Drivers of flowering time in durum

Melissa McCallum, Courtney Peirce & Kenton Porker, SARDI Waite

Key findings

- There is limited variation in flowering times of Australian durum varieties.
- The main driver of flowering time in durum is photoperiod – this means there are currently no durum varieties suited to pre-ANZAC day sowing, as they flower too early.
- Even the best performing durum varieties were unable to out yield Scepter in any environment, despite similar flowering times.
- Durum wheats have a greater susceptibility to frost and crown rot than bread wheats.

Why do the trial?

Flowering time is a crucial factor in determining yield and yield stability across seasons. To maximise yield it is essential to achieve flowering within the optimal period by sowing at the correct time for a given variety. Understanding of the flowering controls and development type and speed of varieties is essential to managing flowering time. This information is readily available for bread wheats with the optimum flowering period well defined for many areas in SA but is not available for durum wheats. By increasing our understanding of what drives flowering time in durum, yield and yield stability can be improved.

How it was done?

Plot size	1.75 m x 5.0 m	**Seeding date**	<u>Giles Corner (Tarlee)</u>	<u>Loxton</u>
			ToS 1 – 17th April	ToS 1 – 3rd May
			ToS 2 – 22nd May	ToS 2 – 4th June

The trial was a split-plot design with three replicates of 12 varieties (Table 1) at two times of sowing at two sites. The first time of sowing at each site was irrigated with 10 mm to ensure even establishment. Fungicides and herbicides were applied as necessary to keep the crop canopy free of diseas and weeds. Flowering date, frost induced sterility and yield components were measured at maturity and grain yield taken for each plot.

Table 1. Varieties used in field trials at Loxton and Giles Corner.

Scepter*	DBA-Aurora	Saintly	Yallaroi
Trojan*	DBA Spes	Tamaroi	Yawa
Caparoi	DBA Vittaroi	Tjilkuri	UAD 1154197

**indicates bread wheat varieties*

The controls of flowering time for durum were characterised in a controlled environment cabinet in The Plant Accelerator at Waite. The durum and bread wheat varieties included in Table 1 were compared with a range of durum breeding lines for photoperiod (day length) and vernalisation (cold period) requirements. Each pot was monitored for growth stages including stem elongation and flowering.

A more intensive flowering time experiment was conducted in the bird-proof enclosure at Waite Campus. The same 12 varieties were grown in double row x 1 m plots at six times of sowing, once every two weeks from the 10th April to the 19th June. These plots were monitored for growth stages including stem elongation and flowering.

Results and Discussion

Flowering time in durum is primarily driven by temperature and changes in day length (photoperiod). Results from the flowering time trial (Figure 1) showed that as photoperiod increased and sowing was delayed from April through to June there was a decrease in thermal time (growing degree days °C from emergence) to flowering. The controlled environment experiment showed that a few durum varieties respond to a cold period (vernalisation) to trigger flowering, however the response is facultative (will respond to vernalisation but is not always required) not obligate (requires vernalisation) because all varieties were able to flower without a cold period (Figure 2).

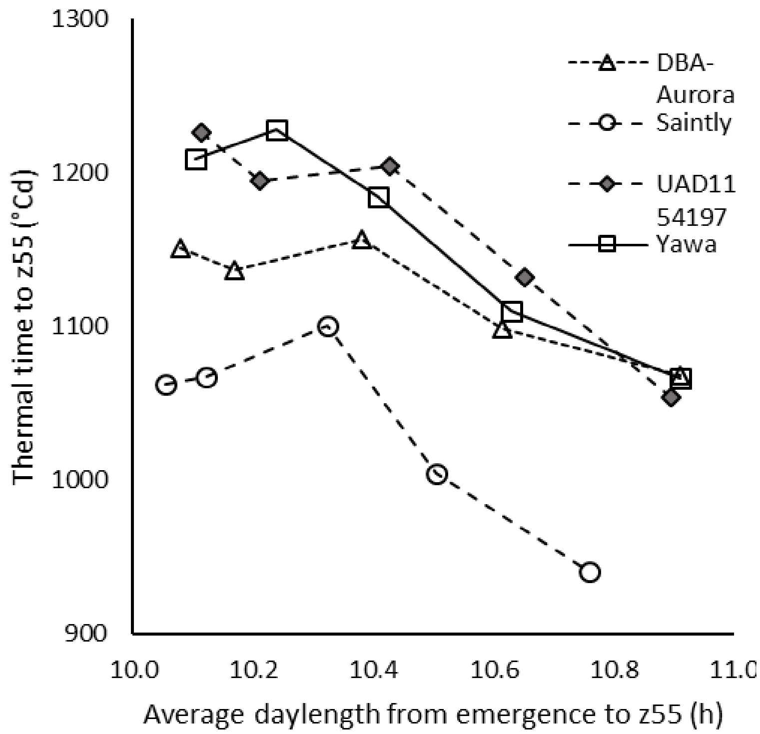

Figure 1. Average thermal time to heading (z55) against the average day length from emergence to heading for selected varieties at last five times (24 April – 19 June) of sowing in the bird-proof enclosure in 2018.

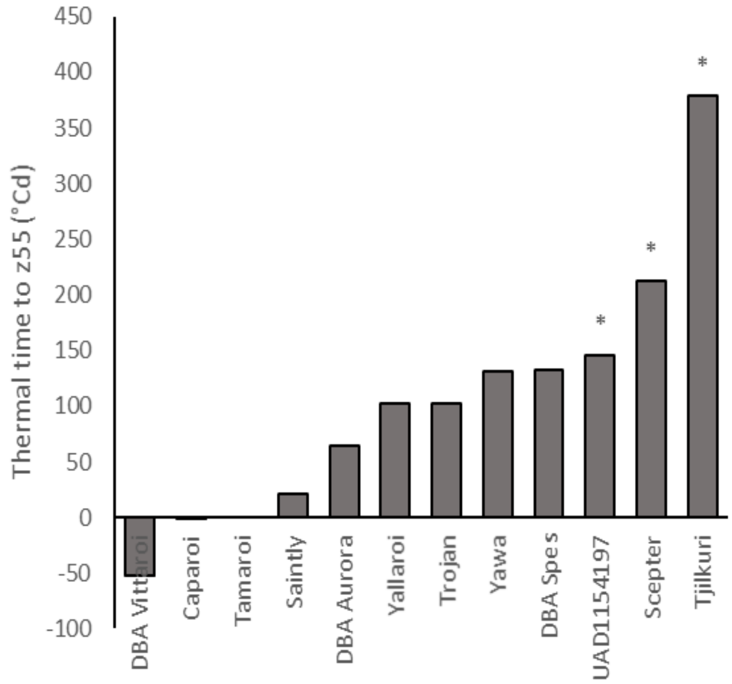

Figure 2. Vernalisation response of durum varieties and two bread wheats (Scepter and Trojan) grown at constant temperature of 22°C under an 18-h photoperiod. Vernalisation response calculated as difference in average growing degree days between non-vernalised and vernalised plants.
**Indicates the least significant difference between growing degree days of non-vernalised and vernalised plants (LSD. 133.2 °Cd; split-plot ANOVA, p≤0.05).*

Tjilkuri and UAD1154197 are responsive to vernalisation meaning a cold period will reduce the time to flowering but is not essential. From our field trials, Saintly and DBA Vittaroi appear to be the fastest developing durum varieties, while Tjilkuri, Yallaroi, and UAD1154197 are the slowest developing. From a late April sowing there was 15 days difference in flowering between DBA Vittaroi and UAD1154197. The lack of an obligate vernalisation and strong photoperiod requirements for flowering means that sowing durum varieties before ANZAC day is not suitable as they will flower too early.

At Giles Corner, the date of 50% heading for durums varied by four weeks (4 August - 1 September) at the first ToS but only nine days (19-28 September) for the second. Scepter out yielded all durum varieties (Table 2). Yawa at the second ToS was the highest yielding durum. Interestingly, Saintly and Scepter flowered within a day of each other at Giles Corner suggesting they have very similar flowering controls, but the yield gap was 0.9 t/ha and 1.5 t/ha for ToS 1 and 2 respectively (Table 2).

At Loxton for ToS 1, heading occurred over three weeks from the earliest variety DBA Vittaroi to the latest UAD1154197. While at ToS 2 heading varied by 16 days from Saintly and DBA Vittaroi to UAD1154197 (Table 3). At the second time of sowing no durum out yielded Scepter. Once again, Saintly and Scepter flowered within one day of each other but Scepter yielded significantly more, with a difference of 0.7 t/ha and 0.6 t/ha at ToS 1 and 2 respectively.

Table 2. Average yields (t/ha) and heading dates for the different varieties at Giles Corner.

	17th April			**22nd May**		
	Yield (t/ha)	% of Scepter average	Heading date	Yield (t/ha)	% of Scepter average	Heading date
DBA Vittaroi	3.0	70	4-Aug	3.2	67	19-Sep
Saintly	3.3	78	13-Aug	3.3	70	19-Sep
DBA Spes	3.0	72	16-Aug	3.2	67	21-Sep
DBA-Aurora	2.8	67	17-Aug	3.3	68	21-Sep
Trojan	4.5	105	21-Aug	4.4	92	21-Sep
Tamaroi	2.8	67	17-Aug	2.8	58	23-Sep
Caparoi	3.2	76	20-Aug	3.2	68	23-Sep
Yawa	3.4	81	29-Aug	4.0	84	23-Sep
Tjilkuri	3.3	78	23-Aug	2.6	53	25-Sep
Yallaroi	3.0	72	24-Aug	2.2	46	26-Sep
UAD1154197	3.0	71	1-Sep	2.7	57	28-Sep
Scepter	4.2	100	13-Aug	4.8	100	18-Sep
LSD (P≤0.05)	*0.4*			*0.7*		

Table 3. Average yields (t/ha) and heading dates for the different varieties at Loxton.

	3rd May			**4th June**		
	Yield (t/ha)	% of Scepter average	Heading date	Yield (t/ha)	% of Scepter average	Heading date
DBA Vittaroi	1.0	71	12-Aug	0.9	55	21-Sep
DBA-Aurora	1.1	74	16-Aug	0.9	56	23-Sep
Tamaroi	1.4	94	18-Aug	0.9	56	23-Sep
Saintly	0.7	52	19-Aug	1.0	62	11-Sep
Trojan	1.4	96	25-Aug	1.3	78	23-Sep
DBA Spes	1.4	96	26-Aug	1.0	62	20-Sep
Tjilkuri	0.7	50	27-Aug	0.8	49	25-Sep
Caparoi	1.1	77	29-Aug	0.9	58	16-Sep
Yallaroi	0.8	58	30-Aug	0.8	51	22-Sep
Yawa	1.3	90	1-Sep	0.7	46	27-Sep
UAD1154197	1.0	71	6-Sep	1.0	62	27-Sep
Scepter	1.4	100	20-Aug	1.6	100	10-Sep
LSD (P≤0.05)	*0.4*			*0.3*		

The yield gap between bread wheats and durum can be explained by the differences in susceptibility to crown rot and frost. Severe crown rot and moisture stress around head emergence and flowering can cause whiteheads and the complete abortion of any grain in the head. Frost can also affect yield, with temperatures below 2°C causing abortion of grain and flowers. At Giles Corner the primary cause of sterility was frost, while at Loxton both crown rot and frost caused sterility (Table 4). All current durum varieties are classified as very susceptible (VS or SVS) to crown rot unlike bread wheat varieties which have higher levels of resistance (Scepter S, Trojan MS) (Wallwork 2018). Durum varieties are also more sensitive to frost.

At Giles Corner, where frost was the major cause of sterility, Saintly and Scepter flowered on the same day at the first ToS but Saintly had double the sterility at 26% (Table 4) and yielded about 0.7 t/ha less (Table 3). There is variation in frost sensitivity of durums with varieties that flowered at similar times showing different levels of sterility i.e. Yawa and Tjilkuri (Table 4).

Table 4. Correlation between yield and sterility for each environment and the average sterility of selected varieties

	Environment							
	Giles Corner ToS 1 17th April		Giles Corner ToS 2 22nd May		Loxton ToS 1 3rd May		Loxton ToS 2 4th June	
Yield: Sterility	-0.53***		-0.66***		-0.45**		-0.35*	
	Sterility (%)	Heading date	Sterility (%)	Heading date	Sterility (%)	Heading date	Sterility (%)	Heading date
Scepter	13%	13 Aug	12%	18 Sep	5%	20 Aug	12%	10 Sep
Saintly	26%	13 Aug	24%	19 Sep	46%	19 Aug	30%	11 Sep
Tjilkuri	50%	23 Aug	43%	25 Sep	19%	27 Aug	26%	25 Sep
Yawa	32%	29 Aug	16%	23 Sep	8%	1 Sep	5%	27 Sep

indicates correlations that were significant at *(P≤0.05), **(P≤0.01), and *(P≤0.001).*

Summary / implications

Flowering time in durum is primarily controlled by changes in photoperiod with a few varieties having a facultative (not always required) response to vernalisation, however the variation in flowering time of durum varieties is very limited compared to that of bread wheats. Currently, there are no durum varieties suited to pre-ANZAC day sowing as they will all flower too early and be exposed to cold stresses. The current variation in durum dictates that sowing is best suited to early to mid-May. Durum wheat may be better suited to later flowering to avoid frost risk, as they are much more sensitive than bread wheats. The lack of variation in development speed for durum means variety selection should focus on other variety qualities, including yield potential and quality characteristics rather than development speed.

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Reference

Wallwork H (2018) 'Cereal Variety Disease Guide 2018' SARDI available at: http://pir.sa.gov.au/__data/assets/pdf_file/0017/311084/Cereal_Variety_Disease_Guide_2018_booklet_WEB.pdf