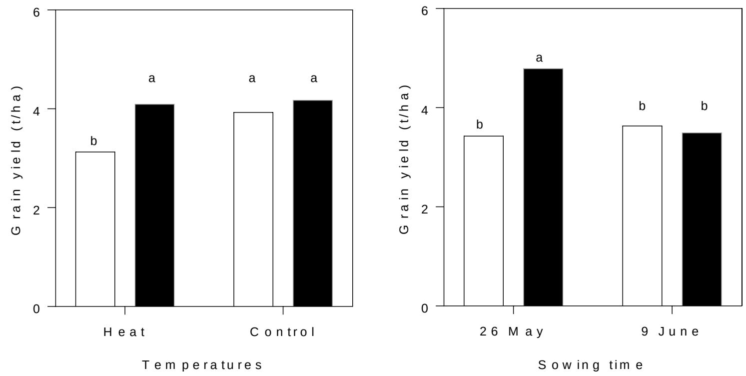

Figure 2. The effect of temperature (left panel) and sowing time (right panel) on grain yield for unfertilised (white bars) and fertilised crops (black bars). Different letters indicate significant differences (P ≤ 0.05) between bars.

Increasing temperatures during the pre-flowering period and the addition of N affected both grain number and thousand grain weight in both sowing times. Elevated temperature reduced grain set by 15%. Applying 100 kg N/ha increased grain set by 50% in the first sowing and 24% in the second sowing time. Delaying sowing decreased the grain number but only in fertilised crops (Figure 3).

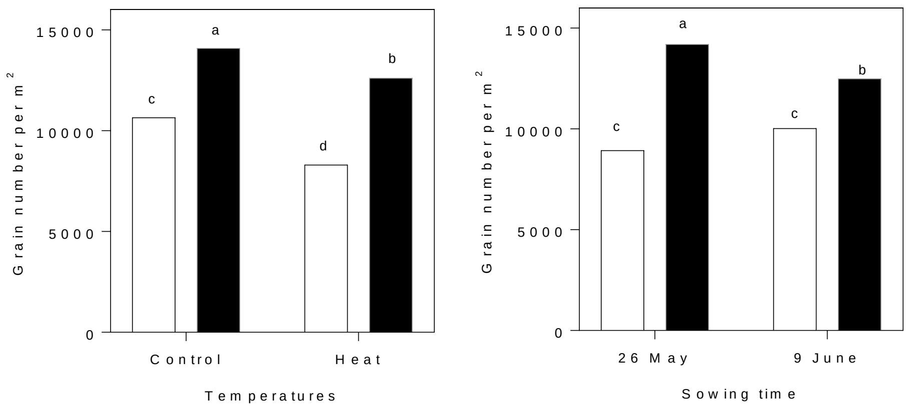

Figure 3. Main effect of temperature before flowering (left panel) and sowing time (right panel) on grain number per m2 for unfertilised (white bars) and fertilised crops (black bars). Different letters indicate significant differences (P ≤ 0.05) between bars.

The significant effects of the temperature, sowing time and N on grain number were transferred to thousand grain weight. Delayed sowing by 15 days reduced grain weight by 19% under high N conditions but not in unfertilised crops (Figure 4), however, the effect was only significant under high N conditions. The heating treatments during pre-flowering did not reduce the thousand grain weight, and even there was a slight increase under fertilised conditions.

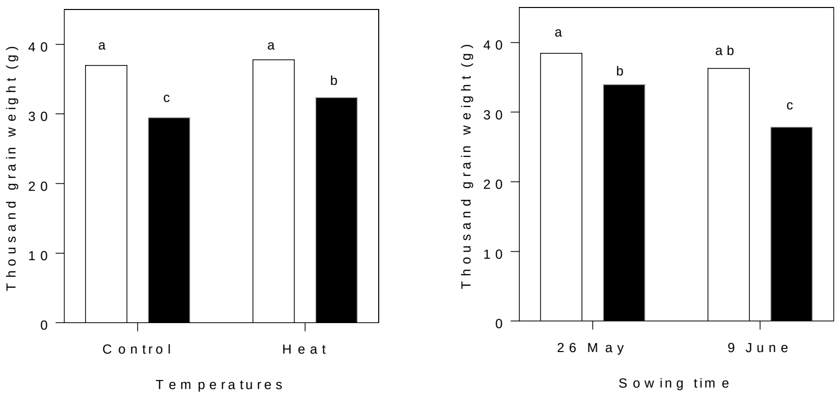

Figure 4. Main effect of temperature before flowering (left panel) and sowing time (right panel) on thousand grain weight for unfertilised (white bars) and fertilised conditions (black bars). Different letters indicate significant differences (P≤0.05) between bars.

Temperature effects after flowering

For crops sown on 23 June, Mace (3.46 t/ha) out-yielded Spitfire (2.78 t/ha). Increasing average temperature by 1.7 °C, reduced the yield of Mace by 15% but did not affect Spitfire (Figure 5). The reasons for the difference in response between cultivars are unknown, but this indicates that certain combinations of varieties and nitrogen rate could improve yield under elevated temperature. Nitrogen fertilisation did not affect grain yield.

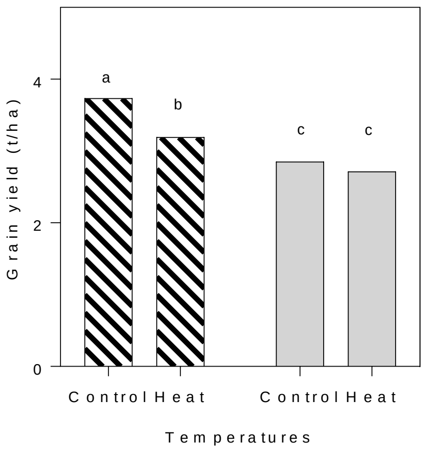

Figure 5. Main effect of temperature during post-flowering for grain yield for Mace (diagonal lines bars) and Spitfire (grey bars). Different letters indicate significant differences between bars.

Grain number was significantly affected by variety, temperature, and N. Mace produced approximately 2150 grains more per square metre than Spitfire. Increasing temperatures produce a significant decrease of 11% on grain number with higher effect under fertilised conditions. Nitrogen fertilisation increased grain number and reduced thousand grain weight.

Summary / implications

In this preliminary study, we showed how N, temperature and sowing time can affect wheat yield and quality. Small temperature increases during critical period for yield determination can seriously impair the yield and quality of wheat. High temperatures during pre-flowering, either manipulated experimentally with heating cubes or with delayed sowing, reduced grain number and yield. This reinforces the importance of early sowing providing frost risks are managed. Nitrogen fertilisation could play an important role in mitigating the impact of higher temperatures on grain number and grain yield. Varieties also differed in yield response to temperature in late-sown crops.

Acknowledgements

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Open-top passive heating cubes at Hart in 2017