The influence of sowing date and species phenology on yield dynamics in frost conditions – Wallacetown 2017

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Key findings

- Although time of heading and flowering are considered the most sensitive stages for frost damage in cereals, sensitivity to early frost damage occurs from the start of stem elongation and is referred to as 'stem frost'.
- Stem frost can be minimised by matching sowing date and cultivar phenology so that stem elongation starts after the period of greatest frost risk.
- Varieties that started stem elongation early (fast developing varieties sown early) were exposed to an increased number of frosts during the susceptible development stages, whilst winter types sown early had an extended vegetative period and were not exposed to the same frost risk, which reduced damage from stem frost.
- Crops can recover from stem frost where there is moisture available to support new tiller growth. However, the resulting effect on phasic development stage synchrony leads to delayed maturity and harvest issues.
- There was no observed difference in frost tolerance of specific cereal species observed in 2017.

Introduction

Oats and barley have traditionally been categorised as more tolerant to frost than wheat. However, these claims are based on the susceptibility of oats and barley to frost damage at flowering (Knights et al. 2017). Matching phenology with an optimum sowing window can allow crops to flower when frost, moisture and heat stress are low, which typically occurs in early October in southern NSW (Riffkin et al. 2011; Harris et al. 2017). As earlier reproductive stages are also sensitive to frost damage, such as stem elongation during periods of high frost incidence and severity, yields can suffer.

Site details

Location	Wallacetown, NSW
Soil type	Red chromosol
Previous crop	Canola
Sowing	Direct drilled with DBS tynes, 250 mm row spacings Target plant density: 150 plants/m^2
Soil pH_{Ca}	4.7 (0–10 cm)
Mineral N at sowing	190 kg N/ha (1.2 m depth)
Fertiliser applied	98 kg/ha mono-ammonium phosphate (MAP) (11% nitrogen (N), 22.7% phosphorus (P), 2% sulfur (S)) at sowing 90 L/ha urea-ammonium nitrate (UAN) (42.5 % nitrogen) (2 July)
Weed control	Pre-emergent: Dual Gold® at 350 mL/ha, Diuron® at 350 g/ha Post-emergent: Lontrel™ at 60 g/ha, Precept® at 1.5 L/ha

Disease and pest management		
		Seed treatment: Hombre® Ultra at 2 mL/kg and Gaucho® at 1.2 mL/kg In-crop: Prosaro® at 300 mL/ha (19 June) Mascot® Duo at 240 mL/ha (2 November)
	In-crop rainfall	199 mm (April–October) (long-term average is 321 mm)
Treatments	**Varieties**	Wheat: Emu Rock⊕, Scepter⊕, Cutlass⊕, LongReach Trojan⊕, EGA Eaglehawk⊕, LongReach Kittyhawk⊕ Barley: La Trobe⊕, Commander⊕, Urambie⊕ Oats: Mitika⊕, Durack⊕, Bannister⊕
	Sowing date (SD)	SD1: 11 April 2017 SD2: 20 April 2017 SD3: 4 May 2017 SD4: 25 May 2017

Results

Fast developing varieties such as Emu Rock⊕ and La Trobe⊕ sown early (11 April) reached stem elongation in mid June, four weeks earlier than the winter wheat and barley varieties LongReach Kittyhawk⊕ and Urambie⊕. The number and severity of frosts during the 2017 season resulted in all varieties, regardless of maturity type, being exposed to frost from stem elongation through to flowering. However, the faster developing varieties were exposed to more frosts during the sensitive stem elongation phase and, as a result, suffered severe yield penalties.

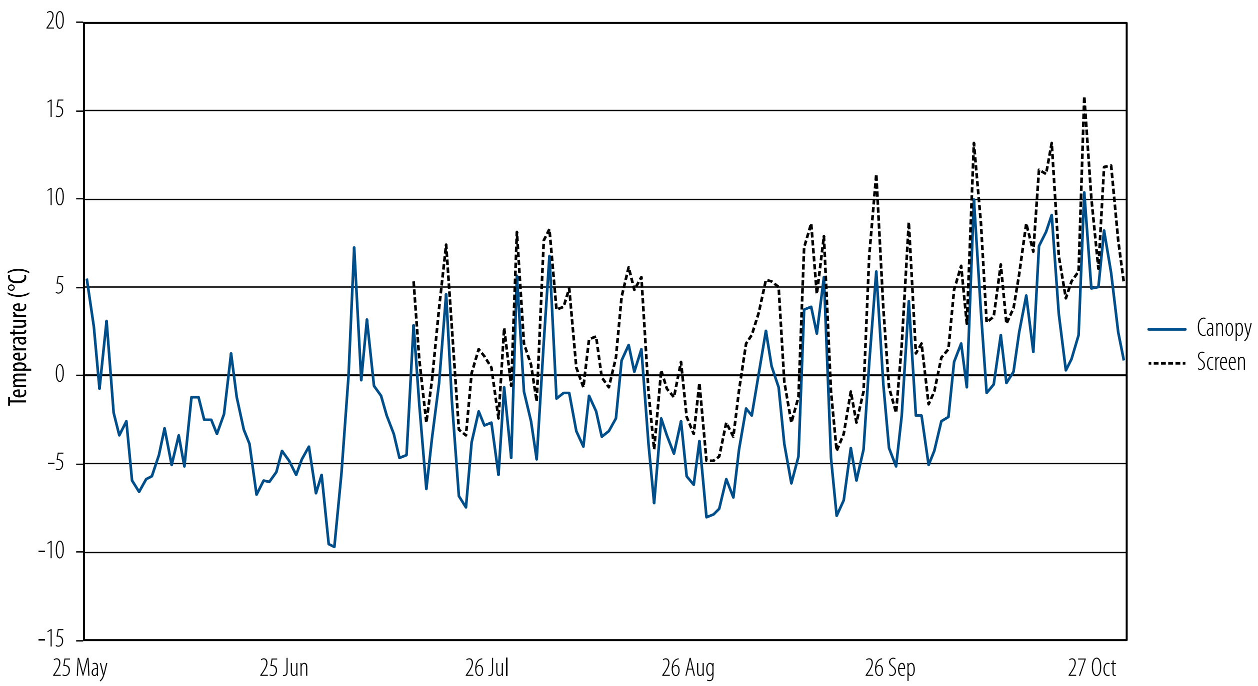

Figure 1. Minimum daily temperatures at the experiment site measured at the top of the crop canopy (solid line) using unshielded Tiny Tag data loggers (TGP-4017, manually moved up in 10 cm intervals through the season) and inside a radiation screen (dashed line) located on the paddock edge.

Slow developing winter wheat and barley varieties exhibited stable yields across all sowing dates. The vernalisation requirement in these varieties slowed the time to stem elongation (GS31). This allowed the winter varieties to avoid some of the stem frost damage.

Delaying the start of stem elongation through varietal selection and optimum sowing time for those varieties increased grain yields (Figure 2). Scepter⊕ was the highest performing wheat variety achieving 5.36 t/ha with a 25 May sowing date. Similarly, La Trobe⊕ performed the best from the later sowing, which emphasises the need to match sowing time with cultivar selection. Using winter type varieties stabilised yield across all sowing dates. LongReach Kittyhawk$^{\phi}$ wheat and Urambie$^{\phi}$ barley, with their relatively long vegetative period, only incurred minor stem frost damage and achieved yields between 4 t/ha and 5 t/ha (Table 2).

For earlier sowing dates, the yields achieved by the spring varieties such as Emu Rock$^{\phi}$ and La Trobe$^{\phi}$ were due mostly to regrowth after frost. Frost killed early-formed stems and tillers that had progressed rapidly to stem elongation. After the frost, tillers regrew and October rain supported grain filling. Varieties such as Scepter$^{\phi}$ and Cutlass$^{\phi}$ yielded well across all sowing dates, showing some flexibility in the 2017 season, undoubtedly attributed to the late rainfall that supported the grain fill in late formed regrowth.

The poor performance of the oats from the first two sowing dates, with only a slight yield improvement in the latter two sowing dates is due to limited phenological differences in the oat varieties used. All three varieties have fast to mid–fast development and hence should be sown mid to late May in frost-prone areas, to avoid frost exposure during sensitive development stages.

Despite the regrowth contributing a substantial amount of grain in early-sown spring cereal varieties, the regrowth resulted in sporadic and staggered flowering times, which could not be precisely measured. This led to delayed maturity in wheats as green regrowth continued through to late November and early December. The regrowth supported yields, however, harvest was delayed as immature spikes and stems had high moisture levels.

Table 2. Grain yield of the 12 varieties from the four sowing dates at Wallacetown, 2017.

Species	Variety	Phenology*	Yield (t/ha)			
			SD1: 11 Apr	SD2: 20 Apr	SD3: 4 May	SD4: 25 May
Wheat	Emu Rock	VF	2.84	2.83	3.43	3.99
	Scepter	MF	4.01	4.31	4.36	5.36
	Cutlass	MS	4.12	3.76	4.67	4.90
	LongReach Trojan	M	3.74	3.83	4.60	4.43
	EGA Eaglehawk	MS	3.76	3.63	3.77	3.56
	LongReach Kittyhawk	W	4.26	3.96	4.38	4.07
	Mean		3.79	3.72	4.20	4.38
Barley	La Trobe	F	2.09	2.49	3.88	5.00
	Commander	M	3.33	3.66	4.55	5.04
	Urambie	W	4.24	4.90	5.16	5.12
	Mean		3.22	3.68	4.53	5.05
Oats	Bannister	M	2.80	2.71	3.50	3.27
	Durack	F	2.35	1.92	2.86	2.53
	Mitika	MF	2.03	2.15	2.79	2.92
	Mean		2.39	2.26	3.05	2.91
l.s.d. (*P*<0.05) Yield		genotype	0.41	0.47	0.43	0.35
		wheat	0.27	0.25	0.19	0.35
		barley	0.30	0.52	0.24	0.15
		oats	0.46	0.42	0.35	0.24

* VF – Very fast, F – Fast, MF – Mid–fast, M – Mid, MS – Mid–slow, S – Slow, W – Winter

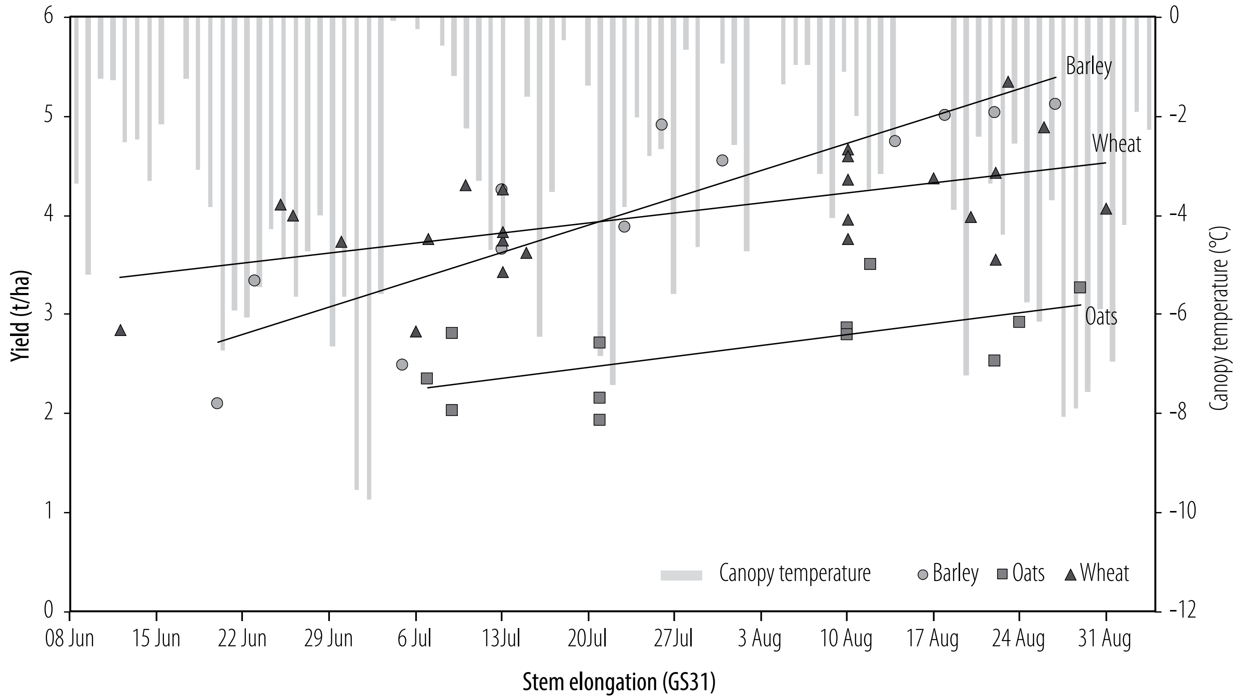

Figure 2. The relationship between the appearance of first node (GS31) and yield (t/ha) for the three cereal species used in the Wallacetown frost experiment. The incidence and severity of frosts measured at canopy height (shown in light grey bars) indicates the number of frosts when stem elongation occurred too quickly.

Summary

The 2017 season involved high frost incidence and severity, demonstrating the extent to which frost events can limit yield potential. Despite these seasonal conditions, the outcomes of the experiment emphasised that frost effects can be mitigated through matching phenology and sowing time, allowing the crop to reach sensitive stem elongation, heading and flowering stages post frost-risk period. Winter varieties performed well in this experiment having the most stable yields due to their longer vegetative phase. Faster developing wheats such as Scepter$^{\phi}$ and Cutlass$^{\phi}$ showed flexibility in the sowing dates in 2017 as the late rainfall allowed regrowth to mature after stem frost in the earlier sowings. This was the first year of an ongoing experiment, hence, further research in 2018 will improve our understanding of how frost interacts with different cereal species.

References

Harris, F, Koetz, E & Menz, I 2017, 'The effect of sowing date on phenology and grain yield of wheat in southern NSW 2016', www. grdc.com.au/resources-and-publications/grdc-update-papers/tab-content/grdc-update-papers/2017/02/the-effect-of-sowing-date-on-phenology-and-grain-yield-of-wheat-in-southern-nsw-2016, downloaded 26 April 2018.

Knights, S, Belford, R & Juttner, J 2017, *GRDC's National Frost Initiative – 2017 Southern Update*. Paper presented at the Grains Research Update.

Riffkin, PA, Eagles, HA, Eastwood, RF, Edwards, J, Fettel, NA, Martin, PJ, Simpfendorfer, S, Holloway, G, O'Leary, GJ, Hunt, JR, McClelland, T & Poole, N 2011, *Time of Sowing Fact Sheet*. Grains Research and Development Corporation: www.grdc.com.au/__data/assets/pdf_file/0019/100738/grdcfstimeof sowingsouthpdf.pdf, downloaded 16 January 2018.

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