Influence of sowing date on wheat phenology and grain yield – Cudal 2019

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Key findings

- The 2019 dry spring conditions affected genotype performance, influencing flowering time and grain yield responses.
- Current varieties were not broadly adapted across sowing dates from mid April to late May.
- Highest grain yields were achieved across phenology types in response to sowing dates, with very slow spring types maximising yield from the mid April sowing date (SD), with later sowing dates favouring faster developing spring genotypes, which achieved the highest grain yields in 2019.

Introduction

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

Site details

Location	South Bowen Park, Cudal NSW
Soil type	Red–brown chromosol
Previous crop	Canola
Sowing	Direct drilled with Horwood Bagshaw seeding units, spaced at 220 mm using a GPS auto-steer system.
Target plant density	160 plants/m^2
Soil pH_{Ca}	5.2 (0–10 cm); 5.2 (10–30 cm)
Mineral nitrogen (N)	192 kg N/ha at sowing (1.5 m depth)
Fertiliser	• 100 kg/ha mono-ammonium phosphate (MAP) (sowing) • 150 kg/ha urea (sowing)
Weed control	• **Knockdown**: Glyphosate (450 g/L) 2.0 L/ha • **Pre-sowing**: Sakura® (850 g/ka pyroxasulfone) 118 g/ha + Avadex® Xtra (500 g/L tri-allate) 1.6 L/ha + trifluralin (480 g/L) 1.6 L/ha (SD1: 17 April, SD2: 6 May and SD3: 20 May)

This research paper is an extract from the publication *Southern NSW Research Results 2021*, available at https://www.dpi.nsw.gov.au/agriculture/broadacre-crops/guides/publications/southern-nsw-research-results

	• **In-crop**: Axial® (100 g/L pinoxaden and 25 g/L cloquintocet-methyl) 300 mL/ha + Precept® (125 g/L MCPA and 25 g/L pyrasulfotole) 2 L/ha + Adigor® (adjuvant) 500 mL per 100 L water (18 June)
Disease management	• **Seed treatment**: Hombre® Ultra (360 g/L imidacloprid and 12.5 g/L tebuconazole) 200 mL/100 kg seed • **Fertiliser treatment**: Flutriafol (250 g/L) 400 mL/ha • **In-crop**: Prosaro® 420 SC (210 g/L prothioconazole and 210 g/L tebuconazole) 300 mL/ha (15 August)
Pest management	• Talstar® 250 EC (250 g/L bifenthrin) 80 mL/ha (23 May) • Aphidex® WG (500 g/kg pirimicarb) 250 g/ha (15 August and 17 September) • Fastac® Duo (100 g/L alpha-cypermethrin) 100 mL/ha (17 September)
Rainfall	In-crop (April–October): 145 mm; long-term average: 353 mm
In-crop supplementary irrigation (sprinkler)	• 10 mm: SD1 only post sowing (29 April) • 20 mm: all sowing dates (5 August) • 20 mm: all sowing dates (24 September)
Severe temperature events	• Four heat stress events (days >30 °C) during October including a 32.5 °C day (6 October) and 11 heat stress events during November. • Four frost events (days <0 °C), 5 August 0°C, 6 August −1.5 °C, 14 August 0 °C and 10 September −1.0 °C.
Harvest date	28 November 2019

Treatments

Genotype

Thirty-six wheat genotypes (Table 1), varying in phenology responses.

Sowing date (SD)

- SD1: 17 April 2019
- SD2: 6 May 2019
- SD3: 20 May 2019

Results

Phasic development

The optimal flowering period (OFP) for Cudal derived from modelling using long-term climatic data occurs in the second and third week of October, where risk from frost, heat and moisture stress on grain yield is minimised. In 2019, the flowering window spanned from 13 September to 18 October. This window was shorter than previous seasons as the slow winter types, Manning$^{(\phi)}$ and RGT Accroc, did not flower and set grain from the 20 May sowing (SD3) because of the spring drought conditions. Additionally, frosts in August coincided with sensitive reproductive stages in the very fast and fast spring types, causing stem death and delayed flowering dates. Genotype × sowing date combinations, which flowered in the window from late-September to early-October, achieved the highest grain yields in the 2019 season – two weeks earlier than the OFP for Cudal (Figure 1).

Table 1 Expected phenology responses of the 2019 experiment genotypes.

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

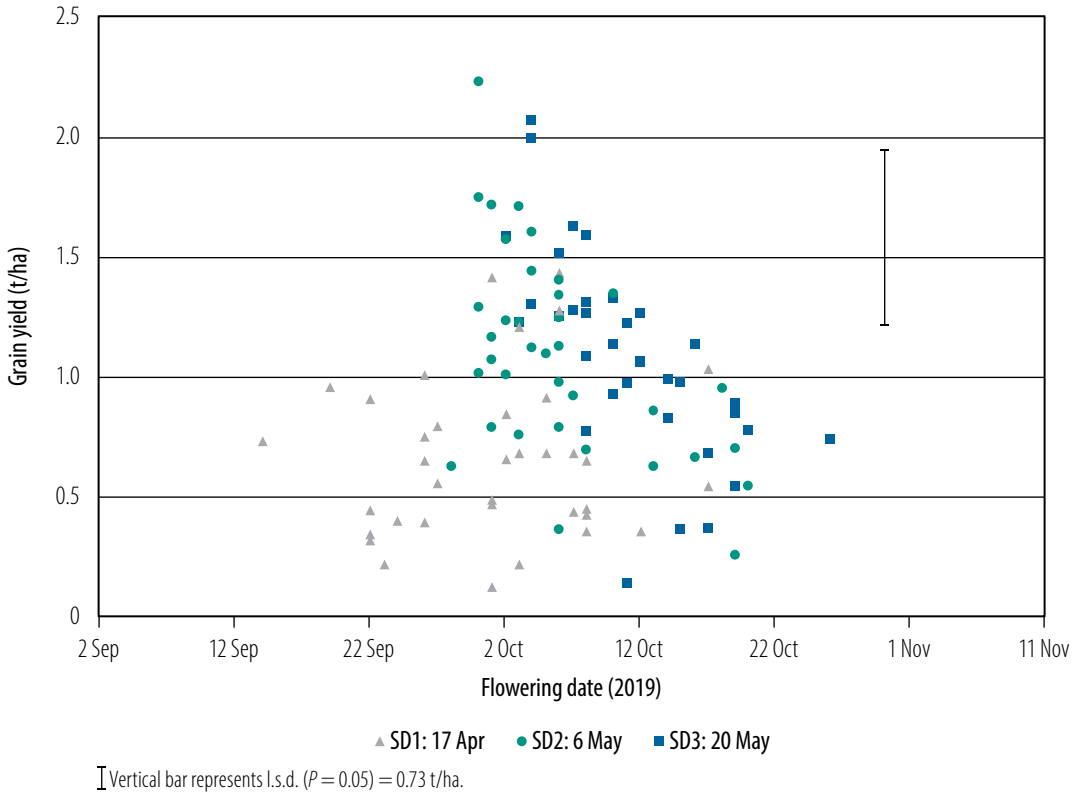

Figure 1 Relationship between flowering date and grain yield for 36 genotypes sown on three dates at Cudal, 2019.

Early phasic development highlighted the speed of the very fast and fast spring types (Figure 2), with Vixen$^{\Phi}$ and Scepter$^{\Phi}$ reaching growth stage 30 (GS30) on the 9 June and 11 June for SD1 compared with LongReach Nighthawk$^{\Phi}$ (25 June), EGA Wedgetail$^{\Phi}$ (30 June) and DS Bennett$^{\Phi}$ (16 July). The slower development through growth stages following GS30 between the very fast spring wheat Vixen$^{\Phi}$ and a long season spring LongReach Nighthawk$^{\Phi}$ was emphasised with Vixen$^{\Phi}$ recording a grain yield of 0.32 t/ha for SD1 and LongReach Nighthawk$^{\Phi}$, the third highest yielding genotype in SD1, 1.27 t/ha. Frost damage through the critical stem elongation phase in August and early September severely affected Vixen$^{\Phi}$.

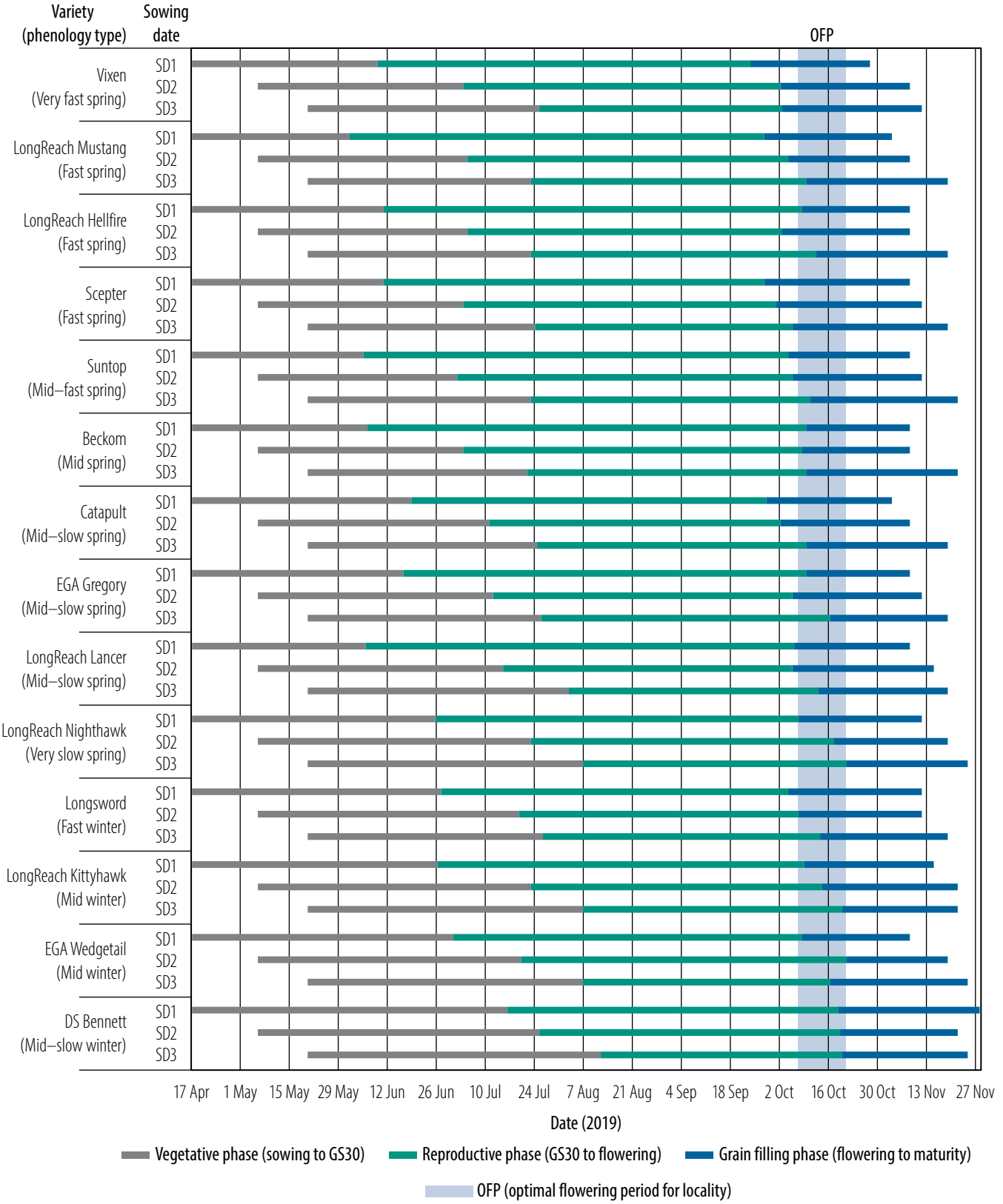

Figure 2 Influence of sowing date on phasic development of selected genotypes sown on three dates at Cudal, 2019.

Even with the drought conditions of the 2019 season, the vernalisation and photoperiod holds were demonstrated, with long season spring and winter types delaying stem elongation and flowering, avoiding the frost damage, and flowering in the OFP. Consistent with previous work by Harris et. al. 2018 and Harris et. al. 2019, genotypes with a strong photoperiod hold such as DS Bennett$^{\Phi}$ had a compact flowering period, flowering within a two day period across all three sowing dates in 2019, compared with Longsword$^{\Phi}$, another winter wheat but with a weak photoperiod hold that flowered

over eight days. The hot, dry conditions in October coincided with the grain filling phase of later flowering genotypes that flowered through mid October, limiting yield potential and resulting in a significant yield decline in 2019.

Grain yield

Grain yield and genotype rankings varied significantly across sowing dates (late April to late May) supporting previous research in the region that genotypes are not broadly adapted across sowing dates (Table 2). In 2019, the highest yielding genotypes were the very fast spring wheats in SD2, with LongReach Dart$^{\Phi}$ achieving 2.23 t/ha. In SD1 the highest yielding genotype was the very slow spring genotype EGA Eaglehawk$^{\Phi}$ (1.43 t/ha), escaping the frost damage and still being able to fill grain despite the hot dry October–November period. Figure 3 shows the different yield response curves for a group of genotypes with the winter wheat LongReach Kittyhawk$^{\Phi}$ having a flatter response across sowing dates. The very slow spring wheat LongReach Nighthawk$^{\Phi}$ peaked in SD1 and Vixen$^{\Phi}$, a very fast spring wheat, maximised yield in SD2.

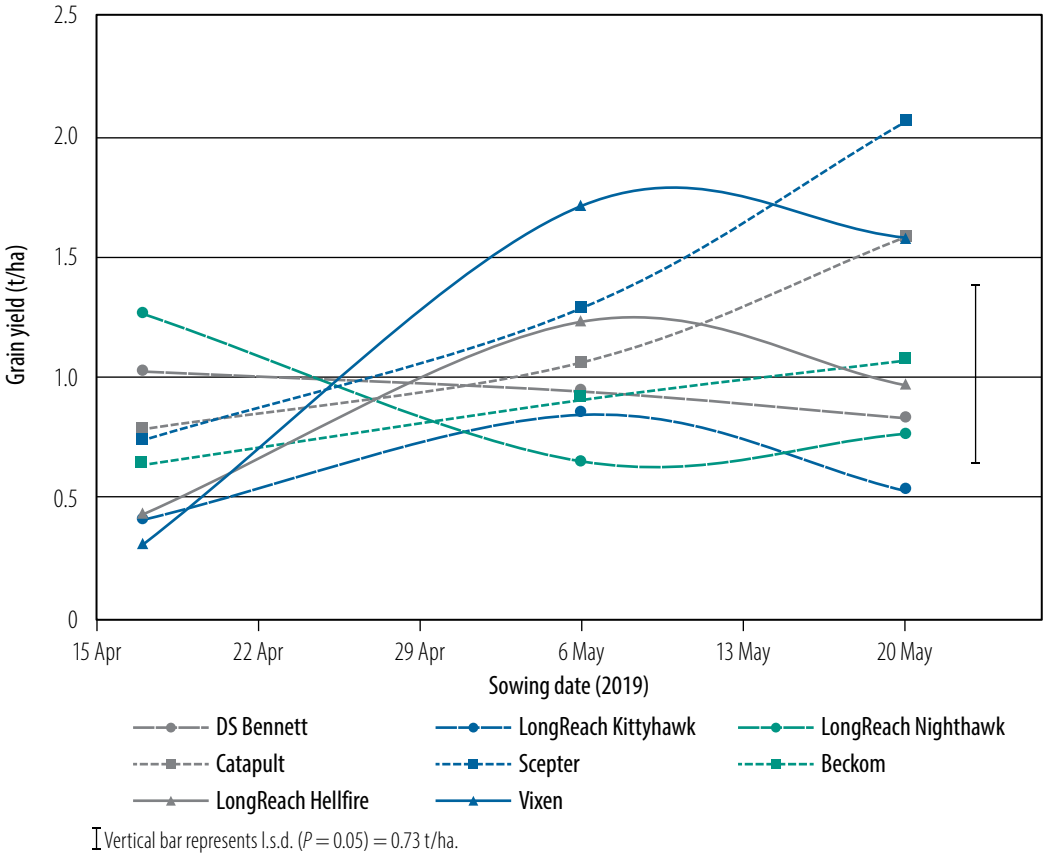

Figure 3 Grain yield of selected genotypes across three sowing dates 17 April, 6 May and 20 May at Cudal, 2019.

Table 2 Grain yield of genotypes across four sowing dates at Cudal, 2019.

Genotype	SD1: 17 April		SD2: 6 May		SD3: 20 May	
	Grain yield (t/ha)	Rank	Grain yield (t/ha)	Rank	Grain yield (t/ha)	Rank
Beckom	0.65	19	0.91	24	1.08	18
Catapult	0.79	11	1.07	19	1.59	4
Condo	0.90	9	1.74	2	1.25	13
Coolah	0.84	10	1.40	8	0.99	21
Corack	0.65	18	1.01	20	1.22	14
Cutlass	0.34	32	0.75	28	1.13	16
DS Bennett	1.03	5	0.95	23	0.84	26
DS Pascal	1.41	2	0.79	26	1.06	19
EGA Eaglehawk	1.43	1	0.62	32	0.89	25
EGA Gregory	0.45	24	1.44	7	0.97	22
EGA Wedgetail	0.68	14	0.70	29	0.36	35
H45	0.73	13	0.79	27	1.30	8
Janz	0.49	22	1.00	21	1.22	15
Longsword	0.22	34	1.24	12	1.05	20
LongReach Dart	0.44	25	2.23	1	1.26	11
LongReach Hellfire	0.44	26	1.23	13	0.97	23
LongReach Kittyhawk	0.42	27	0.86	25	0.54	32
LongReach Lancer	0.91	8	1.12	17	1.26	12
LongReach Mustang	0.39	29	1.23	14	0.76	29
LongReach Nighthawk	1.27	3	0.66	31	0.77	28
LongReach Reliant	0.56	20	1.33	10	1.32	7
LongReach Spitfire	0.47	23	1.09	18	0.83	27
LongReach Trojan	1.00	6	1.57	6	1.63	3
Mace	0.22	35	1.16	15	1.30	9
Manning	0.13	36	–	–	–	–
Mitch	0.65	17	0.69	30	0.36	34
RGT Accroc	0.54	21	0.54	34	–	–
RGT Zanzibar	0.35	30	1.12	16	0.68	31
Scepter	0.75	12	1.29	11	2.06	1
Sunlamb	0.35	31	0.26	36	0.37	33
Sunmax	0.68	16	0.97	22	1.27	10
Sunprime	0.96	7	1.70	4	1.51	6
Suntop	0.68	15	1.60	5	0.93	24
Sunvale	1.20	4	1.34	9	1.13	17
TenFour	0.40	28	0.62	33	1.99	2
Vixen	0.32	33	1.71	3	1.58	5
Mean	0.66		1.09		1.07	
l.s.d. ($P = 0.05$) Genotype	0.42					
l.s.d. ($P = 0.05$) SD	0.12					
l.s.d. ($P = 0.05$) Genotype × SD	0.73					

Grain quality

There were significant differences between genotypes, sowing dates and the interaction between genotype and sowing date for grain quality parameters (Table 3). The dry seasonal conditions affected grain protein accumulation, with low grain yield and the high paddock N levels resulting in high protein levels, ranging from 14.7%–18.4%. Even with the high protein levels, there were significant differences in genotype responses for protein accumulation, for example, LongReach Spitfire$^{\Phi}$ and LongReach Hellfire$^{\Phi}$ had higher grain protein concentrations than other genotypes at similar yield levels (Figure 4).

Grain screening percentages increased as sowing and flowering date was delayed. However, the early frost events that delayed flowering of the quicker genotypes and the ongoing moisture stress through the key grain setting and flowering period limited grain numbers and reduced the effects normally seen in a dry hot grain filling period.

Test weight (TWT) varied depending on maturity type, with the very fast and fast maturity genotypes showing an increase in TWT as sowing was delayed. Mid and mid–slow genotypes generally had peaks from SD2 and the winter types showed a decrease in TWT across sowing dates.

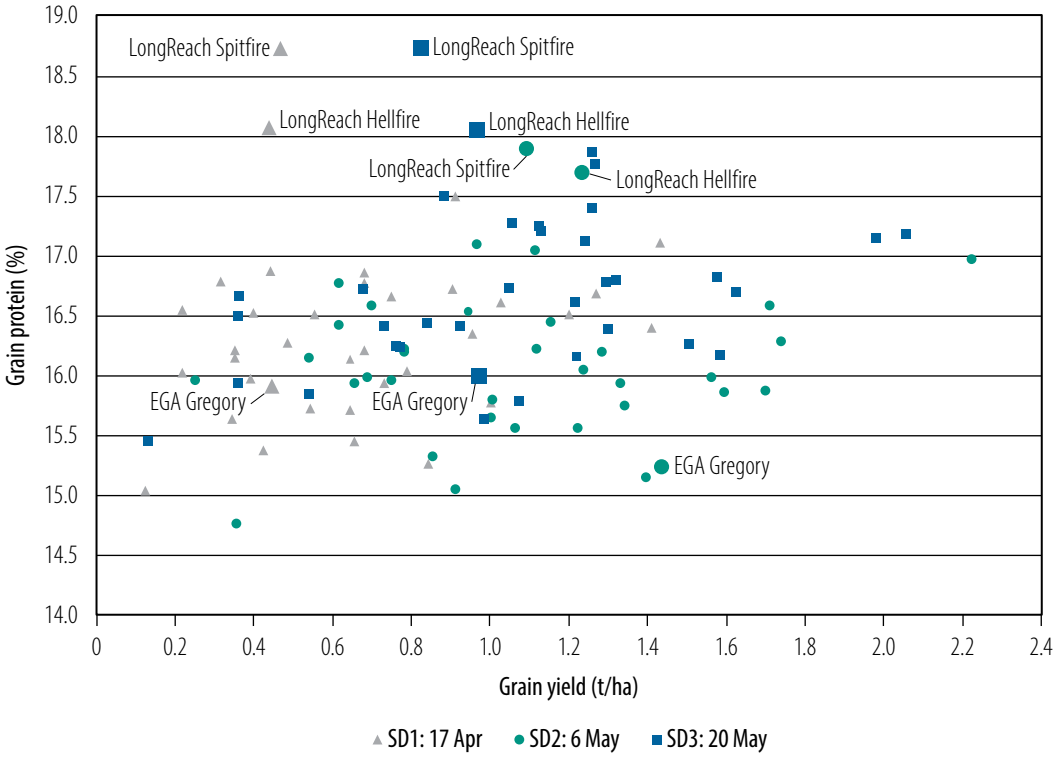

Figure 4 Relationship between grain yield and grain protein for 36 genotypes sown on three dates at Cudal, 2019.

Table 3 Grain protein, screenings and test weight of 36 genotypes across three sowing dates at Cudal, 2019.

Genotype	SD1: 17 April			SD2: 6 May			SD3: 20 May		
	Grain protein (%)	Screenings (%)	Test weight (kg/hL)	Grain protein (%)	Screenings (%)	Test weight (kg/hL)	Grain protein (%)	Screenings (%)	Test weight (kg/hL)
Beckom	15.7	1.6	81.2	15.0	2.1	81.4	15.8	3.2	82.7
Catapult	16.0	0.8	81.2	15.5	1.2	81.9	16.2	1.9	82.9
Condo	16.7	1.0	80.4	16.3	0.4	81.6	17.1	2.2	83.9
Coolah	15.3	0.4	81.3	15.1	2.6	83.4	15.6	4.0	82.7
Corack	16.1	0.1	81.7	15.8	0.4	82.5	16.1	0.7	82.6
Cutlass	15.6	0.6	81.1	15.9	0.9	82.1	17.2	1.2	81.6
DS Bennett	16.6	3.3	80.8	16.5	5.3	80.3	16.4	4.5	80.5
DS Pascal	16.4	1.1	81.2	16.2	2.3	83.0	17.3	3.7	82.5
EGA Eaglehawk	17.1	6.7	81.1	16.8	5.4	81.5	17.5	6.9	81.4
EGA Gregory	15.9	1.2	79.6	15.2	2.1	82.8	16.0	3.2	82.8
EGA Wedgetail	16.9	1.2	79.5	16.6	1.7	80.1	16.5	2.7	79.6
H45	15.9	3.6	80.1	16.2	3.7	80.4	16.4	7.0	82.2
Janz	16.3	0.2	80.7	15.6	1.4	82.6	16.6	1.6	83.4
Longsword	16.0	0.6	80.2	16.0	2.1	80.2	16.7	2.2	80.8
LongReach Dart	16.9	0.0	81.4	17.0	1.3	82.4	17.4	3.1	83.0
LongReach Hellfire	18.1	0.8	81.4	17.7	0.5	83.3	18.0	1.2	83.9
LongReach Kittyhawk	15.4	0.5	84.0	15.3	1.1	83.9	15.8	3.6	82.4
LongReach Lancer	17.5	1.0	81.3	17.0	2.6	82.6	17.9	4.1	82.6
LongReach Mustang	16.0	0.2	81.7	15.5	0.4	83.5	16.2	1.7	84.3
LongReach Nighthawk	16.7	3.7	81.6	15.9	5.7	81.3	16.2	5.4	81.3
LongReach Reliant	16.5	0.3	80.6	15.9	2.2	83.2	16.8	4.5	83.0
LongReach Spitfire	18.7	0.3	80.8	17.9	1.1	81.8	18.7	1.0	83.7
LongReach Trojan	15.8	0.5	83.0	16.0	1.2	83.9	16.7	2.4	83.6
Mace	16.5	–	80.2	16.4	1.0	80.8	16.8	1.1	81.9
Manning	15.0	3.3	76.8	–	–	–	–	–	–
Mitch	15.4	2.7	79.7	16.0	5.5	80.8	15.9	6.6	80.6
RGT Accroc	15.7	3.7	80.1	16.1	4.3	79.9	–	–	–
RGT Zanzibar	16.1	0.7	80.3	16.2	1.9	81.1	16.7	2.1	80.0
Scepter	16.7	0.2	80.8	16.2	0.7	82.0	17.2	1.7	83.2
Sunlamb	16.2	3.1	79.6	15.9	4.4	81.1	16.6	4.0	81.2
Sunmax	16.8	3.3	80.8	17.1	2.9	82.0	17.8	3.7	81.8
Sunprime	16.3	1.4	80.2	15.9	1.9	81.5	16.2	4.4	82.8
Suntop	16.2	2.4	81.4	15.8	4.3	83.5	16.4	4.4	82.2
Sunvale	16.5	0.6	82.2	15.7	2.1	82.6	17.2	3.9	83.2
TenFour	16.5	0.9	79.1	16.4	1.9	79.6	17.1	2.7	80.9
Vixen	16.8	0.3	79.6	16.6	0.1	80.9	16.8	0.4	82.6
Mean	16.4	1.4	80.7	16.1	2.3	81.8	16.7	3.3	82.1
l.s.d. ($P = 0.05$) Genotype	0.4	0.7	0.6						
l.s.d. ($P = 0.05$) SD	0.1	0.2	0.2						
l.s.d. ($P = 0.05$) Genotype × SD	0.6	1.3	1.0						

Summary

The 2019 season was one of the driest on record and included several frosts during the critical stem elongation phase through August and September, followed by periods of heat shock at flowering and grain fill for many of the genotypes included in the experiment. The season favoured the very fast–fast developing genotypes, sown mid–late May (SD2 and SD3), where flowering time avoided frost damage and grain filling occurred before the onset of severe moisture and heat stress. The relationship and development patterns of the genotypes, even in a 1:100 year event, were consistent with previous years' experimental findings with genotype performance driven by seasonal conditions. No one genotype maturity group was adapted to all three sowing dates in 2019, supporting previous work that growers can maximise grain yield by selecting varieties that target the OFP based on seasonal sowing opportunities.

References

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Acknowledgements

This experiment was part of the 'Optimising grain yield potential of winter cereals in the northern grains region' project, BLG104, 2017–20, a joint investment by GRDC and NSW DPI under the Grains Agronomy and Pathology Partnership (GAPP).

We sincerely thank Rob Bowman and family, South Bowman Park, Cudal, for hosting the field experiment and acknowledge the technical support of Lorraine Thacker, David Cupitt and Gabriel Brown.

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