Managing frost risk through better wheat agronomy

Mohammad Amjad and Ben Biddulph, Department of Agriculture and Food Western Australia (DAFWA) Northam and South Perth

AIM

To investigate adaptation of new wheat varieties in their resilience to frost stress during the growing season.

TRIAL DETAILS

Property: Gary Lang
Plot size & replication: 1.54 m x 20 m & 3 replication
Soil type: Sandy
Crop Variety: 24 varieties
Application Date: Pre-emergent at seeding - 18 May, 08 June Post-emergent – 18 July
Sowing Date: 18 May 2012 & 08 June 2012
Seeding Rate: 150 plants/m2 (i.e. Mace @ 80 kg/ha)
Fertiliser (kg/ha): Agras N0 1@110 kg/ha, 50 kg Urea
Paddock rotation: Lupins 2011
Herbicides: Pre-emergent - Glean 25 gm, Treflan 480 1.5 Lt, Sprayseed 250 4.0 Lt
Post-emergent – Bromicide 1.4 Lt, Crusher 0.5 Lt

BACKGROUND

Radiant frost risk in spring is the single most important issue affecting the wheat yield and profitability in the central agricultural region. Recent frost research by Biddulph (2012) reported that damage to crops from frost may occur at any stage of development but is most damaging at and around flowering. Symptoms of frost damage can occur as sterility and stem damage. Physical damage to the plant occurs when ice forms inside the plant tissue, as expanding ice bursts membranes, resulting in mechanical damage and dehydration injury (Biddulph, 2012). Frost generally damage and reduce both yield and grain quality.

New wheat cultivars may differ in their resilience (i.e. ability to yield or maintain quality) in response to stresses of radiant frosts. Agronomy trials were conducted to assess current and new varieties and elite lines for managing frost risks in aligned with Ben Biddulph's pre breeding frost studies at Merredin.

METHODOLOGY

Twenty-four wheat cultivars were sown at two different times, starting at close to the break (dry sowing, 18 May) and late sowings (following at approximately 3 week interval, 8 June). The trial was sown in a split plot design across three banks, with time of sowing as main plots and varieties were randomised as subplots. The following data was collected during the spring season:

- Heading date for varieties (24 varieties x 2 TOS x 3 reps = 144 plots)
- Tag 30 plants per plot @heading
- Flowering date for varieties
- Collect/clip heads @ maturity

The trial was machine harvested at maturity and grain quality samples were collected.

RESULTS & DISCUSSION

The trial site was closely monitored for weeds, insects and diseases throughout the growing season. Plant establishment data was collected and matched very well with the target plant population sown at both time of sowings.

Flowering date

The ear emergence (heading) and flowering (anthesis) dates for different varieties were observed at two sowing dates (Table1). Calingiri and Magenta flowered late on 3rd Oct and 29 Sep when sown on 18 May where as all other varieties flowered earlier. The new tool "Flower Power" was also used to predict the flowering date for different varieties at two sowing dates at Wickepin. The flower power is an online tool to predict when wheat varieties flower in Western Australia and display frost and heat risk (http://grains.agric.wa.gov.au/flower-power). The predicted flowering dates for different varieties were 4 to 14 days and 2-5 days earlier than observed flowering at earlier sowing (18 May) and late sowings (8 June) (Table 1). This tool has given some prediction of flowering time and frost risks but data on new varieties is not yet included in the model.

	TOS1 (18 May)			TOS1 (18 May)		
Variety	**Heading**	**Flowering**	***Predicted flowering date using Flower Power***	**Heading**	**Flowering**	***Predicted flowering date using Flower Power***
Calingiri	29-Sep	3-Oct	*19-Sep*	5-Oct	9-Oct	*5-Oct*
Cobra	11-Sep	17-Sep		29-Sep	3-Oct	
Corack	11-Sep	17-Sep		24-Sep	29-Sep	
Correll	17-Sep	21-Sep		5-Oct	9-Oct	
Eagle Rock	17-Sep	21-Sep	*17-Sep*	3-Oct	5-Oct	*3-Oct*
Emu Rock	11-Sep	17-Sep		24-Sep	29-Sep	
Envoy	17-Sep	21-Sep	*12-Sep*	29-Sep	3-Oct	*30-Sep*
Estoc	17-Sep	21-Sep		29-Sep	3-Oct	
Fortune	21-Sep	24-Sep	*18-Sep*	5-Oct	9-Oct	*4-Oct*
GrenadeCL plus	17-Sep	21-Sep		29-Sep	3-Oct	
ImposeCL plus	11-Sep	17-Sep		29-Sep	3-Oct	
JusticaCL plus	17-Sep	21-Sep		5-Oct	9-Oct	
Mace	11-Sep	17-Sep	*14-Sep*	29-Sep	3-Oct	*1-Oct*
Magenta	24-Sep	29-Sep	*19-Sep*	5-Oct	9-Oct	*6-Oct*
Scout	21-Sep	24-Sep		3-Oct	5-Oct	
Wyalkatchem	17-Sep	21-Sep	*12-Sep*	3-Oct	5-Oct	*30-Sep*
Yitpi	17-Sep	21-Sep	*26-Sep*	3-Oct	5-Oct	*8-Oct*
Young	11-Sep	17-Sep		24-Sep	29-Sep	
Zippy	11-Sep	17-Sep	2-Sep	24-Sep	29-Sep	*24-Sep*

Table 1: Heading date and flowering date observed and predicted (using Flower Power) for different varieties at two times of sowing at Wickepin in 2012 (data on unreleased cultivars is not included)

Grain yield

The prolonged cold temperature during the growing season (Fig. 1) followed by few heavy frost events on the site (Table 2) resulted in reduced grain yield for all varieties in both May and June sowings (Table 3). Early sown crop on 18 May was more severely damaged by frost (site mean yield 0.41 t/ha) compared to June sowing (site mean yield 1.41 t/ha). Varieties sown on 18 May yielded less because they flowered fully in the frost damage window (mid to late September). Crops sown on 8 June flowered late (late September to early October) and avoided some of early frost damage.

Longer season varieties such as Calingiri and Magenta avoided the frost damage to greater extent and yielded around 1t/ha and 2 t/ha in May and June sowings. Comparatively longer season cultivars might better suited to avoid some of the frost damage if sown late and thus flowered later than shorter season varieties.

The tagged 20-30 heads were clipped at 6 different dates depending on the physiological maturity of variety (22-Oct, 31-Oct, 2-Nov, 8-Nov, 14-Nov, 22-Nov) from each plot for sterility estimates. The grain quality and sterility data is not available at reporting.

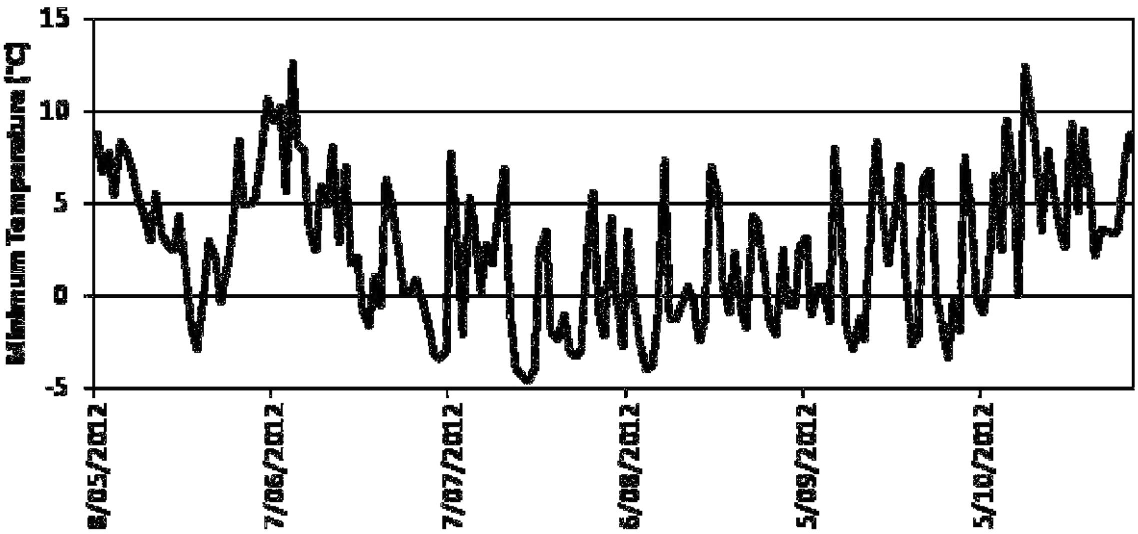

Figure 1: Minimum temperature recorded during 2012 growing season at Wickepin (Thanks to GRDC NVT for gathering data using the tiny tags on the nearby Canola NVT site)

Potential yield and economic cost of frost

The potential yield was estimated at 1.97 t/ha using the yield constraint calculator without frost at Wickepin (http://grains.agric.wa.gov.au/node/mycrop-interactive-wheat-diagnostic-tool). The Yield Constraint Calculator is based on the modified French and Shultz (1984) equation this tool estimates water-limited yield potential to account for soil plant available water capacity (PAWC), stored soil water at sowing and the gross amount of seasonal rainfall. The frost damage was estimated 50-80% reduction in grain yield with $150-$250/ha loss of income. As the grain quality data is being collected, therefore, the yield and economic cost of frost damage in different varieties by sowing dates is not yet available at reporting.

Frost event No.	1	2	3	4	5	6	7	8	9	10
Frost date	12-Sep	13-Sep	14-Sep	15-Sep	19-Sep	23-Sep	24-Sep	27-28 Sep	28-29 Sep	29-30 Sep

Table 2: Major frost events observed during spring in 2012 at Wickepin (Thanks to Facey Group for providing data)

Variety	TOS 1 (18 May)	TOS2 (8 June)
Calingiri	1.09	2.03
Cobra	0.25	1.36
Corack	0.14	1.43
Correll	0.67	1.67
Eagle Rock	0.56	1.28
Emu Rock	0.19	0.98
Envoy	0.25	1.44
Estoc	0.18	1.3
Fortune	0.31	1.58
ImposeCL plus	0.08	0.77
JusticaCL plus	0.58	1.78
Mace	0.41	1.4
Magenta	0.93	2.28
GrenadeCL plus	0.29	1.52
Scout	0.38	1.19
Zippy	0.13	1.18
Wyalkatchem	0.31	1.14
Yitpi	0.52	1.65
Young	0.22	1.27
Site mean yield	***0.41***	***1.41***
	LSD	F pr
Variety	0.33	0.004
TOS	0.26	<.001
Variety.TOS	0.47	0.358
CV	31.5%	

Table 3: The influence of sowing date on grain yield (t/ha) of different varieties at Wickepin (data on unreleased cultivars is not included)

CONCLUSION

The occurrence of frost and subsequent frost damage to grain crops is a complex phenomenon. The factors affecting frost damage in wheat crop include seasonal conditions (temperature, humidity, and wind), soils characteristics (topography, soil type), variety (maturity and flowering window) and agronomic management (sowing date, row spacing, and seed and fertiliser inputs).

In 2012, frost had significantly damaged and reduced the grain yield for all varieties at two different sowing dates at Wickepin. On average the later sowings (8 June) yielded 1 t/ha greater than the earlier sowings (18 May). Comparatively longer season varieties such as Magenta and Calingiri flowered late, avoided some of frost damage and yielded the highest at both sowings.

Preliminary results indicate varieties differed in their relative performance and resilience (i.e. ability to yield) in response to stresses of radiant frosts in both time of sowings. More comprehensive results on variety performance and frost damage will be available after measuring grain quality and sterility estimates.

Variety yield depends more upon flowering date than on other factors in frost prone areas at Wickepin. Delayed sowing was less effected by frost damage compared to earlier sowing. Similar findings were discussed in GRDC frost risk factsheet (http://www.grdc.com.au/uploads/documents/GRDC_FS_Frost.pdf). Delayed sowing especially of mid and long season varieties is one of the important tools to reduce the risk of crop loss due to frost. Growers may also use prediction tools such as 'Flower Power' and 'My Crop' in selecting and managing varieties to reduce the frost risks in their environments.

Further collaborative work will be planned in 2013 in managing frost and minimising damage through better agronomy and variety selection.

ACKNOWLEDGEMENTS

This research is jointly funded by DAFWA and GRDC through "Wheat Agronomy-building system profitability in the Western Region" (DAW00218). Thanks to Facey Group committee for approving and endorsing the wheat agronomy trials at Wickepin. Special thanks to Gary Lang for giving the trial site. Thanks to Bruce Haig and Rob deGruchy for trial management and technical support.