Agronomic adaptions to a changing climate

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Take home messages

- *Sowing too early exposes a crop to a high frost risk at flowering.*
- *Sowing too late exposes a crop to heat shock risk during grain fill.*
- *Use Yield Prophet to determine the least-risk sowing window for the varieties you are planning to sow in 2011.*

Background

Australian grain growers farm in one of the most variable climates in the world. The evidence is now clear that the climate is changing and that future crop production will have to contend with not only a higher atmospheric CO2 content (which changes the rate at which a plant grows) but also alterations in rainfall patterns, higher temperatures during grain fill and higher evaporation rates.

BCG is involved with two projects which investigate (i) the impact of the Millennium drought on the production and financial situation of farms in our region and (ii) the nature of the agronomic adaptations farmers can make to ensure that their production methods are more resilient to future climatic conditions. This paper reports on the agronomic adaptations component of the work.

Aims

To trial and demonstrate two possible agronomic adaptations to a changing climate:

(i) to sow wheat varieties earlier to reduce the possibility of heat shock events during grain fill whilst taking into account the frost risk.

(ii) to sow more than one variety in the one paddock as a mix to ensure that the whole crop is not susceptible to frost and heat shock at the same time.

Method

(i) A replicated trial investigating the impact of different sowing dates on two wheat varieties using different sowing rates and fertiliser N rates was established at Culgoa.

Location:	Culgoa
Treatments:	Time of sowing x two varieties x two seeding densities x two N rates
Replicates:	4
Crop type:	Wheat: Yitpi (mid season) and Axe (short season)
Sowing dates:	16 April and 19 May, 2010

Seeding density:	100 and 150 plants/m²	
Fertiliser:	At sowing	50kg/ha MAP
	23 June	50kg/ha Urea
	28 July	80kg/ha Urea (high N treatment only)
Seeding equipment:	Knife point, press wheels, 30cm row spacing	

(ii) Two on-farm demonstrations with similar treatments to the replicated trial at Culgoa were established.

The sites were sown and harvested with farm machinery. One site was located near Birchip the other near Swan Hill. Four adjacent strips containing four treatments were sown down the length of a paddock. Each treatment was 150m long and the width of an air-seeder. The total length of the trial, including buffer areas, was 700m.

Location:	Birchip and Swan Hill	
Treatments:	Time of sowing x two varieties x two seeding densities x two N rates	
Crop type:	Wheat: Yitpi (mid season) and Axe (short season)	
Sowing dates:	Birchip - 20 May and 7 June; Swan Hill - 27 April and 27 May	
Seeding density:	100 and 150 plants/m²	
Fertiliser:	*Birchip*	
	At sowing	50kg/ha MAP (5kg N/ha)
	26 July	50kg/ha Urea (23kg N/ha) - High N plots
	Swan Hill	
	At sowing	50kg/ha MAP (5kg N/ha)
	6 July	40kg/ha Urea (18kg N/ha) – High N plots
		20kg/ha Urea (9kg N/ha) – Low N plots
Replicates:	1	
Trial Design:	Nearest neighbour	
Previous crop:	Vetch (Birchip), Wheat (Swan Hill)	
Seeding equipment:	Knife point, press wheels, 30cm spacings	

(iii) A replicated trial at Culgoa investigating the impact of sowing two wheat varieties with differing maturity in the same plot.

Location:	Culgoa	
Treatments:	Mix of Yitpi (mid season) and Axe (early season); and mix of Correll (mid season) and Young (mid-early season)	
Replicates:	4	
Crop type:	Wheat	
Sowing date:	19 May, 2010	
Seeding density:	150 plants/m² (equal amounts of each variety)	
Fertiliser:	19 May	50kg/ha MAP
	23 June	50kg/ha Urea
Seeding equipment:	Knife point, press wheels, 30cm row spacings	

Results

(i) Replicated trial at Culgoa (Time of sowing x two varieties x two seeding densities x two N rates).

Changing the time of sowing of varieties with different maturities is one of the main risk management strategies that farmers can employ to reduce the chances of frost and heat stress during flowering and grain-filling. It is generally the case that crops sown early have a higher yield potential compared with crops sown later. However, the risk profile of a sowing date changes with different varieties. In the trial we compared the early season wheat variety, Axe, with the mid-season variety, Yitpi.

Crop growth of Axe and Yitpi sown in April and May were simulated using Yield Prophet®. The simulated yield for mid-April sown crops (at 50% probability) was higher compared with the yield for mid-May sown crops. However, the frost risk was much higher for the early sown crops and the heat shock risk was higher for the later sown crop (Table 1).

Table 1. Simulated yield, expected flowering time and frost and heat shock risk for two varieties at two sowing dates.

Variety	Sowing date	Simulated yield# t/ha	Expected flowering date	Moderate frost* (% of years)	Moderate heat shock* (% of years)
Axe	16 April	3.0	9 Aug	29	0
	19 May	2.5	15 Sep	6	7
Yitpi	16 April	3.4	22 Aug	19	0
	19 May	2.6	2 Oct	2	17

\# *Simulated yield from Yield Prophet (using APSIM).*

* *Moderate frost refers to 0 to -2°C; Moderate Heat shock refers to 34 to 36°C.*

We tested the above theory of frost and heat shock risk by placing electronic temperature sensors at head height in the crop. There were several frosts during the 2010 season which coincided with flowering of the two varieties sown at two different dates. Figure 1 outlines the frost occurrences in relation to the flowering time of the two varieties sown at two different times of sowing. A severe frost occurred during 6, 7 and 8 August which corresponded with the flowering of the April sown Axe (refer to Table 1).

Crop yield

The early sown crop, 19 April, was sprayed twice for locust control in early May but unfortunately the locust pressure was such that most of the young plants were eaten down to ground level and only a few plants survived. The early sown plots had to be abandoned; the following discussion on yield response due to different treatments applies only to the second time of sowing.

Seeding rate

Both varieties were sown at 100 and 150 plants/m^2 (equivalent to 41 and 62kg/ha for Axe, and 46 to 69kg/ha for Yitpi). Sowing crops at lighter densities may be an adaptation suited to drier autumns because fewer plants would use less water compared with higher seeding density. In this trial, no effect of seeding rate on yield or protein was observed, but the screenings were slightly higher at the higher seeding rate (for example for Axe from 5.2 to 6.5% screenings for the low and high seeding rate respectively, $P<0.01$, LSD=1.2%). The increase in screenings for Yitpi was similar and also significant.

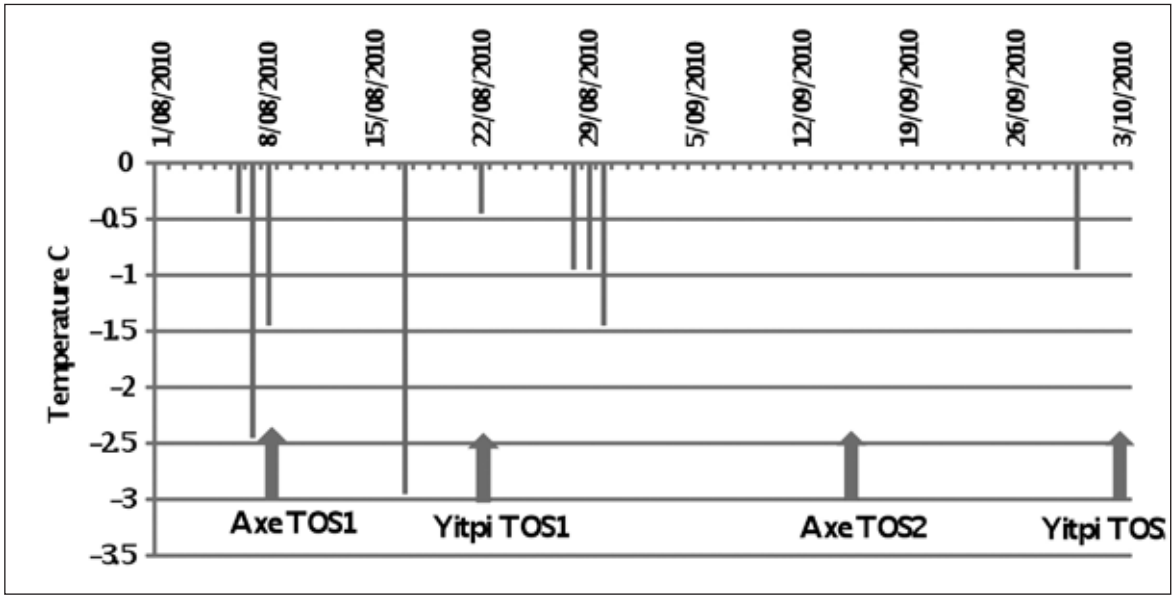

Figure 1. Occurrence of frost during the flowering period in 2010. The flowering time of the variety by time of sowing is represented by the arrows.

N application

The crop was sown with 5kg N/ha and a further 23kg N/ha was top-dressed on 23 June. In late July, Yield Prophet showed a high probability (80%) of achieving an economic response to more N and half of the plots were top-dressed on 28 July with 37kg N/ha. The yield response to the July topdressing of N was highly significant: 0.6t/ha (in Axe from 3.6 to 4.2t/ha; in Yitpi from 3.2 to 3.9t/ha; $P<0.001$, LSD 0.3t/ha). The effect on grain protein of top-dressing N was also significant (Axe from 9.4 to 9.8%; Yitpi from 8.9 to 9.3%; $P<0.01$, LSD 0.4%). The second top-dressing of N did not affect screenings.

(ii) On-farm demonstration at Birchip and Swan Hill (time of sowing x variety x seeding rate x N rate)

Birchip:

The site was located in a paddock with moderate subsoil limitations (40 to 70cm layer had chloride reading of 1800ppm, and an EC of 0.6dS/m). The site had a previous legume history and was high in soil available N (prior to sowing the soil contained 230 kg available N/ha to 1m depth).

The first sowing took place on 16 April, but had to be abandoned because of extensive locust damage to the crop at the two to three leaf stage. The second sowing occurred on 20 May. There was no regrowth after the locust damage on the first time of sowing and these strips were re-sown on 7 June.

The growing season rainfall at the site was 348mm (decile 10) and the crop yield was exceptional at an average yield of 5.8t/ha. Throughout the season, Yield Prophet simulated a high probability of obtaining a 6t/ha crop, assuming the rainfall fell at the right time. Yield Prophet simulations during the season also determined that there would be no response to in-crop N applications.

No differences in yield were obtained between the two varieties, Axe and Yitpi, and there was also no response to time of sowing, seeding rate or in-crop N application (Table 2).

Table 2. Birchip on-farm demonstration, yield results for Axe and Yitpi at two times of sowing, two seeding rates and top-dressing of N fertiliser.

Time of Sowing	Seeding Rate (plants/m^2)	Top-dress (kg N/ha)	N Yield (t/ha)	
			Axe	Yipti
20 May	100	0	5.7	5.4
20 May	150	0	5.9	5.8
20 May	100	23	5.9	5.7
20 May	150	23	5.8	5.7
7 June	100	0	5.7	5.9
7 June	150	0	6.0	5.8
7 June	100	23	5.4	5.8
7 June	150	23	5.9	5.8

The on-farm demonstration was laid out as a nearest neighbour design, there were no significant differences in yield between treatments.

Swan Hill: The site was located on a Mallee land system, on a flat to sloping rise with a sandy loam soil to a depth of 40cm and at greater depth a sandy clay loam to at least 130cm. The soil has no subsoil limitations but because it is light and sandy, leaching of nutrients can be a problem. 2010 had a growing season rainfall of 329mm (decile 10).

The first sowing occurred on 27 April, with the second a month later on 27 May. On 16 July, treatment plots were spread with either 9 or 18kg N/ha. The plot yields are presented in Table 3. There was a large amount of variation in yield between treatments and no consistent yield response could be ascertained. The plots with the shaded yields in the table yielded very well and were located towards one end of the trial on a sloping rise. It is thought that soil type variation had a greater effect on yield than the treatments.

Yield Prophet simulations showed that all treatments were nitrogen limited towards the end of the season. Over the critical spring months when the crop was flowering and filling, 185mm of rain fell. On sandy soils, this would have resulted in leaching of available nitrogen. Yield Prophet simulated nitrogen non-limited yields for Yitpi were in the 5 to 6t/ha range.

Table 3. Swan Hill on-farm demonstration, yield results for Axe and Yitpi at two times of sowing, two seeding rates and top-dressing of N fertiliser (the shaded results refer to higher yielding plots as a result of soil variation).

Time of Sowing	Seeding Rate (plants/m^2)	Top-dress (kg N/ha)	N Yield (t/ha)	
			Axe	Yipti
27 April	100	9	2.75	2.61
27 April	150	9	3.17	3.37
27 April	100	18	1.43	2.57
27 April	150	18	2.26	4.10
27 May	100	9	3.50	3.51
27 May	150	9	1.47	1.82
27 May	100	18	3.32	3.24
27 May	150	18	2.55	2.46

(iii) Replicated trial at Culgoa of a mixed sowing of two varieties – one mid season, the other early season

Another strategy to reduce the risk of frost at flowering and heat shock at grain-filling is to sow two varieties of wheat with different flowering times in the same paddock. This strategy will ensure that not all the wheat in the paddock is flowering at the same time in the event of a frost. Similarly for heat shock: not all of the wheat will be grain-filling at the same time. In this trial, two replicated treatments of a mid season and early season wheat variety were mixed and sown together (we used mixes of Yitpi and Axe; and Correll and Young). In each mix there was a two week difference in the flowering time between the two varieties (Table 4).

Table 4. Simulated flowering dates for each variety in the sowing mix, Culgoa.

Treatment 1 - Mix	Flowering date	Treatment 2 – Mix	Flowering date
Axe	15 September	Young	23 September
Yitpi	2 October	Correll	8 October

The yield of both treatments was 3.8t/ha, protein 9.4% and screenings 5%. There were no significant differences between the two mixes of wheat varieties.

If the practice of mixing two varieties of wheat is used, then the delivery of the grain produced must be considered. If two varieties of different classification were sown, the lowest classification must be stated at delivery. In addition, if plant breeder royalties need to be paid, then delivering alternative loads of each variety will overcome payment issues.

Interpretation

BCG is investigating a range of practices which will improve our ability to manage farm production in a highly variable and changing climate. In the future, managing the farm will be even more dependent on sound business practices and linking the potential of the land to the season. Through programs such as Yield Prophet®, BCG is providing farmers with tested tools to:

- assess the impact of likely rainfall outcomes during the season on yield
- determine variety flowering time by date of sowing, to assist in developing least frost and heat shock risk sowing windows
- identify when crops are likely to be nitrogen limiting and work out the dollar return on in-crop N application

All of this will assist in better decision making before and during the season.

The agronomic adaptations to manage climate change in this year's trial work were focused on gaining a better understanding of the impact of time of sowing on when a particular variety is likely to flower. The aim was to minimise the risk of frost and heat shock damage during flowering and grain filling.

Acknowledgments

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