Effect of anthesis date on grain yield and yield components of wheat – Trangie 2009-2012

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Abstract
The response of a range of wheat varieties to sowing date was examined at Trangie Agricultural Research Centre from 2009-2012. Grain yield related strongly with both anthesis date and grain number m^{-2} in the drier seasons of 2009 and 2012. There was a weak to moderate relationship between grain yield and anthesis date in the more favorable seasons of 2010 and 2011, with a weak relationship between grain yield and grain number in 2011. There was a weak relationship between grain yield and individual grain weight in 2010 and 2012 only. Grain growers in the region have historically managed crops conservatively to limit stress during the post-anthesis grain fill period; however grain number (which is largely affected pre-anthesis) had a stronger relationship with grain yield than did grain weight, suggesting that management could focus more on minimising pre-anthesis stress.

Key words
Grain number, grain weight, sowing date, pre- and post-anthesis stress

Introduction
Wheat is the major winter grain crop planted in the Western Plains region of NSW, an area covering the shires of Narromine, Warren, Gilgandra, Coonamble and Bogan. The NSW Grains Report from October 2012 reports that wheat comprised 70% of the area planted to winter crops in that season. The soils of this region vary but are generally of moderate to high water holding capacity (from 100 to 300 mm plant available water). Although historical rainfall records show a summer dominant rainfall pattern, both inter and intra-seasonal rainfall can be highly variable. The farming systems of the region are based on storing out-of-season (November – March) rainfall in the soil, with crops then supplemented by winter rainfall. Crops are often managed conservatively (e.g. low seeding rates, low nutrition inputs, wide seeding rows) as there is a fear of drought occurring during grain fill which may lead to 'haying-off' and reduced grain size.

Sowing time decisions and varietal phenology both affect the wheat crops potential exposure to frost damage (declining risk from late winter) and heat stress (increasing risk from early spring). Sowing time decisions may also affect the partitioning of water use for pre and post-anthesis growth. Cooper (1992) reports an optimum anthesis date of 15 September for Trangie, beyond which grain yield decreases due more to increased temperature than moisture stress.

Experiments were conducted at Trangie Agricultural Research Centre from 2009 to 2012 to determine the response of a range of wheat varieties to 3-4 sowing dates, including dates that are considered 'early' (late April – early May), 'main' (mid-May) and 'late' (June). This paper reports on the findings in terms of the effect of anthesis date and yield components on final yield outcomes.

Methods
Wheat time of sowing experiments were conducted over four seasons (2009-2012) at Trangie Agricultural Research Centre (31.99ºS, 147.95ºE) on a grey vertosol soil with a water holding capacity of 183 mm. This location experiences a temperate to sub-tropical climate, with hot summers, mild winters and summer dominant rainfall (Figure 1). Experiments were sown as a split-plot design, with sowing date as the main plot and varieties as sub-plots. Treatments were replicated three times. All experiments were managed for optimised nutrition and to limit the effects of pests and diseases. Sowing dates were similar across seasons (Table 1) but varieties differed from season to season, with five varieties (Crusader, EGA Gregory, Livingston, Sunvale, Sunzell) sown in each season. Anthesis date was recorded as the date where 50% of

ears had yellow anthers (on a whole plot basis). Grain yield (GY) was based on machine harvest, with grain analysis completed on these machine harvested samples. Grain number m^{-2} (GN) was calculated from GY and one hundred grain weight (GW) of each treatment.

Table 1: Sowing dates, number of varieties in each trial, plant available water (PAW) at sowing and rainfall from soil water coring to maturity (in-crop rain) in four wheat variety by sowing date experiments at Trangie Agricultural Research Centre from 2009 to 2012.

Season	Sowing dates	No. of varieties	PAW mm (sow)	In-crop rain (mm)
2009	27 Apr, 18 May, 12 June	36	76	168
2010	20 Apr, 3 May, 19 May, 10 June	18	174	363
2011	30 Apr, 16 May, 9 June	18	178	230
2012	3 May, 21 May, 12 June	15	171	127

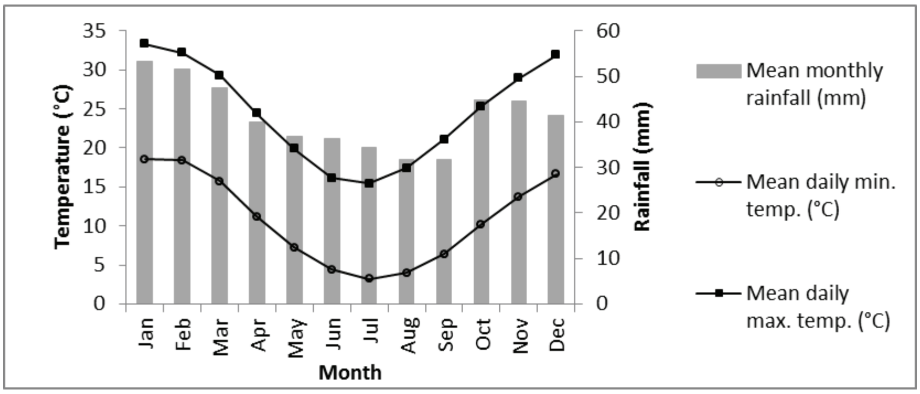

Figure 1: Average (1922-2014) climatic conditions for Trangie Agricultural Research Centre, NSW.

Results and discussion

The experiments in the seasons 2010-2012 were all sown into a near full soil moisture profile (Table 1). In comparison, the soil moisture profile in 2009 was approximately 100 mm less. In-crop rainfall ranged from very low in 2012, low in 2009, average in 2011 to well above average in 2010. The overall temperature through the growing season was well above average in 2009 but close to average for 2010 to 2012.

Due to the very warm late-winter and spring conditions (both minimum and maximum temperatures) in 2009 the treatments that reached anthesis early (from mid-August) had the highest GY. From this point GY was negatively related to anthesis date (Figure 2).
The relationship between anthesis date and GY was curvelinear in 2010-2012 (Figure 2), with a stronger effect of anthesis date on GY in the drier year of 2012. There were a number of late winter and early spring frosts recorded in 2012 that potentially reduced GY of the early flowering treatments; however in 2010 and 2011 there were no major frost events recorded. In 2010 and 2011 the treatments that reached anthesis early were likely unable to make full use of the resources available in those favourable seasons. The optimum anthesis dates were similar for the seasons 2010-2012 (about 12 September).

Over the experimental period, the rate of GY decline after the optimum anthesis date ranged from a low of 33 kg ha.day^{-1} in 2011 to a high of 57 kg ha.day^{-1} in 2012. The average GY reduction over the four seasons after the optimum anthesis date was 1.1% day^{-1}, which is similar to the 1.3% day^{-1} reported by Cooper (1992) from experiments conducted at the same location.

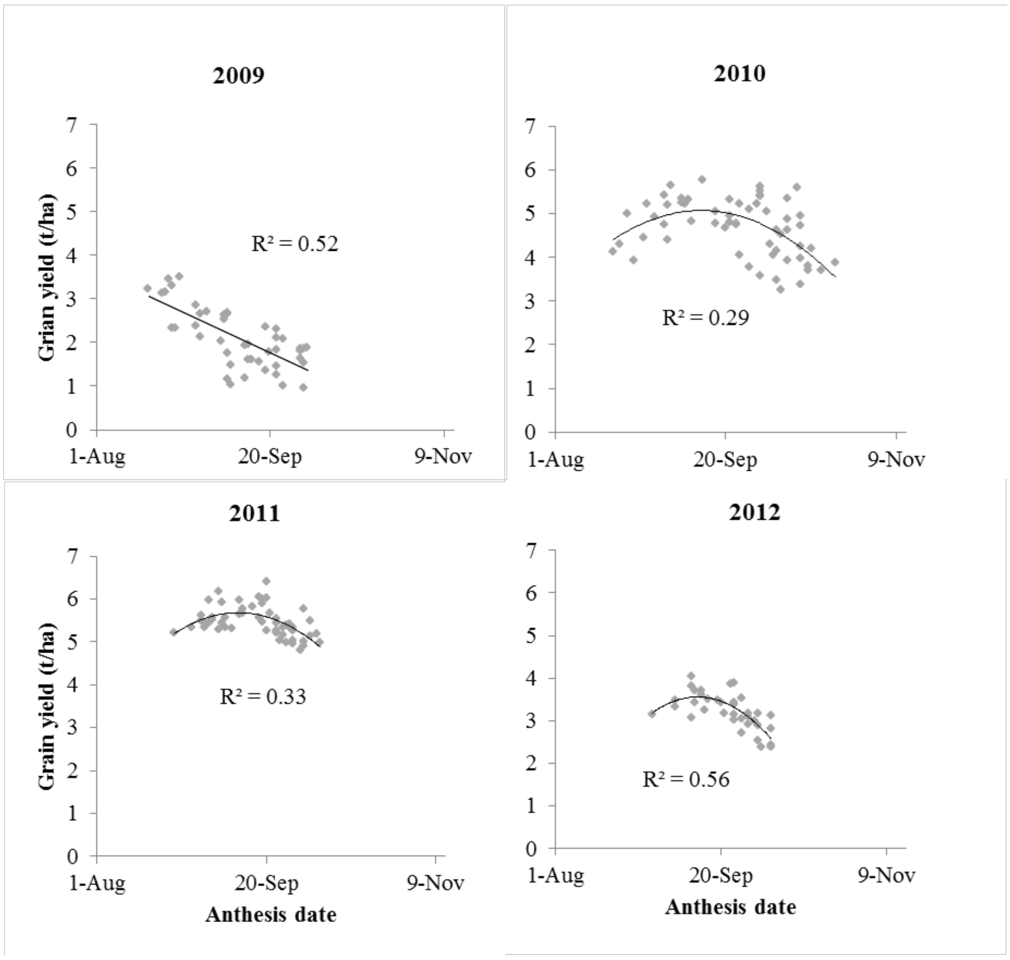

Figure 2: Regression of anthesis date and grain yield was significant (p<0.001) in wheat variety by time of sowing experiments from 2009 to 2012 at Trangie Agricultural Research Centre. The relationship was strongest in the drier years 2009 and 2012.

There were strong positive relationships between grain number (GN) and GY in the drier seasons of 2009 (R^2 = 0.91) and 2012 (R^2 = 0.66). There was a weaker relationship in the 'average' season of 2011 (R^2 = 0.25) and no significant relationship in the very wet season of 2010 (Figure 3). A regression of individual grain weight (GW) with GY was also completed for each season. The regression was significant (but weak) only in the seasons 2010 (R^2 = 0.08) and 2012 (R^2 = 0.30).

Fischer (2011) reports that final GN of wheat is most affected by stress in the period leading up to anthesis, while GW is more affected by conditions post anthesis. In these experiments the relationship between GN and GY was overall stronger than the relationship between GW and GY, suggesting that stress pre-anthesis was affecting grain yield more than stress post-anthesis. Importantly, it was in the drier years of 2009 and 2012 where GN related to final GY most strongly. It has been for these types of drier years that conservative agronomic practices have been implemented; however this research would suggest that conserving resources for the grain fill period may not lead to positive grain yield outcomes (though there may be implications for grain marketing).

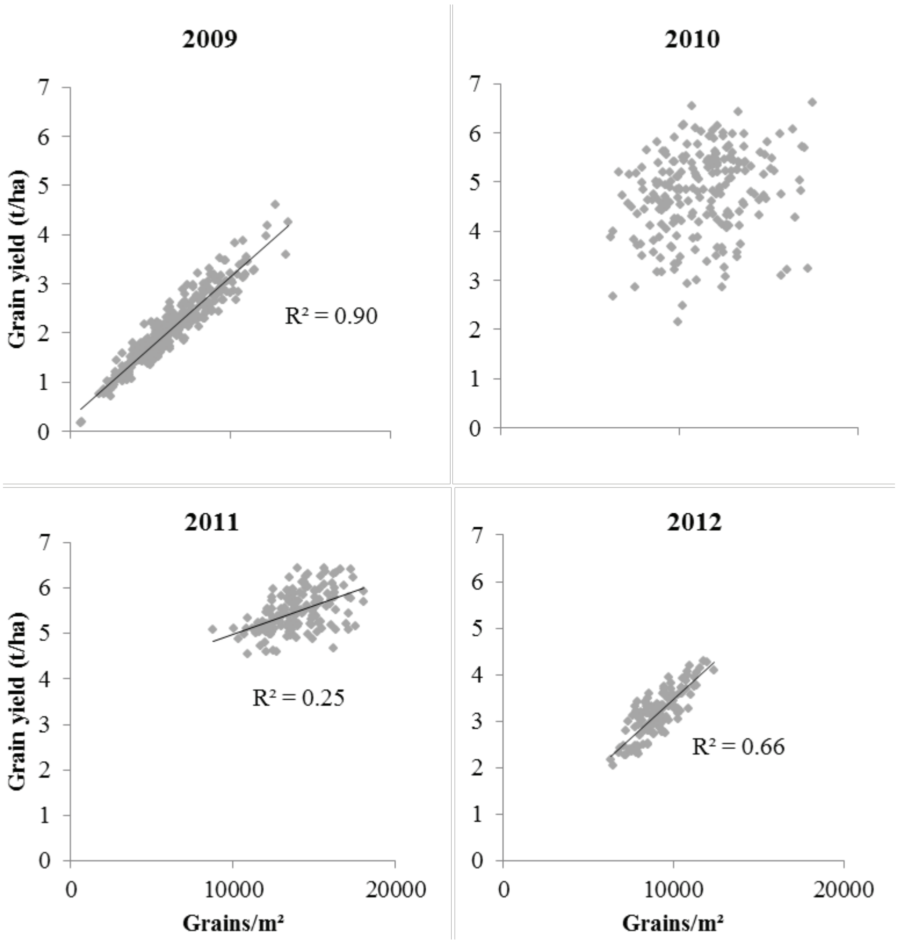

Figure 3: Regression of grain number (grains/m^2) and grain yield of wheat in variety by time of sowing experiments from 2009 to 2012 at Trangie Agricultural Research Centre was significant in all experiments ($p<0.001$) with the exception of 2010. The relationship was strongest in the drier years 2009 and 2012.

Conclusions

Wheat growers in the Western Plains region of NSW have historically managed crops conservatively, the aim being to limit the amount of stress on the crop during the grain filling phase, especially in dry years. Taking the two drier years of 2009 and 2012 in this research as an example, the efforts of these growers may be counter-productive, as it was the drier years where GN most strongly related to GY. Only in one of these drier seasons (2012) did GW have a significant effect on grain yield.

References

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