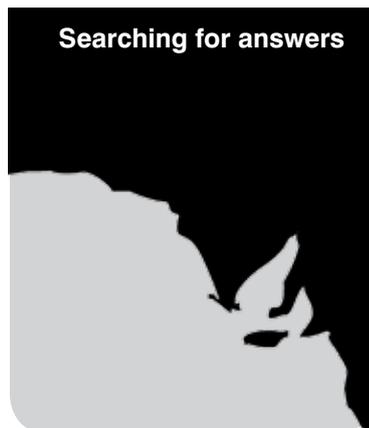


Understanding the risk of heat stress: what do we know about the likelihood and consequence?

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RESEARCH



Key messages

- When considering the time of flowering it is apparent that a warmer, low rainfall location like Minnipa (flowering in September) may have less risk of heat events than a medium rainfall region like Roseworthy (flowering later in October).
- A purpose built chamber was able to function well in the field and heat the enclosed air to 35°C.
- More work is needed to quantify the impact of hot days on wheat yields.

Why do the trial?

High temperatures during spring have long been recognised as one of the weather risks for grain farmers in southern Australia, particularly if they occur around crop anthesis. Risk is defined as the likelihood x consequence. Therefore to investigate the risk of heat stress we look at the likelihood by considering the climatology (chance of getting high temperatures in the climate records) and the consequence by reproducing heat events in the field using a purpose built chamber.

Spring heat events in the SA grain

belt are due to a northerly flow of air associated with a passing high pressure system to the east of the region and an approaching cold front to the west (Figure 1).

Background

There has been an increase in the average number of hot days (>35°C) for Australia since digitised temperature records from 1957 (<http://www.bom.gov.au/cgi-bin/climate/change/extremes/timeseries.cgi>). Minnipa and Roseworthy are consistent with this trend having set recent records in the number of days over 30, 35 and 37°C. Minnipa has more hot spring days than Roseworthy. Table 1 shows that between 15 September and 24 November there is an equal or higher chance of getting a hot day at Minnipa than Roseworthy. However, when assessing the risk of heat stress on crops, flowering must be considered. Wheat crops at Minnipa would commonly flower mid-September, whereas most crops at Roseworthy flower around mid-October. The earlier flowering at Minnipa is due to warmer growing conditions and also variety choice to match spring moisture availability. At Roseworthy not only are there advantages of a longer growing season, early flowering has an unacceptable frost risk. The chance of getting over 30°C at Minnipa around 15 September is only 0.2% compared to 1.2% at Roseworthy on 15 October, suggesting Roseworthy crops are at higher risk of heat stress at flowering than Minnipa. Late sown crops in a mild year could still be flowering into November at Roseworthy, but hot November temperatures in Minnipa are aiding

harvest. Table 1 also highlights the increase in heat stress risk as flowering becomes later.

How was it done?

We wanted to investigate whether we could show any affect on field wheat yield after just one hot day. To do this we required 4 main components: the chamber, heater, thermostat control and monitoring equipment.

- The chamber, with dimensions of 1.5 x 0.5 x 1.2 m (L x W x H), was constructed with Standard-Clear-Greca polycarbonate sheeting (\$200-\$300 per box) which blocks most UV radiation (200 to 400 nm) and has a very high (90%) and uniform transmittance between 400 and 1600 nm. An adjustable lid was also constructed which allowed some air flow in/out due to the corrugation of the polycarbonate. Each chamber enclosed two rows of wheat for a length of 1.5 m.
- The heating was provided by a standard 1200 W fan heater (\$20), powered in the field by a generator.
- We used a commercially available control thermostat (Carel) that allowed temperature control to 0.1°C. The thermostat, attached to a power board (total \$560), controlled the heater.
- Temperature and humidity inside the box was monitored at 5 minute intervals using a TinyTag Ultra2 temperature and humidity logger (\$470) placed inside a small Stevenson type screen (\$70) and hung from the centre of the chamber just below canopy height.

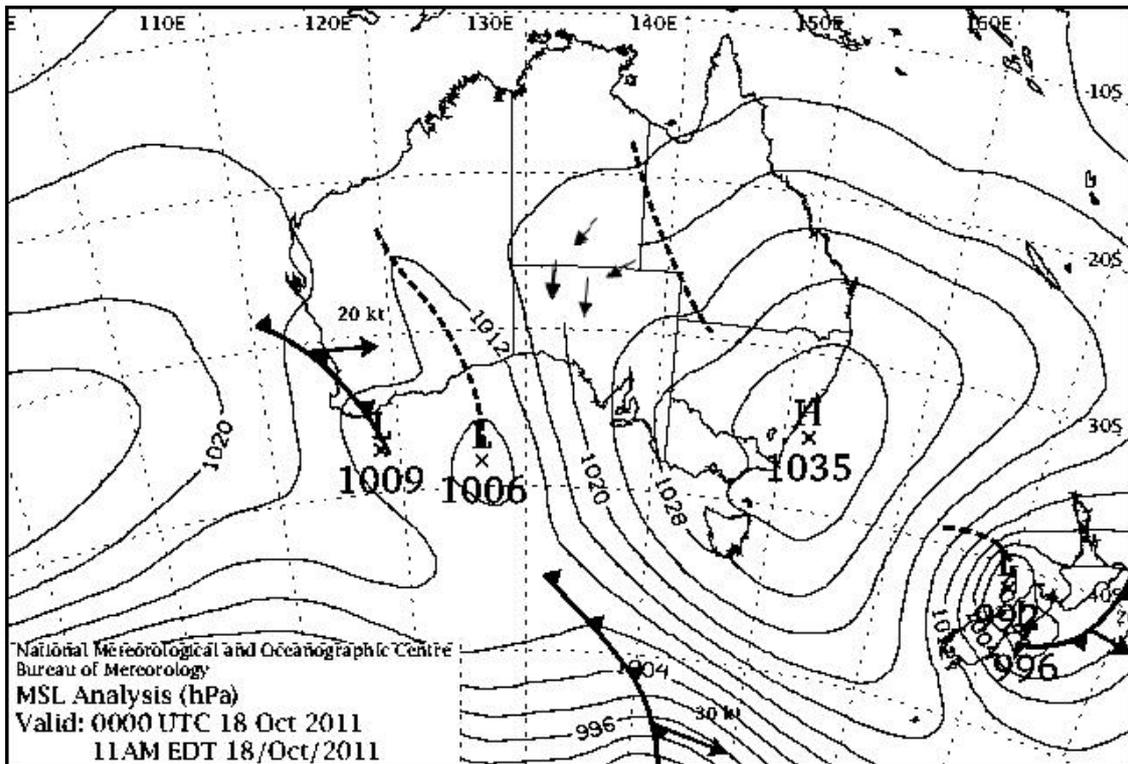


Figure 1 Mean Sea Level Pressure chart for 18 October 2011. Arrows show the northerly direction of winds affecting SA due to the high pressure cell (H) to the right. The recorded maximum temperature on this day was 36°C in Minnipa, Eyre Peninsula.

Field trials were conducted at the Waite Campus, Urrbrae (6 km south of Adelaide), during the 2009 (Figure 2) and 2010 seasons, and at Roseworthy during 2011. Each plot was heated for just a single day during the season, around anthesis. The thermostat control was used from 10am to slowly increase the temperature to a maximum of 35°C at midday, and maintained for 3 hours before being allowed to decrease steadily back to ambient temperature by 5pm when the chambers were removed.

What happened?

The TinyTag measurements inside the heat chambers showed that temperatures during the day of heating successfully reached 35°C as intended (Figure 4). In the first year of the experiment (2009) we measured losses of around 20%. In the second year the overall trend was for the most sensitive period to be the relatively small window between ear emergence and the start of flowering. Although the average of the heated treatment was about 10% less than the average of the unheated control,

the plot to plot variability was too high for this to be statistically significant. Last year we did not find any differences between the heated and control plots.

What does this mean?

There is plenty of evidence from other researchers and farmer experience that hot spring weather is damaging to crop yields. In some cases researchers have subjected wheat to prolonged and extreme heat whereas in this trial we were trying to mimic the effect of a single spring day that was hot (35°C for three hours) but not extreme (12 October 2004 was over 40°C in parts of the Mallee).

Possible reasons for our results not showing an impact in two of the three years include:

- The single day of heating (with 35°C for three hours) may not have a damaging impact on the crop.
- Other factors such as soil moisture at the time of the event and conditions in the weeks leading up to or following the heat event may be major factors influencing

the level of damage.

- The heat chamber may not accurately mimic the heat event in the field.
- In each year the treatments were applied in the weeks prior to and just after flowering. However the time of the crop stage when the heat is applied might be so critical that small differences in the timing of the heating influenced the results.

It is difficult to define a clear relationship between air temperature and crop damage due to other factors such as crop stage and soil moisture. In low rainfall farming regions, the use of early sowing and quick varieties seem to be sound ways to escape moisture stress and heat stress. This strategy will only work in areas where late frosts are rare. Where frost risk is higher there is a complex trade-off between risks of frost, heat and moisture stress.

Acknowledgements

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Table 1 The chance (%) of getting a maximum temperature of 30, 35 or 37°C at least once during a 10 day window centred on the given date between 15 September and 24 November. Probabilities are for Minnipa (left side of column; M) and Roseworthy (R), South Australia, 1957-2009

Temp (°C)	15 Sept		25 Sept		5 Oct		15 Oct		25 Oct		4 Nov		14 Nov		24 Nov	
	M	R	M	R	M	R	M	R	M	R	M	R	M	R	M	R
30	3.6	0.7	7.6	2.7	12	5.2	16	8.7	24	15	28	18	35	27	41	33
35	0.2	0.0	1.1	0.0	1.9	0.4	3.5	1.2	5.7	2.9	8.4	5.0	13	9.6	18	14
37	0.0	0.0	0.0	0.0	0.7	0.2	1.7	0.5	2.8	0.7	4.6	2.2	7.5	4.5	11	8.0



Figure 2 Chamber set up in the field over two rows of wheat, showing a heater at the bottom and TinyTag in a Stevenson screen hanging at canopy height within the chamber

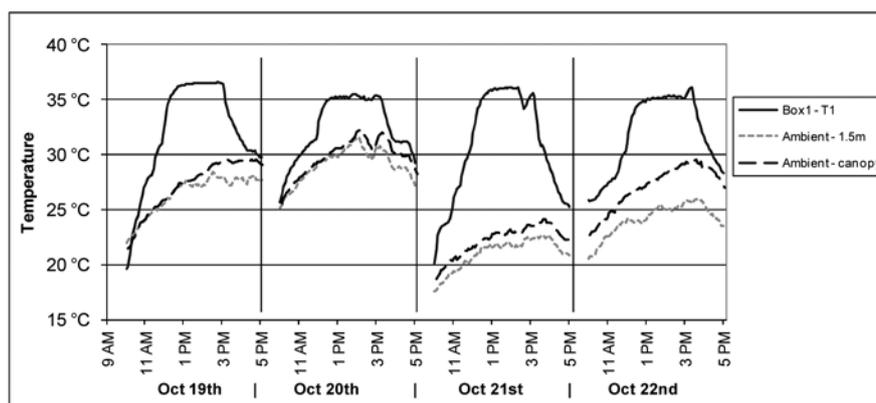


Figure 3 Temperature at crop canopy height in a heat chamber (Box 1-T1) exposed to high temperatures during post anthesis stage. Ambient air temperature was taken at the edge of the plots at 1.5 m height, and at canopy height in non-treated crops. The chamber was placed over a different plot on 4 consecutive days, 19-22 October 2009

