Department of Primary Industries

Wheat phenology and yield responses to sowing time – Marrar 2019

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Key findings

- Phenology and grain yield responses were significantly influenced by seasonal conditions in 2019.
- Severe heat stress and terminal drought conditions favoured faster developing spring genotypes, which achieved the highest grain yields in 2019.
- Grain yield responses varied in response to sowing date, and highest yields occurred when phenology was matched with recommended sowing windows.

Introduction

In 2019, field experiments were conducted across 10 sites in the northern grains region (NGR) to determine the influence of phenology on grain yield responses for a diverse set of wheat genotypes. This paper presents results from the Marrar site (southern NSW) and discusses the influence of sowing date (SD) on the phenology and grain yield responses of a core set of 36 wheat genotypes.

Site details

Location	Takada, Marrar NSW
Soil type	Red chromosol
Previous crop	Canola
Sowing	• Direct drilled with DBS tynes spaced at 240 mm using a GPS auto-steer system. • Target plant density: 140 plants/m^2
Soil pH_{Ca}	5.3 (0–10 cm); 5.4 (10–30 cm)
Mineral nitrogen (N)	At sowing (1.5 m depth): 134.5 kg N/ha
Fertiliser	• 90 kg/ha mono-ammonium phosphate (MAP) (sowing). • 42 kg N/ha urea (28 June).
Weed control	Knockdown • Glyphosate (450 g/L) 2 L/ha. Pre-emergent • Sakura® 118 g/ha + Avadex Xtra 1.6 L/ha + Trifluralin (480 g/L) 0.8 L/ha. In-crop • Axial® 300 mL/ha + Precept® 2 L/ha (SD1 and SD2: 13 May). • LVE MCPA 570 600 mL/ha + Paradigm 25 g/ha (SD3 and SD4: 18 July). • Axial® 300 mL/ha (SD3 and SD4: 25 July).

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Disease and pest management	Seed treatment • Hombre® Ultra 200 mL/100 kg. • Gaucho® 600 120 mL/100 kg. Fertiliser treatment • Flutriafol 250 g/L (400 mL/ha). Foliar fungicide • Prosaro® 300 mL/ha (SD1 and SD2: 4 June, SD3 and SD4: 28 August).
Rainfall	• In-crop (April–October): 194.5 mm • In-crop long-term average: 293 mm
Severe temperature events	• Seven heat stress events (days >30 °C during October), including 31.1 °C (3 October) and 34.1 °C (6 October) (coinciding with critical flowering and early grain-filling stages, significantly influencing yield). • 10 frost events (days <0 °C), no days recorded below –2 °C (minimal influence of frost in 2019).
Harvest date	• 14 November 2019 (SD1 and SD2). • 27 November 2019 (SD3 and SD4). • 11 December 2019 Manning$^{\Phi}$ (all SDs), RGT Accroc$^{\Phi}$ (all SDs) and DS Bennett$^{\Phi}$ (all SDs) due to delayed maturity.

Treatments

Thirty-six wheat genotypes (Table 1), varying in phenology responses were sown on four sowing dates in 2019:

- SD1: 5 April
- SD2:18 April*
- SD3: 6 May
- SD4: 20 May.

*SD2 was established with 10 mm supplementary watering via drippers.

Table 1 Expected phenology responses of the 2019 experiment genotypes.

Phenology type	Genotypes*
Winter (W)	Longsword$^{\Phi}$ (Fast), LongReach Kittyhawk$^{\Phi}$ (Mid), EGA Wedgetail$^{\Phi}$ (Mid), DS Bennett$^{\Phi}$ (Mid–slow), RGT Accroc$^{\Phi}$ (Slow), Manning$^{\Phi}$ (Slow)
Very slow (VS)	EGA Eaglehawk$^{\Phi}$, RGT Zanzibar$^{\Phi}$, **LongReach Nighthawk**$^{\Phi}$
Slow (S)	Cutlass$^{\Phi}$, Sunlamb$^{\Phi}$, Sunmax$^{\Phi}$
Mid (M)	**Catapult**$^{\Phi}$, Coolah$^{\Phi}$, DS Pascal$^{\Phi}$, EGA Gregory$^{\Phi}$, LongReach Lancer$^{\Phi}$, LongReach Trojan$^{\Phi}$, Mitch$^{\Phi}$
Mid-fast (MF)	Beckom$^{\Phi}$, Janz, LongReach Reliant$^{\Phi}$, Suntop$^{\Phi}$, Sunvale$^{\Phi}$
Fast (F)	Corack$^{\Phi}$, **LongReach Hellfire**$^{\Phi}$, LongReach Mustang$^{\Phi}$, LongReach Spitfire$^{\Phi}$, Mace$^{\Phi}$, Scepter$^{\Phi}$, Sunprime$^{\Phi}$
Very fast (VF)	Condo$^{\Phi}$, LongReach Dart$^{\Phi}$, H45, TenFour$^{\Phi}$, Vixen$^{\Phi}$

*New releases in **bold**.

Results

Phasic development

When considering variety options at sowing, growers should aim to synchronise crop development with seasonal patterns, so that flowering occurs at an optimal time. This period is a trade-off between increasing drought and heat threat, and declining frost risk.

Generally, the highest yields are achieved at Marrar when genotype and sowing date combinations flower in early to mid October. In 2019, the flowering window spanned from 18 August to 21 October, and was directly influenced by severe drought conditions, significant heat stress and mild frost conditions. The highest yields were achieved when flowering occurred early to mid September (2–3 weeks earlier than long-term data, see previous results in Harris et al., 2018; Harris et al., 2019). There was a significant decline in grain yield when flowering occurred after late September (Figure 1).

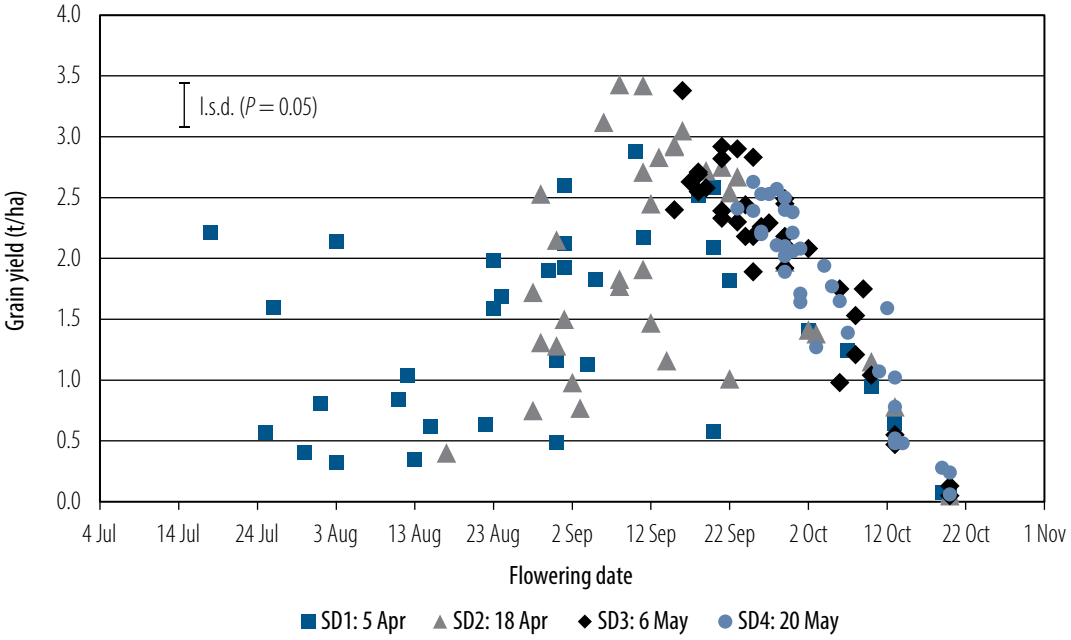
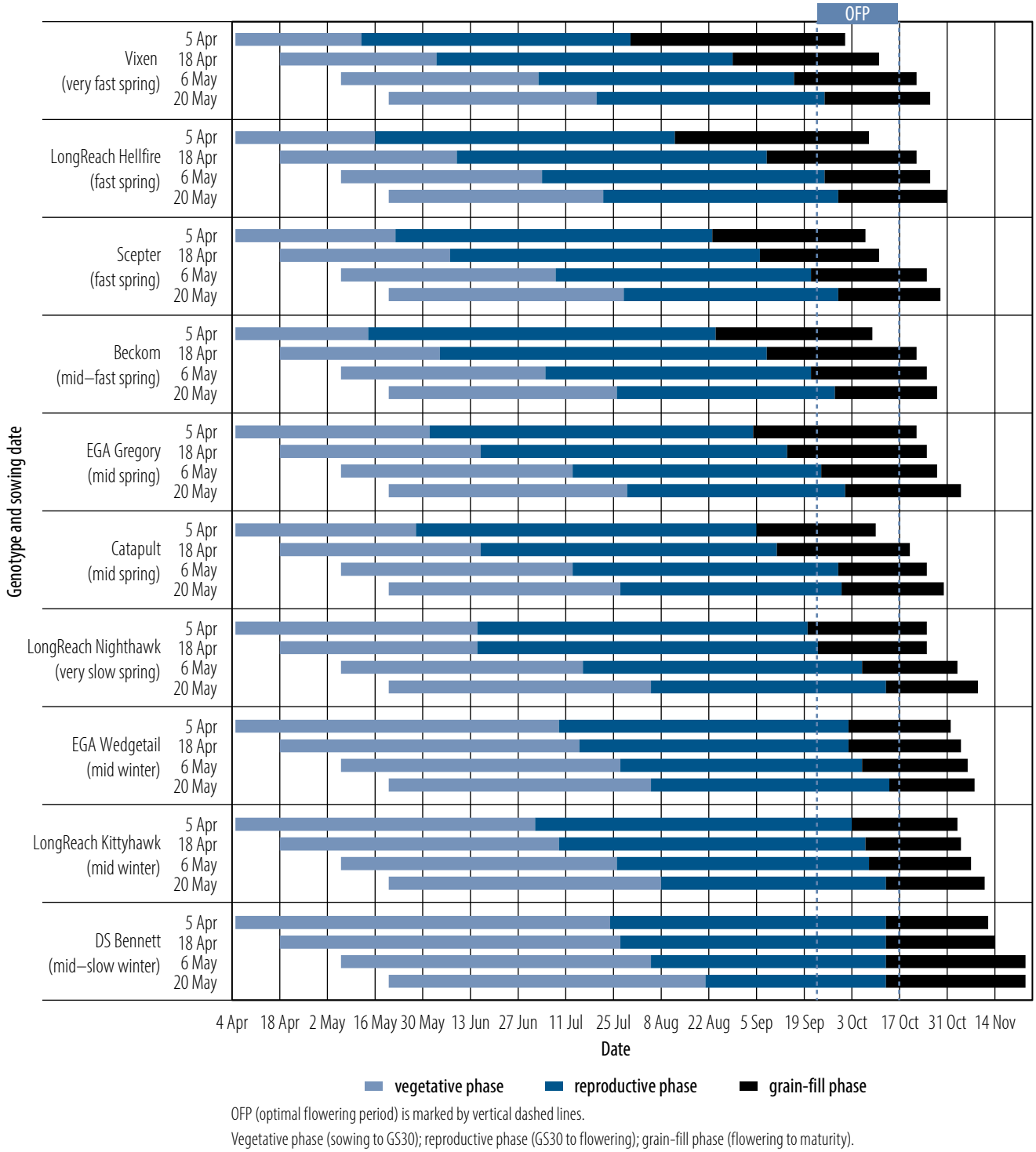


Figure 1 Relationship between flowering date and grain yield for 36 genotypes sown on four sowing dates at Marrar, 2019.

There are varied development responses to vernalisation and photoperiod among the genotypes tested, which resulted in phasic development varying significantly with respect to sowing date (Figure 2). This variation influenced the flowering grain yield responses shown in Figure 1. Faster developing spring types (with minimal response to vernalisation), when sown early (characterised by warmer temperatures and longer days), developed quickly and flowered earlier than the optimal flowering period (OFP). For example, new release Vixen$^{\Phi}$, flowered on 30 July from SD1, which was two months earlier than the OFP yielding 0.40 t/ha. However, when sown on either SD3 or SD4 (May), Vixen$^{\Phi}$ flowered on 16 September (SD3) and 25 September (SD4) and achieved the highest yield ranking (SD3: 3.38 t/ha and SD4: 2.63 t/ha, Table 2).

In contrast, the slower developing winter types had prolonged vegetative phases from earlier sowing dates (afforded by their vernalisation requirement) and had later, more stable flowering dates across sowing treatments. Whilst mid-winter types EGA Wedgetail$^{\Phi}$ and LongReach Kittyhawk$^{\Phi}$ recorded similar flowering dates, differences were observed in pre-flowering phases in response to sowing date, which has been reported previously (Harris et al., 2018; Harris et al., 2019). In 2019, LongReach Kittyhawk$^{\Phi}$ reached GS30 6–7 days faster than EGA Wedgetail$^{\Phi}$ for SD1 and SD2, while there was only 1–3 days difference for SD3 and SD4 (Figure 2). DS Bennett$^{\Phi}$ was slower, reaching GS30 9–18 days later than EGA Wedgetail$^{\Phi}$ across sowing dates (Figure 2). DS Bennett$^{\Phi}$ has previously reported stable flowering dates afforded by a strong photoperiod response (Harris et al., 2018; Harris et al., 2019). However, in 2019 severe drought and heat stress conditions significantly delayed flowering

(also observed in other slower developing genotypes) a result of spikes not progressing beyond the booting phase or emerging from the flag leaf and as such flowering was not observed on a large proportion of tillers.



OFP (optimal flowering period) is marked by vertical dashed lines.

Vegetative phase (sowing to GS30); reproductive phase (GS30 to flowering); grain-fill phase (flowering to maturity).

Figure 2 Influence of sowing date on phasic development of selected genotypes sown 5 April, 18 April, 6 May and 20 May at Marrar, 2019.

Grain yield

Grain yields and genotype rankings varied significantly across the sowing dates (early April to late May) (Table 2), which confirms that genotypes are not broadly adapted to sowing date. In 2019, mid–fast developing spring types sown in late April achieved the highest grain yields (e.g. Beckom$^{\Phi}$, LongReach Trojan$^{\Phi}$), and fast spring types in early May (Vixen$^{\Phi}$) (Table 2). While there were yield penalties when fast developing spring wheats were sown in early April, there was a 2–3 week shift in earlier OFP under severe heat and terminal drought conditions. But slow spring and winter genotypes flowered too late, and recorded the lowest grain yields for 2019 (Figure 3).

Important note: while all seasons are unique, it is important to consider long-term phenology and yield data to determine varietal responses and adaptation to growing environment.

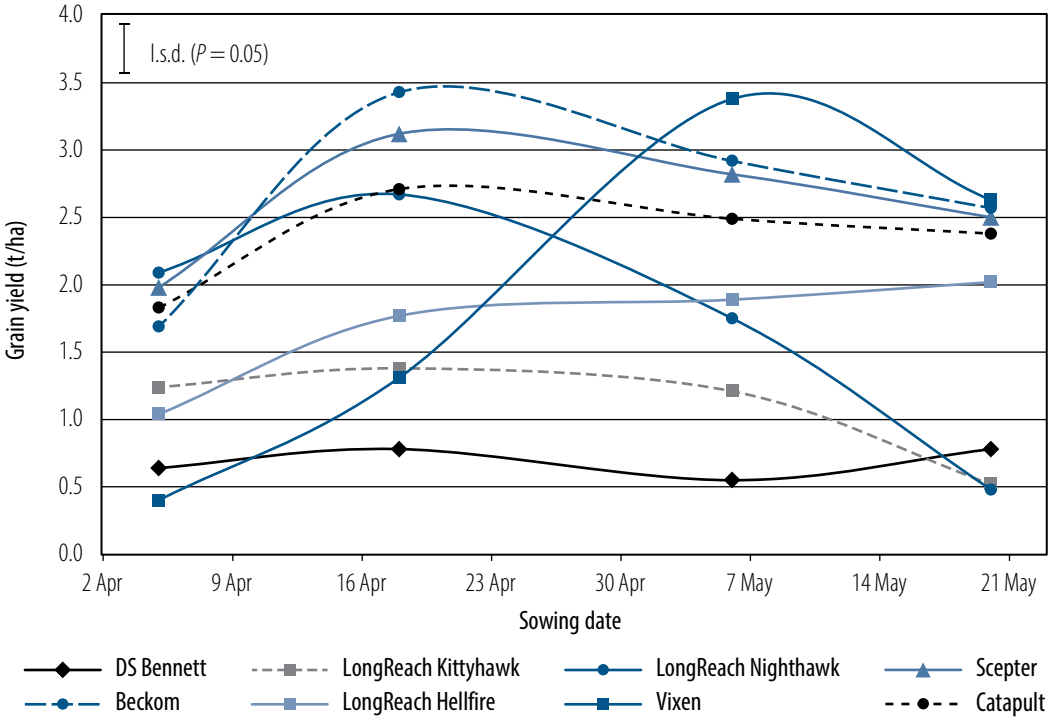


Figure 3 Grain yield of selected genotypes across four sowing dates: 5 April, 18 April, 6 May and 20 May at Marrar, 2019.

Grain quality

Despite significant differences within genotype, sowing date and the interaction between genotype and sowing date, seasonal conditions significantly influenced grain quality in 2019 (Table 3). Generally, grain protein and screenings were high and test weight low.

Table 2 Grain yield of genotypes across four sowing dates at Marrar in 2019.

Genotype	Grain yield (t/ha)*							
	SD1: 5 April		SD2: 18 April		SD3: 6 May		SD4: 20 May	
Beckom	1.69	(15)	3.43	(1)	2.92	(2)	2.57	(2)
Catapult	1.83	(13)	2.71	(10)	2.49	(11)	2.38	(9)
Condo	2.14	(7)	2.15	(15)	2.69	(7)	2.20	(12)
Coolah	2.17	(6)	2.92	(6)	2.29	(18)	1.27	(26)
Corack	0.84	(24)	1.50	(21)	2.90	(3)	2.40	(7)
Cutlass	0.49	(31)	1.47	(22)	2.45	(12)	1.94	(18)
DS Bennett	0.64	(26)	0.78	(31)	0.55	(33)	0.78	(29)
DS Pascal	2.88	(1)	3.05	(4)	2.11	(23)	1.77	(20)
EGA Eaglehawk	1.82	(14)	1.97	(16)	1.04	(31)	0.50	(31)
EGA Gregory	1.13	(21)	1.16	(27)	2.18	(20)	1.71	(21)
EGA Wedgetail	1.41	(18)	1.41	(23)	0.98	(32)	0.48	(32)
H45	1.60	(16)	1.72	(20)	2.55	(10)	2.22	(10)
Janz	0.62	(28)	1.91	(17)	2.18	(21)	1.89	(19)
Longsword	0.58	(29)	1.01	(29)	1.92	(25)	1.64	(23)
LongReach Dart	0.57	(30)	0.40	(34)	2.40	(14)	2.41	(6)
LongReach Hellfire	1.04	(22)	1.77	(19)	1.89	(26)	2.02	(17)
LongReach Kittyhawk	1.24	(19)	1.38	(24)	1.21	(30)	0.52	(30)
LongReach Lancer	2.12	(8)	2.93	(5)	2.26	(19)	1.39	(25)
LongReach Mustang	0.32	(34)	1.28	(26)	2.58	(9)	2.10	(14)
LongReach Nighthawk	2.09	(9)	2.67	(11)	1.75	(27)	0.48	(33)
LongReach Reliant	1.16	(20)	1.83	(18)	2.30	(17)	2.11	(13)
LongReach Spitfire	0.35	(33)	0.77	(32)	2.39	(15)	2.21	(11)
LongReach Trojan	2.60	(2)	3.42	(2)	2.44	(13)	2.06	(16)
Mace	0.63	(27)	0.98	(30)	2.33	(16)	2.53	(3)
Manning	0.06	(36)	0.05	(36)	0.05	(36)	0.06	(36)
Mitch	1.90	(12)	2.45	(14)	2.18	(22)	1.59	(24)
RGT Accroc	0.08	(35)	0.07	(35)	0.13	(35)	0.28	(34)
RGT Zanzibar	2.58	(3)	2.75	(8)	1.53	(29)	1.02	(28)
Scepter	1.98	(10)	3.12	(3)	2.82	(5)	2.50	(5)
Sunlamb	0.95	(23)	1.15	(28)	0.47	(34)	0.24	(35)
Sunmax	2.52	(4)	2.54	(12)	1.75	(28)	1.07	(27)
Sunprime	2.21	(5)	2.53	(13)	2.71	(6)	2.39	(8)
Suntop	1.59	(17)	2.83	(7)	2.83	(4)	2.08	(15)
Sunvale	1.93	(11)	2.72	(9)	2.08	(24)	1.65	(22)
TenFour	0.81	(25)	0.75	(33)	2.63	(8)	2.53	(4)
Vixen	0.40	(32)	1.31	(25)	3.38	(1)	2.63	(1)
Mean	1.36		1.86		2.04		1.66	
l.s.d. ($P = 0.05$)								
Genotype	0.19							
SD	0.06							
Genotype × SD	0.38							

* Yield ranking according to sowing date treatment in parentheses.

Table 3 Grain protein (GP), screenings (SCRN) and test weight (TWT) of genotypes across four sowing dates at Marrar in 2019.

Genotype	SD1: 5 April			SD2: 18 April			SD3: 6 May			SD4: 20 May		
	GP (%)	SCRN (%)	TWT (%)	GP (%)	SCRN (%)	TWT (%)	GP (%)	SCRN (%)	TWT (%)	GP (%)	SCRN (%)	TWT (%)
Beckom	15.3	9.7	75.6	12.6	15.0	78.0	12.9	12.1	78.8	14.2	19.3	80.3
Catapult	14.9	12.0	76.1	14.0	15.0	79.8	14.3	9.6	81.6	15.1	11.4	81.3
Condo	15.5	12.6	72.7	14.7	12.9	71.1	13.4	19.3	78.3	15.8	21.9	78.9
Coolah	13.8	15.3	76.0	12.7	12.1	79.7	13.9	12.6	81.1	14.7	16.0	80.5
Corack	16.6	5.7	70.0	15.1	8.8	75.2	13.5	14.6	80.9	15.4	13.4	79.8
Cutlass	16.7	6.7	74.1	15.6	9.7	78.9	14.7	11.9	79.6	16.2	15.2	79.2
DS Bennett	14.8	14.3	75.1	14.8	15.2	76.3	16.0	11.7	76.0	16.1	14.0	77.8
DS Pascal	13.3	10.5	79.3	14.0	9.4	78.4	15.3	10.1	80.2	16.1	13.5	79.9
EGA Eaglehawk	15.6	8.4	78.6	15.1	8.1	80.8	15.8	13.4	79.9	16.5	10.4	73.6
EGA Gregory	15.2	12.2	72.1	15.4	12.3	77.4	15.1	10.2	81.3	15.3	11.1	81.3
EGA Wedgetail	15.6	9.5	75.4	15.7	10.9	75.5	15.5	17.8	75.3	16.1	9.1	69.9
H45	15.1	8.7	71.2	15.4	13.0	72.2	12.9	26.5	77.9	14.4	22.4	80.4
Janz	16.6	5.6	71.5	15.3	9.3	76.8	15.3	10.0	80.5	15.5	13.9	81.7
Longsword	17.2	3.2	73.1	16.4	5.3	76.8	15.5	6.7	80.0	15.7	7.0	80.1
LongReach Dart	16.1	12.4	62.9	17.7	6.0	70.9	14.9	13.7	79.8	15.4	20.1	80.0
LongReach Hellfire	18.8	7.0	71.2	17.0	10.8	77.3	16.3	11.2	80.8	17.3	13.8	81.6
LongReach Kittyhawk	15.7	6.1	80.7	15.4	5.5	81.7	15.5	7.9	82.0	16.0	7.6	79.1
LongReach Lancer	16.3	10.9	74.6	15.6	12.4	78.4	16.2	14.1	79.1	16.9	12.6	80.2
LongReach Mustang	15.2	12.9	63.7	15.5	10.7	75.0	14.9	14.7	79.6	15.9	12.7	81.2
LongReach Nighthawk	14.8	7.2	78.7	13.7	10.7	80.4	14.7	11.5	80.5	16.3	7.0	75.8
LongReach Reliant	15.7	14.9	72.6	15.2	10.5	74.9	14.7	15.6	79.5	16.0	18.8	84.0
LongReach Spitfire	17.8	6.3	70.6	17.6	5.1	73.5	15.9	13.8	80.1	16.2	17.7	80.9
LongReach Trojan	13.8	13.4	73.5	13.2	12.9	78.0	14.3	10.3	82.2	15.6	17.0	81.6
Mace	16.5	8.4	69.8	15.7	9.0	73.9	14.4	9.7	79.9	15.0	12.9	80.4
Manning	15.6	10.3	73.1	15.1	11.1	76.3	14.9	13.3	79.2	15.7	14.6	79.3
Mitch	13.7	12.6	70.6	13.6	16.2	74.2	14.6	18.5	77.2	15.7	23.9	77.8
RGT Accroc	16.9	7.0	69.5	16.4	7.8	72.7	16.2	11.7	75.2	17.1	9.4	75.9
RGT Zanzibar	14.2	19.1	77.3	13.8	16.0	78.8	14.6	13.7	79.2	15.6	15.6	77.7
Scepter	15.1	17.0	73.9	13.5	18.6	77.0	13.8	15.2	80.1	15.0	17.4	81.5
Sunlamb	16.0	6.7	74.4	15.2	7.7	76.0	16.1	7.1	73.7	15.9	15.0	74.8
Sunmax	15.0	12.8	78.8	15.3	8.5	80.4	16.0	7.6	81.9	16.8	9.5	79.9
Sunprime	15.3	11.6	69.4	14.4	15.7	71.5	14.2	22.2	76.1	15.7	23.8	77.6
Suntop	15.6	10.1	76.2	13.8	12.2	77.7	13.7	15.9	80.7	15.3	15.2	82.0
Sunvale	15.3	9.3	76.5	14.8	8.8	80.0	16.3	12.1	80.3	16.7	12.6	82.2
TenFour	15.6	12.1	66.9	16.4	12.9	69.6	14.8	16.9	76.4	14.4	17.3	77.6
Vixen	16.4	8.4	65.4	16.3	14.1	72.3	13.9	17.2	76.6	15.2	15.2	77.4
Mean	15.6	10.3	73.1	15.1	11.1	76.3	14.9	13.3	79.2	15.7	14.7	79.3
l.s.d. ($P = 0.05$)												
Genotype	0.4	2.0	1.4									
SD	0.1	0.7	0.5									
Genotype × SD	0.9	4.1	2.8									

Summary

Seasonal conditions significantly influenced phenology, yield and grain quality responses to sowing date in 2019. Severe drought and heat stress, combined with minimal frosts resulted in optimal flowering time for maximum grain yield shifting 2–3 weeks earlier than average. This favoured quicker developing spring genotypes sown earlier than their optimal sowing window based on previous data, and slow developing spring and winter genotypes suffered significant yield penalties. We observed differences in phenology and yield responses among genotypes with similar flowering dates, indicating the significant influence sowing date can have on pre-flowering and grain filling phases, which was amplified by extreme drought conditions. These results highlight the interaction between phasic development and yield formation, how this can be amplified under severe seasonal conditions, and the importance for growers to consider long-term responses when choosing cultivars and management through sowing date.

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