Does temperature affect variety and N decisions?

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Key Findings

- Nitrogen fertiliser decisions need to take into account variety and sowing date.
- Yield losses may reach up to 0.67 t/ha per °C during the critical period (20 days before to 10 days after flowering) for yield determination.

Why do the trial?

Heat stress can reduce grain yield of wheat in Australia by 10-15%. Variety selection, nitrogen (N) rate, and sowing time are key factors determining the attainable grain yield. Nitrogen management remains one of the most important and risky decisions for farmers. Shifts in sowing times and variety selection modify the environmental conditions during the critical period for yield determination (20 days before and 10 days after flowering). For instance, while early sowing may improve the yield of some late maturing varieties, it could also increase the risk of frost for early maturing varieties sown too early. To tailor nitrogen input to sowing time and variety, we need an understanding of the interactions between N, temperature and crop phenology. Therefore, four experiments were carried out to develop guidelines to manage the 3-way interaction between N, variety and sowing date.

How was it done?

Plots size	1.75 m x 6 m and 2 x 15 m	**Fertiliser**
Seeding date	13/5/17 and 14/5/18	Urea (46:0)
	26/5/17 and 27/5/18	@ 0 kg N/ha, 2-4 leaf & first node
	9/6/17 and 24/6/18	@ 50 kg/N ha, 2-4 leaf & first node
	23/6/17 and 10/7/18	@ 100 kg N/ha, 2-4 leaf & first node
		@ 200 kg N/ha, 2-4 leaf & first node

Field trials were carried out at Turretfield and Hart in 2017 and at Roseworthy and Mintaro in 2018. In each location, trials combined four sowing times, six wheat varieties, and four N rates. Varieties were selected based on N requirements and phenology (Table 1). Nitrogen treatments consisted of unfertilised controls, and three fertiliser rates (50, 100 and 200 kg N/ha) applied as urea. Nitrogen application was split in 50% at early tillering and 50% just before stem elongation.

Additionally, an experiment was established at Hart 2017 and Roseworthy 2018 to look at temperature and other factors confounded in sowing time trials. Two temperature regimes were compared: unheated controls and crops heated with open-top passive heating cubes (1.5 m wide, 1.5 m length and 1.5 height) (Photo 1). These thermal regimes were established in crops of Mace and Spitfire, with two N rates (0 and 100 kg N/ha). The timing of heating was from booting to 10 days after flowering and from 10 days after flowering until maturity.

Table 1. Wheat varieties trialed.

Variety	Maturity type
Axe (AGT)	Early flowering and very early maturity variety suited to southern Australia
Cobra (LongReach)	High yielding early-mid maturity variety suited to high yielding areas of Southern Australia
Mace (AGT)	Early to mid-season maturity and has been the leading wheat variety in both WA and SA in recent seasons
Scout (LongReach)	Mid maturity variety, derived from Yitpi
Spitfire (LongReach)	Is an early mid maturing variety with high grain size and consistently high grain protein
Trojan (LongReach)	Mid-late maturing variety

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

For the pooled data we estimated a maximum yield with a method similar to French and Schultz. An upper limit of yield (95 percentile) was calculated as a function of the mean (average) temperature during the critical period (20 days before and 10 days after anthesis). For each treatment, a yield gap was obtained as the difference between actual yield and yield at the boundary.

Results and discussion

Grain yields ranged between 5.96 t/ha (Mace, 200 kg N/ha sown at Hart on 13 May 2017) and 0.13 t/ha (Cobra, 200 kg N/ha at early sowing at Mintaro date 2018). Across two seasons, yields averaged 3.5 t/ha in 2017 and 1.54 t/ha in 2018. The variation in grain yield was mainly due to rainfall, N availability and frost events.

The relationship between grain yield and the mean temperatures during critical period (20 days before and 10 days after flowering) had an upper limit (boundary) function indicating a maximum potential yield loss of 0.67 t/ha per ºC (Figure 1a). In all locations, delaying sowing (from May into June) decreased yield with the exception of Mintaro, where recurrent frost favoured later sowings (Figure 1b).

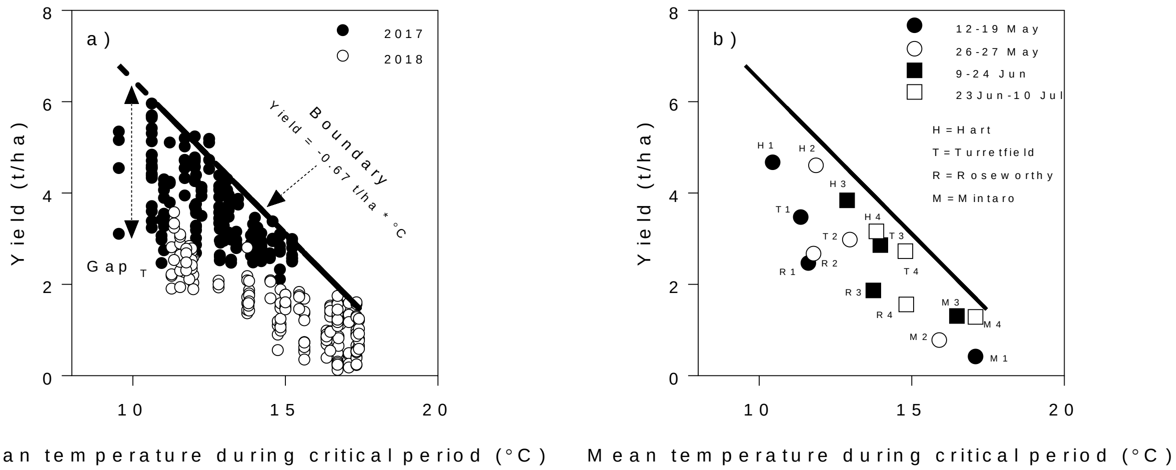

Figure 1. (a) Boundary line for the relationship between grain yield and mean temperature during the critical period for all treatments in 2017 (closed symbols) and 2018 (open symbols). The line is an upper limit with a slope of 0.67 t/ha per ºC. (b) Average yield across varieties and N treatments for each sowing time and location combination as a function of mean temperature during critical period.

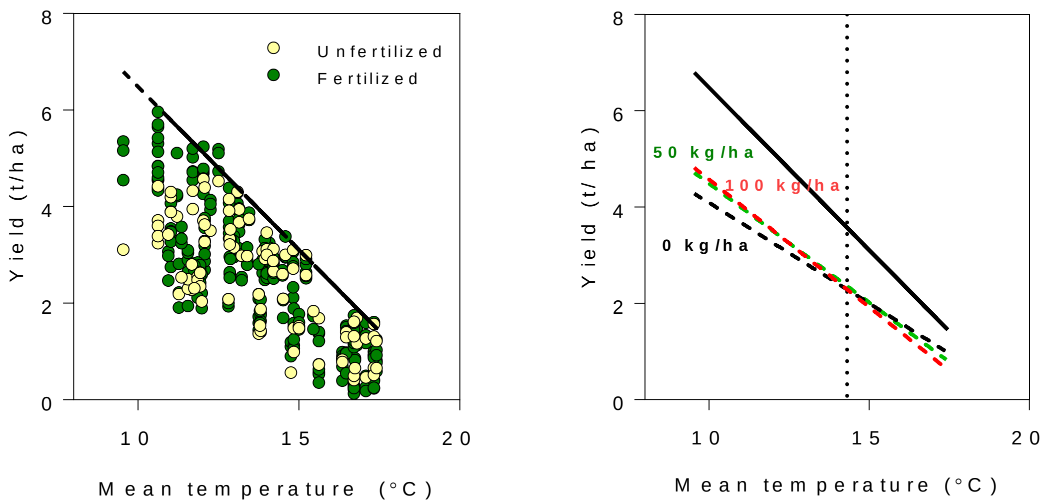

Figure 2. Grain yield as a function of mean temperature during critical period for fertilised (green) and unfertilised (yellow) plots (left panel) and different treatments (right panel) of 0 kg N/ha (black), 50 kg N/ha (green) and 100 kg N/ha (red). Dashed lines indicate the average regression line for each treatment, continuous black line indicates the boundary function. Vertical dotted line indicates break temperature point between treatments.

The response of grain yield to N depended mainly on location (N availability, rainfall), time of sowing and their interaction. In general, N had a positive effect on grain yield across locations and varieties. However, there was interaction with the mean temperature during critical period that is important (Figure 2). Advantages of N fertilised treatments disappeared when mean temperatures during critical period increase over 14.3 °C.

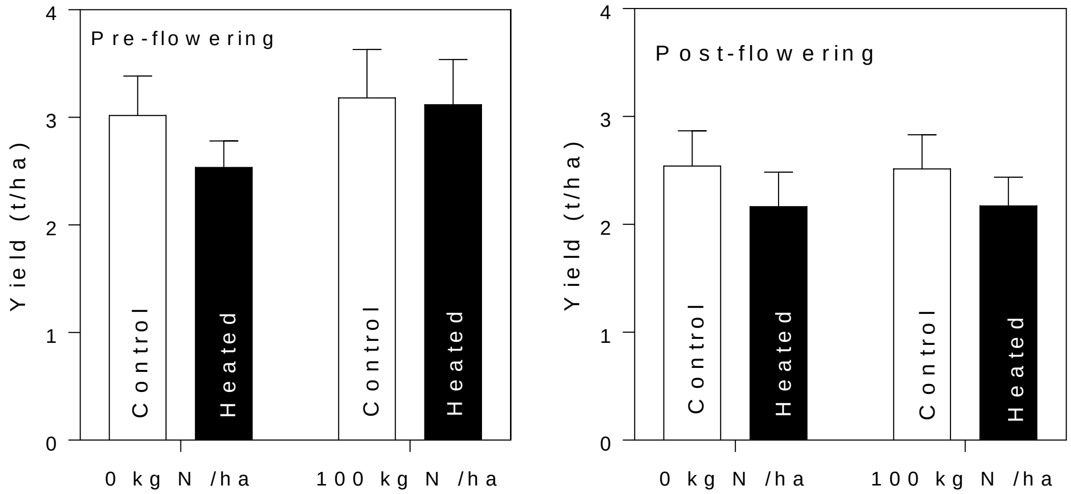

Figure 3. Average of two years of experiments for the main effect of temperature and time of heating (left panel = pre-flowering, right panel = post-flowering) on grain yield for unfertilised and fertilised crops. Whiskers indicate standard error of the mean for each treatment.

Results of the heating cubes were in line with the sowing date trials indicating a positive effect of N to maintain grain yield, especially when higher temperature occurs during the period of grain number determination (pre-flowering treatment) (Figure 3). Heating cubes reduced the yield of crops in both periods of heating (before and after flowering) (Figure 3). Fertilising crops with 100 kg N/ha reduced the impact of higher temperatures mainly through sustaining the grain number per square meter.

Summary / implications

Mid-May sowing increased yield potential, i.e. yield in the absence of stress. Delaying sowing reduced yield potential up to 0.67 t/ha per °C of mean temperature during critical period. Adequate N nutrition and longer-season spring varieties reduced the yield gaps in relation to temperature. Responses to N become more erratic when temperatures during the critical period increase above ~14.5 °C. Strategic N management (50-100 kg N/ha) may help to mitigate the effect of higher temperatures on grain number and yield.

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