Wheat time of sowing and cultivar selection can be used to manage risk in low rainfall southern Australia.

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Abstract
The optimal window for sowing mid-season maturity wheat varieties is relatively short in low rainfall systems. Using a range of maturity type and sowing time combinations may provide flexibility that enables a greater proportion of the farm to be sown at optimal sowing time. A study at Minnipa Agricultural Centre measured grain yield in response to wheat maturity type and time of sowing over two growing seasons. Both seasons tested had above average growing season rainfall (>300 mm) and relatively long growing seasons. In one year the first time of sowing (early-May) had the highest grain yield and the third time of sowing (mid-June) the lowest yield, with early-mid season varieties (Mace and Wyalkatchem) having higher grain yields than both the early (Axe) and mid-late (Correll) season varieties at the first time of sowing. In the second year Axe had a higher grain yield than Mace at the third time of sowing. Further analysis of the potential on-farm application of using a range of maturity type and sowing time combinations was analysed using simulation modelling. By identifying the optimal flowering window for this environment, it was possible to modify cultivar selection to suit a range of sowing dates. These combinations were then analysed for the distribution of potential yield outcomes.

Introduction
In southern Australia, dryland farming systems require crop production systems that are resilient to the occurrence of reduced and unseasonal rainfall, increased mean temperature, and extreme events such as heat waves and droughts. Opportunities to address these challenges may be possible through growing wheat varieties with a range of maturities. Trials were established at the Minnipa Agricultural Centre, Eyre Peninsula to measure the comparative performance of a range of wheat maturity types in response to time of sowing (TOS) in two different growing seasons. The possibility of selecting maturity type relative to sowing window being used as an agronomic management tool was further explored using the APSIM crop model.

Materials and Methods
Field Experiments
The experiments were established on the Minnipa Agricultural Centre *on a sandy clay loam (lithocalcic calcarosol, Isbell, 1997) with 0.6 m depth to chemical constraints. Total mineral nitrogen (N) (kg/ha, 0-0.6 m) and Colwell extractable phosphorus (P) (mg/kg, 0-0.1 m) were measured from samples collected pre-sowing (23 April 2009 and 24 May 2010).*The field experiment had a completely randomised block design with treatment factors of TOS and cultivar with four replicates of each treatment. The levels of treatment for each factor for the two growing seasons are detailed in Table 1. In both years fertiliser was banded below the seed at sowing as mono-ammonium phosphate (MAP) at 55 kg/ha to supply 10 kg/ha of N and 11 kg/ha of P. Plots received pre-seeding glyphosate and trifluralin and post emergent broad-leaf weed control. **Plots were biomass sampled at specific individual variety growth stages and machine harvested at maturity with total grain weighed, yield calculated and a subsample assessed for grain protein content and test weight.** There was no recorded temperature below 2^{o}C in either year.

Table 1. Varieties sown at 3 sowing dates in 2009 and 2010 in response to 10 mm or greater rainfall events with the growing season rainfall available from each time of sowing (TOS)

Year		*TOS 1*	*TOS 2*	*TOS 3*
2009	***Varieties: Axe, Wyalkatchem, Mace, Gladius, Correll***	***4 May***	***26 May***	***18 June***
	Growing season rainfall (mm)	***297***	***272***	***222***
2010	***Cultivars: Axe, Wyalkatchem***	***25 May***	***11 June***	***1 July***
	Growing season rainfall (mm)	***300***	***256***	***233***

Modelling Experiments

The **APSIM** wheat model was used to simulate crop production **(**Keating et al. 2003**)** at Minnipa Agricultural Centre on the sandy clay loam soil, for the season types 1960-2010, with variation in sowing date and cultivar, and this site has been parameterised for APSIM previously (in Whitbread et al. 2011). Sowing dates were with the occurrence of 10mm of rain or at window end in 15 day sowing windows between March 15 and July 15. The cultivars used were early (H45), mid (Gladius), late (spring type-Bolac) and late (winter type-Wedgetail).

Results and Discussion

Field Experiments

In 2009 total mineral N was 117 kg/ha, while Colwell P was 33 mg/kg. Both sowing soil N and P were well above the critical values for nutrient deficiency. The effect of the interaction between TOS and cultivar on biomass, grain yield and grain quality was significant in 2009. As expected biomass production was greater with a longer growing season for TOS 1 plots, but there was not a direct relationship between the highest biomass producing and the highest grain yielding treatments. Within TOS 1, early maturing wheat was lowest yielding while early-mid Mace was highest yielding, and all yields were higher than yields produced at TOS 2 and 3. At TOS 2, the early maturing variety was again the lowest yielding wheat, while all other varieties produced similar yields. At TOS 3, yields were less than TOS 1 and 2, and early-mid Mace produced a better yield than early-mid, mid and mid-late wheats which was an equivalent yield to early maturing Axe. Within each TOS, protein was significantly greater for later maturing varieties, and the most consistent protein levels were produced at TOS 2. In contrast, within a TOS, test weights tended to be higher for the early maturing varieties.

Table 2. 2009 anthesis biomass, grain yield, protein content, and test weight of wheat varieties in response to maturity type and time of sowing

TOS	Cultivar	Maturity Type	Anthesis (tDM/ha)	Grain yield (t/ha)	Protein (%)	Test weight (g/hL)
1	Axe	Early	7.7	4.3	11.1	83.7
1	Mace	Early-Mid	5.9	4.9	11.0	82.7
1	Wyalkatchem	Early-Mid	6.1	4.7	12.6	80.8
1	Gladius	Mid	7.4	4.7	12.0	81.8
1	Correll	Mid-Late	7.0	4.4	12.3	79.7
2	Axe	Early	5.2	3.3	11.3	82.1
2	Mace	Early-Mid	5.8	3.6	11.4	83.0
2	Wyalkatchem	Early-Mid	5.7	3.8	12.3	82.3
2	Gladius	Mid	5.6	3.6	12.2	81.3
2	Correll	Mid-Late	5.3	3.7	12.2	80.2
3	Axe	Early	4.5	3.0	10.9	82.1
3	Mace	Early-Mid	3.2	3.1	10.9	80.8
3	Wyalkatchem	Early-Mid	5.0	2.8	11.7	81.1
3	Gladius	Mid	4.3	2.8	11.9	80.0
3	Correll	Mid-Late	4.8	2.8	12.2	77.2
LSD ($P \leq 0.05$) TOS x cultivar			*1.6*	*0.3*	*0.4*	*1.7*

In 2010 pre-seeding total mineral N at 76 kg/ha and Colwell P at 24 mg/kg were close to a deficiency value. The interaction between TOS and maturity type had a significant effect on all measurements. Axe produced lower dry matter at TOS 1 and 2, and lower grain yields at TOS 2, but a higher yield at TOS 3. Grain proteins were higher with lower yields at a given TOS, and test weights were higher at TOS 2 and 3.

Table 3. Wheat biomass at stem elongation, grain yield and protein content, and test weights in response to maturity type and time of sowing in 2010

TOS	Cultivar	Maturity Type	Stem elongation (tDM/ha)	Grain yield (t/ha)	Grain protein (%)	Test weight (g/hL)
1	Axe	Early	0.7	3.0	11.8	74
1	Wyalkatchem	Early-Mid	1.1	3.0	11.8	74
2	Axe	Early	0.8	2.8	12.0	77
2	Wyalkatchem	Early-Mid	1.4	3.4	10.5	77
3	Axe	Early	0.9	3.5	10.5	77
3	Wyalkatchem	Early-Mid	1.0	3.2	10.8	77
LSD ($P \leq 0.05$) TOS x cultivar			*0.2*	*0.3*	*0.3*	*1*

The anticipated fit of an early maturing variety is for use when the sowing opportunity becomes late and the yields produced in the two years of field trials support this when comparing early maturing Axe with the Wyalkatchem early-mid maturity type.

Modelling Experiments

To identify the optimal sowing window, the 100 year climate data was analysed for Minnipa Agricultural centre to generate the probability of either a heat (>30ºC) or frost (<2ºC) shock occurring. The occurrence of frost risk is quite low at Minnipa, and it is the occurrence of heat shock that is likely to be a greater limitation for crop production in this environment (Figure 1). The optimum flowering date is in early September, due to the rapidly increasing risk of temperatures >30 ºC after this date and a frost probability of only 1%. Care is required when regionally extrapolating this flowering window within the region, as Wudinna for example, which is 35 kms away, has a significantly higher frost risk in the Winter months (Bureau of Meterology Climate Data, accessed 2012).

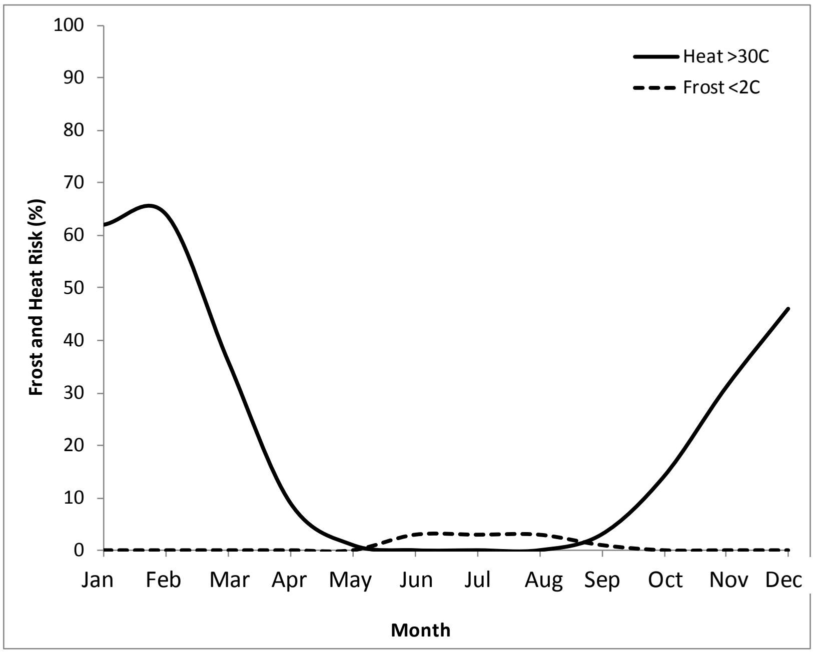

Figure 1. Average frost (<2ºC) and heat (>30ºC) risk for each month at Minnipa Agricultural Centre based on 100 year climate data (Bureau of Meterology Climate Data).

The mean simulated wheat yields suggest that, as expected, the early maturing wheat types yielded best when sown late in the window 1-15 June, and the resultant flowering date of 19 September coincides with a relatively low heat shock risk (Figure 2.A). Mid-maturing varieties yielded best on sowing dates between 1 May to 15 June, however the flowering date from the last sowing window of 1 to 15 June increased the risk of heat shock to approximately 10% (Figure 2.B). The use of late maturing spring type wheat had maximum mean yield when sown quite early in the window 16 April to 15 May and the resultant flowering date had a heat shock risk of approximately 5% (Figure 2.C). Finally late maturing winter wheat required sowing early on 15-30 of April, and at this sowing time had a similar heat risk of 5%, however winter wheat had a rapid drop off in mean yield for sowing dates beyond this window.

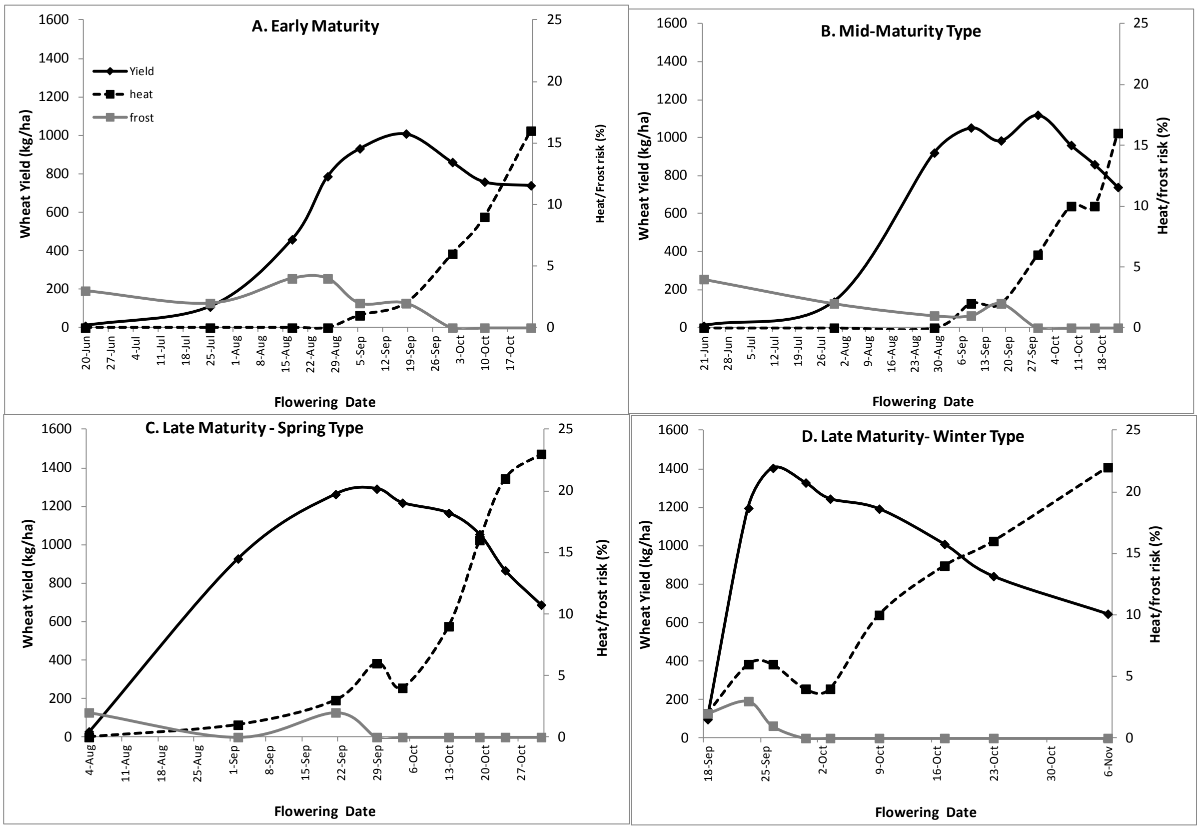

Figure 2. The modelled mean (1950-2010) wheat yield (kg/ha) for A. Early maturing, B. Mid maturing, C. Late maturing- spring type and D. Late maturing-winter type wheats sown at 2 week intervals from the 15th of March to the 15th of July at the Minnipa Agricultural Centre. The different sowing dates are represented by their resultant sequential flowering dates and the relationship of this resultant flowering date with heat and frost risk is shown using the dashed line and grey line respectively.

Conclusions

The results from two above average rainfall seasons demonstrate the benefit of early sowing of early-mid varieties (Wyalkatchem and Mace), while a shorter season variety (Axe) offered yield benefit at a later sowing date. Simulation modelling was in agreement with these findings; early maturing varieties were only of benefit at very late sowing dates, mid-maturing varieties were the best yielding cultivars across a longer sowing window, while the later maturing cultivars had very early optimal sowing dates to avoid heat and frost shock during flowering.

References

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