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Influence of sowing date on phenology, grain yield and quality of wheat – Edgeroi, 2017

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Key findings

- High grain yields can be achieved from a range of variety × sowing date (SD) combinations. This enables growers to exploit differences in wheat phenology types for various SDs.
- Optimum yields were achieved by targeting flowering in the early part of the optimal window (defined by the risk of frost and heat and moisture stress).
- Yield response curves showed that slow developing, spring types (e.g. Sunmax$^{\Phi}$ and DS Pascal$^{\Phi}$) achieved optimal yields when sown early. In contrast, very fast spring varieties (e.g. LongReach Mustang$^{\Phi}$) suffered significant yield penalties of up to 49% from SD1 due to frost damage, performing better with a delayed sowing date.
- Delayed sowings of later maturing varieties (e.g. EGA Eaglehawk$^{\Phi}$ and Sunmax$^{\Phi}$), increased the potential for down graded grain quality due to increased screenings (>5%) associated with heat and moisture stress at flowering.
- Improved understanding of phenology responses of different varieties to various SDs will help to optimise yield potential and assist with variety selection and uptake.

Introduction

Phenology refers to the timing of the plant lifecycle or development phases such as flowering. Wheat development and maturity is primarily controlled by varied responses to vernalisation (Vrn) and photoperiod (Pdp) genes (Harris, Graham et al. 2018). The combination of variety and SD can influence the timing of environmental stresses during key developmental phases, such as flowering and grain formation. The range of developmental patterns due to Vrn and Ppd responses in Australian wheat varieties provides growers with flexibility in SD, which can be used to manage the risk of frost, heat, and moisture stress at flowering. Genotypes that respond to vernalisation require a period of cold temperatures (i.e. 3–10 °C) to progress from vegetative to reproductive development, with 'winter' wheats having the strongest vernalisation requirements (e.g. EGA Wedgetail$^{\Phi}$). Photoperiod sensitive genotypes require long day conditions to progress to the reproductive phase, with short day conditions prolonging the vegetative phase and delaying the transition to reproduction (e.g. Sunmax$^{\Phi}$). Varieties that are insensitive to photoperiod and vernalisation, mature predominantly in response to accumulated thermal time or day degrees (e.g. LongReach Mustang$^{\Phi}$).

When selecting a variety × SD combination, the aim is to match plant phenology with seasonal conditions so that crops flower during an optimal period. In the northern grains region (NGR) the optimum flowering window is considered an agronomic compromise between avoiding excessive yield loss due to frost and ensuring that flowering occurs early enough to enable a long grain-fill period, before heat and moisture stress restrict yield potential.

In 2017, field experiments were conducted across eight environments in the NGR from Wagga Wagga in southern NSW and north to Emerald in central Queensland, to determine the influence of different maturity groupings on crop development and yield potential for a core set of genotypes. This paper reports specifically on the results from Edgeroi in north-western NSW.

Site details

Location	Lockslea, Edgeroi, NSW.
Soil type	Grey–black vertosol.
Previous crop	Chickpea.
Sowing	• Direct-drilled with Boss parallelogram tyne. • Spacings 330 mm × 5 rows. • Plots 12 m long on 2 m centres.
Starting soil nitrogen (N)	~ 227 kg N/ha (0–120 cm).
Starting soil phosphorus	• Colwell: 16 mg/kg (0–10 cm), 3 mg/kg (10–30 cm). • BSES: 45.6 mg/kg (0–10 cm), 27.3 mg/kg (10–30 cm).
Starting water	~68 mm plant available water capacity (PAWC) to 120 cm.
Fertiliser	60 kg/ha Granulock Z.
Weed control	• Knockdown: Glyphosphate (450 g/L) 1.2 L/ha. • In-crop: 900 mL/ha Starane® Advanced + Uptake® 500 mL/100 L water (7 July).
Disease management	• Seed treatment: Vibrance® + Emerge®. • Flutriafol-treated fertiliser (200 ml/ha).
Rainfall	• In-crop (April–October): 177 mm, decile 2 • In-crop long-term average: 310 mm • In-crop long-term median: 292 mm

Treatments

- Thirty-two wheat varieties, varying in maturity (Table 1).
- Split-plot design, three replicates.
- Treatments: sowing date (blocked), genotype (randomised within blocks).
- Sowing dates: 20 April (SD1), 8 May (SD2) and 30 May 2017 (SD3).

Table 1 Variety maturity grouping

Maturity grouping	Genotype
Winter (W)	EGA Wedgetail$^{\phi}$, Longsword$^{\phi}$, LongReach Kittyhawk$^{\phi}$, RGT Accroc, Manning$^{\phi}$
Very slow (VS)	EGA Eaglehawk$^{\phi}$, Sunlamb$^{\phi}$
Slow (S)	DS Pascal$^{\phi}$, Cutlass$^{\phi}$, Kiora$^{\phi}$, Mitch$^{\phi}$, Suntime$^{\phi}$, Sunmax$^{\phi}$
Mid-slow (MS)	Coolah$^{\phi}$, DS Faraday$^{\phi}$, EGA Gregory$^{\phi}$, LongReach Lancer$^{\phi}$
Mid (M)	Beckom$^{\phi}$, Janz, Sunvale
Mid-fast (MF)	DS Darwin$^{\phi}$, LongReach Reliant$^{\phi}$, LongReach Trojan$^{\phi}$, Suntop$^{\phi}$
Fast (F)	Corack$^{\phi}$, Mace$^{\phi}$, Scepter$^{\phi}$, LongReach Spitfire$^{\phi}$
Very fast (VF)	Condo$^{\phi}$, LongReach Dart$^{\phi}$, H45, LongReach Mustang$^{\phi}$

Results

Temperature and flowering time – Edgeroi 2017.

Based on the probability of a 1:10-year event of temperatures <0 °C and >30 °C, the period from late August to mid–late September is considered the preferred flowering window for this location. The flowering window for this experiment spanned 106 days (10 July to 24 October), a reflection of the range of genotype × SD combinations and phenology responses (Figure 1).

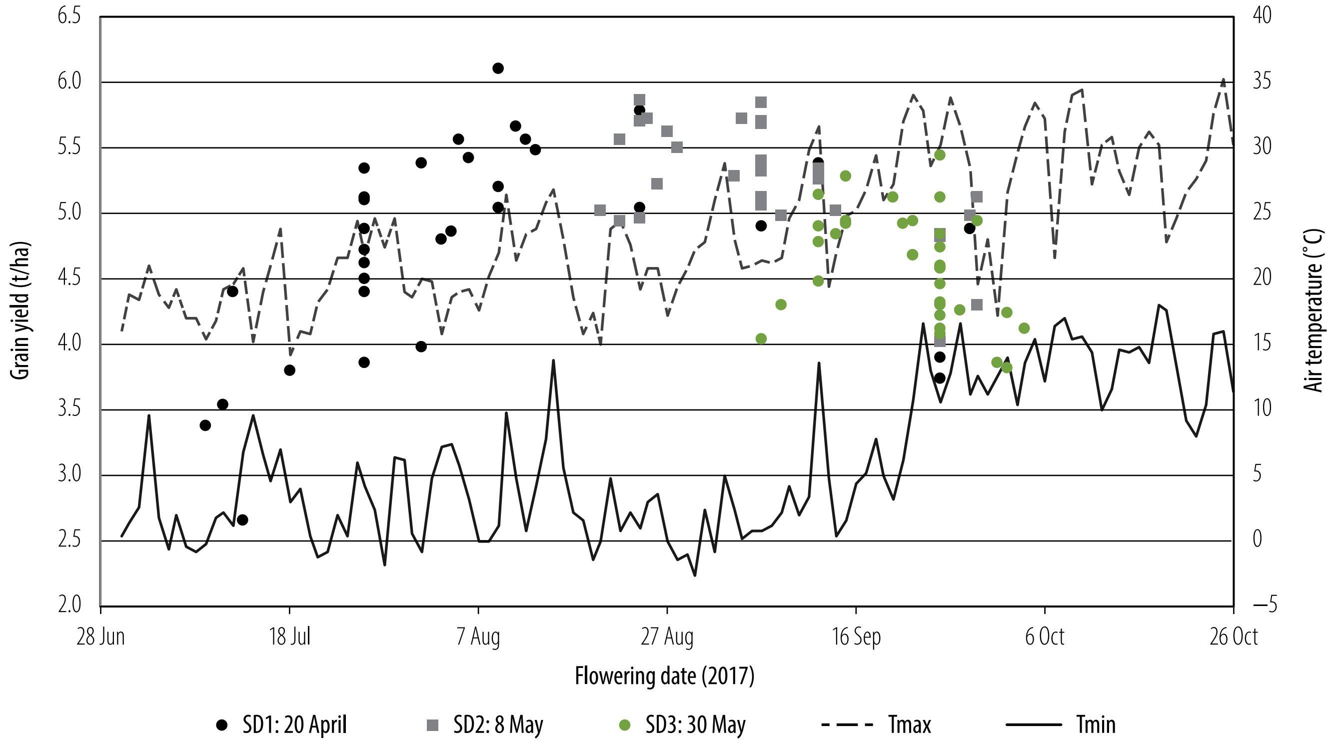

Figure 1 Relationship between temperature, flowering date and yield of wheat genotypes at Edgeroi, 2017.

Grain yield

There were distinct differences in different variety's yield potential to SD. Slow developing spring types (e.g. Sunmax⁽ᵇ⁾ and DS Pascal⁽ᵇ⁾) achieved optimal yields when sown early. Later sowings resulted in a negative yield response (Figure 2). This is further illustrated when looking at the effect of SD on phasic development: Sunmax⁽ᵇ⁾ for example from SD1 reached GS30 (stem elongation) on 20 June, and flowered in the optimal window on 7 September, while delayed SDs pushed flowering outside the optimum flowering window (Figure 3). In terms of effect on potential yield, DS Pascal⁽ᵇ⁾ suffered a 1.7 t/ha or 29% decrease in yield. Delayed flowering caused a 5.79 t/ha yield for SD1 (flowering on 25 August) vs 4.09 t/ha for SD3 (flowering on 29 September) (Table 2).

In contrast, the faster developing spring types achieved higher yields relative to the mean from the later sowing date, as seen by a positive yield response curve (e.g. LBP Mustang⁽ᵇ⁾) in Figure 2. Very fast varieties, with minimal vernalisation and photoperiod requirements, sown early (SD1) into warm temperatures, progressed rapidly and reached GS30 on 30 May–4 June (Figure 3). The rapid development of these VF varieties meant that they were exposed to an increased risk of frost, flowering from 10 July to 19 July (Figure 1). The VF varieties suffered significant yield penalties ranging from 28% to 49% from SD1 versus SD2 due to frost damage.

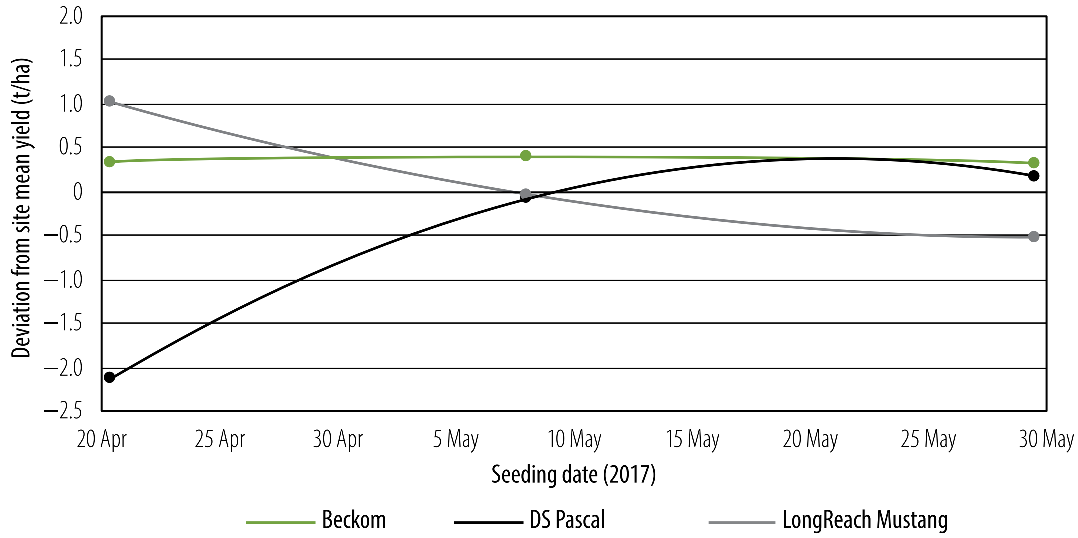

Figure 2 Genotype × sowing date yield response in 2017. Response is the deviation from the SD mean across three sowing dates. Sowing date mean: SD1 4.78t/ha; SD2 5.30t/ha; SD3 4.61t/ha.

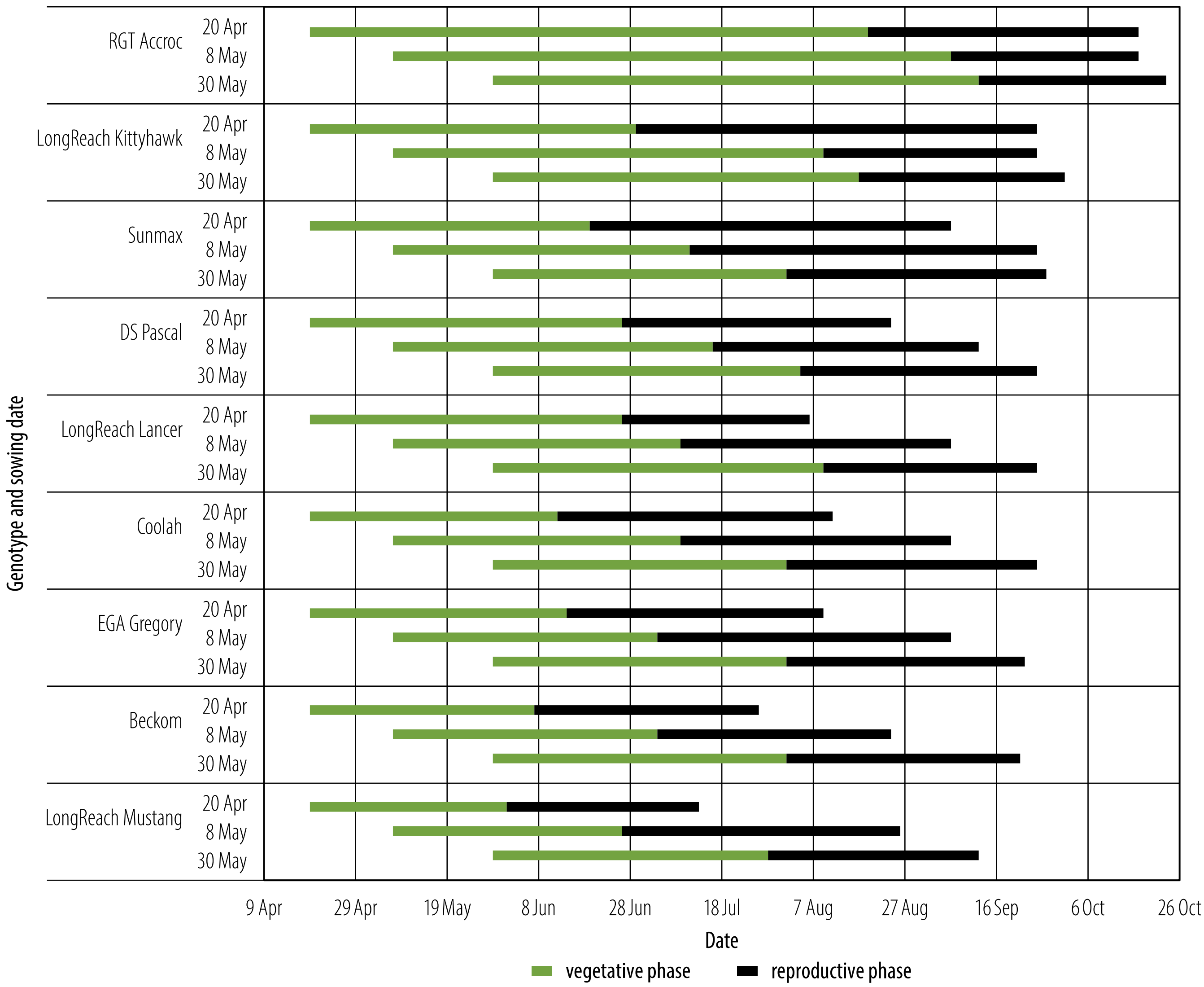

Figure 3 Influence of sowing date on development of selected genotypes sown SD1: 20 April, SD2: 8 May and SD3: 30 May. Vegetative phase (sowing to GS30); Reproductive phase (GS30 to GS65).

At the other extreme, winter varieties, with strong vernalisation requirements such as Manning⊕ and RGT Accroc, flowered too late in this environment, even from SD1, and did not achieve grain fill. RGT Accroc did not reach GS30 from SD1 until 27 July and did not flower until 18 October (Figure 3). Both EGA Wedgetail⊕ and LongReach Kittyhawk⊕, with mid-vernalisation requirements, were able to achieve yields across all SDs. These yields were, however, significantly lower (by~20%) than the mean for any given SD, a reflection of the difference in vernalisation requirement and hence maturity. The faster winter variety Longsword⊕, with less vernalisation requirement on the other hand, was able to achieve comparable yields to the mean for the range of SDs (Table 2).

Despite the increased risk of frost, some M and MF genotypes were able to maintain relatively stable grain yields, (indicated by a flatter slope), across all sowing dates e.g. Beckom⊕ (Figure 2).

Grain quality

Grain quality parameters were significantly affected by genotype, sowing date and the interaction between the two (Table 3). The VF varieties Condo⊕ and H45, both exceeded 5% screenings for SD1, indicative of frost damage most likely occurring during grain fill. In contrast, LongReach Dart⊕, LongReach Mustang⊕ and LongReach Spitfire⊕ had significant yield penalties from SD1 versus SD2 (Table 2), as did Condo⊕ and H45. Screenings for these varieties was >5%, indicative of frost damage occurring before grain filling, most likely during the post head emergence period. Delayed sowings, particularly for VS and winter varieties, increased the potential for down grading due to high screenings (Table 3), from increased heat and moisture stress and delayed flowering affecting the varieties' ability to fill grain.

All genotype × sowing date combinations achieved a test weight of >76 kg/hL. Frost-affected genotypes, e.g. LongReach Dart⊕, LongReach Mustang⊕ and H45 in SD1, or heat and moisture stress (e.g. EGA Eaglehawk⊕ and DS Pascal⊕ in SD3), were lower yielding and had higher grain protein concentration (GPC), underlining the inverse relationship between yield and GPC.

Table 2 Grain yield of genotypes across three sowing dates; percentage of SD mean in parentheses.

Genotype	Grain yield (t/ha)					
	SD1I		SD2		SD3	
Beckom	5.11	(107)	5.70	(108)	4.93	(107)
Condo	3.79	(79)	5.73	(108)	4.91	(107)
Coolah	5.66	(118)	5.10	(96)	4.13	(90)
Corack	4.50	(94)	5.86	(111)	4.93	(107)
Cutlass	5.48	(115)	5.12	(97)	4.58	(99)
DS Darwin	4.40	(92)	5.63	(106)	4.74	(103)
DS Faraday	5.56	(116)	5.35	(101)	4.84	(105)
DS Pascal	5.79	(121)	5.26	(99)	4.09	(89)
EGA Eaglehawk	5.39	(113)	4.98	(94)	4.23	(92)
EGA Gregory	5.05	(105)	5.08	(96)	4.68	(102)
EGA Wedgetail	3.91	(82)	4.30	(81)	3.81	(83)
H45	3.54	(74)	4.95	(93)	4.30	(93)
Janz	4.71	(99)	5.28	(99)	4.47	(97)
Kiora	4.81	(100)	5.02	(95)	4.23	(92)
LongReach Dart	3.38	(71)	5.02	(95)	4.04	(88)
LongReach Kittyhawk	3.73	(78)	4.01	(76)	3.86	(84)
LongReach Lancer	5.43	(113)	5.06	(95)	4.33	(94)
LongReach Mustang	2.66	(56)	5.22	(98)	4.78	(104)
LongReach Reliant	5.56	(116)	5.84	(110)	5.13	(111)
LongReach Spitfire	3.87	(81)	4.96	(94)	4.61	(100)
LongReach Trojan	6.12	(128)	5.68	(107)	4.94	(107)
Longsword	4.88	(102)	4.84	(91)	4.94	(107)
Mace	4.89	(102)	5.51	(104)	5.28	(115)
Mitch	4.86	(102)	5.33	(101)	4.67	(101)
Scepter	5.38	(113)	5.74	(108)	5.12	(111)
Sunlamb	5.05	(106)	5.12	(97)	4.12	(89)
Sunmax	4.91	(103)	4.82	(91)	4.27	(93)
Suntime	5.21	(109)	5.33	(101)	4.57	(99)
Suntop	5.13	(107)	5.40	(102)	4.84	(105)
Sunvale	3.98	(83)	4.99	(94)	4.30	(93)
Mean	4.78	(100)	5.30	(100)	4.61	(100)
l.s.d. (SD)	0.20					
l.s.d. (Genotype)	0.45					
l.s.d. (SD×Genotype)	0.79					

*Manning⁽ᴰ⁾ and RGT Accroc did not achieve a harvestable yield for any SD.

Table 3 Grain protein concentration (GPC), test weight (TWT) and screenings (SCRN) of genotypes across three SDs.

Genotype	SD1: 20 April			SD2: 8 May			SD3: 30 May		
	Protein (%)	TWT (kg/hL)	SCRN (%)	Protein (%)	TWT (kg/hL)	SCRN (%)	Protein (%)	TWT (kg/hL)	SCRN (%)
Beckom	12.3	82.1	2.2	12.4	83.0	1.7	13.1	84.8	4.4
Condo	13.6	82.2	7.0	12.6	84.2	3.0	12.8	85.7	2.9
Coolah	11.2	83.4	1.9	11.4	84.2	1.1	11.6	86.1	3.0
Corack	12.8	82.1	2.0	11.6	84.1	2.7	12.3	83.2	2.7
Cutlass	11.7	84.0	3.0	12.6	84.5	1.4	12.9	85.2	3.6
DS Darwin	13.0	81.8	2.8	12.2	83.6	2.6	12.5	85.3	3.5
DS Faraday	12.2	83.7	2.5	12.7	84.3	2.0	12.7	85.8	3.4
DS Pascal	11.7	81.4	2.3	12.6	80.6	2.8	13.0	83.3	6.5
EGA Eaglehawk	13.4	83.9	3.4	13.7	84.5	6.2	14.0	85.3	7.1
EGA Gregory	12.1	82.7	3.3	12.8	83.7	1.8	12.9	85.3	4.5
EGA Wedgetail	16.3	81.0	1.5	15.7	80.7	2.2	15.4	81.9	2.1
H45	13.0	82.0	6.0	11.3	83.4	1.6	12.0	85.4	2.5
Janz	13.2	83.5	1.4	12.4	82.7	1.1	13.6	84.6	4.7
Kiora	12.2	84.4	1.7	13.1	83.6	2.2	14.2	86.2	6.2
Longsword	15.2	84.5	1.1	13.8	84.9	2.0	13.2	85.4	4.2
LongReach Dart	14.4	81.5	2.7	12.6	83.1	3.0	13.7	83.8	5.8
LongReach Kittyhawk	14.7	85.8	1.5	14.3	85.9	2.0	14.0	84.5	5.2
LongReach Lancer	13.0	82.7	1.7	13.7	83.2	1.3	13.7	85.5	3.0
LongReach Mustang	14.4	80.8	2.9	11.3	83.7	5.1	12.2	85.7	3.1
LongReach Reliant	11.8	84.6	4.8	11.8	84.7	2.3	12.5	85.4	4.8
LongReach Spitfire	15.2	84.3	2.2	13.2	85.0	3.3	14.8	85.6	3.4
LongReach Trojan	11.6	85.6	1.8	12.4	85.5	1.1	12.3	86.5	2.9
Mace	12.3	83.2	1.9	11.4	83.4	1.8	12.3	84.5	4.0
Mitch	12.1	81.4	3.2	12.2	81.3	1.9	12.9	82.2	6.3
Scepter	11.8	83.3	2.5	11.5	84.1	1.8	12.5	84.3	5.5
Sunlamb	14.6	84.4	3.4	14.3	84.3	5.0	14.9	86.1	4.8
Sunmax	13.5	81.9	2.7	13.7	82.8	4.8	14.2	84.5	8.3
Suntime	13.0	83.8	3.2	12.9	84.8	2.1	13.6	85.6	4.4
Suntop	12.4	83.8	2.7	12.1	84.3	3.1	12.5	84.8	6.1
Sunvale	13.3	83.2	2.2	13.9	84.0	1.3	14.3	85.0	3.4
Mean			2.7			2.5			4.4
l.s.d. (Genotype)	0.4	0.7	1.0						
l.s.d. (SD)	0.3	0.4	0.7						
l.s.d. (Genotype×SD)	0.7	1.3	1.7						

Summary

High yields can be achieved from a range of genotype × sowing date combinations, due to differences in phenology (i.e. phasic development and flowering time). In 2017, at Edgeroi, slow maturing varieties (e.g. DS Pascal⁽ᴾ⁾) achieved optimum yields from SD1, with yields declining with delayed SDs (5.79 t/ha SD1 vs. 4.09 SD3). In contrast, VF varieties (e.g. LongReach Mustang⁽ᴾ⁾) suffered significant yield penalties of up to 49% from SD1 due to frost damage (Table 2), and performed better from the delayed sowing dates (2.66 t/ha SD1 vs. 5.22 t/ha SD2). Mid maturing (e.g. Beckom⁽ᴾ⁾) and MF varieties (e.g. LongReach Reliant⁽ᴾ⁾), were able to maintain yield potential across the SDs, despite frost risk. At the other extreme, winter types (e.g. Manning⁽ᴾ⁾ and RGT Accroc) with strong vernalisation requirements, flowered too late even from SD1 and were unable to achieve grain fill.

The results highlight both the effect of frost and heat/moisture stress on wheat's yield potential in the NGR. Encouragingly, the findings show the potential to minimise exposure to stresses by targeting the correct SD and flowering windows. Grain quality parameters, in particular high screenings, were also affected by variety and sowing date, through exposure to frost or heat/moisture stress at flowering. Delayed sowing of winter types and slow spring varieties, and early sowing of VF varieties significantly increased the potential for quality downgrading.

Improved understanding by growers of genotype and phenology responses to various SD opportunities will maximise yield potential of wheat in varying environments across the NGR.

Reference

Harris F, Graham R, Brooke G and Aisthorpe D (2018). Understanding drivers of phenology to increase grain yield of wheat. *Proceedings of GRDC Update*, 27–8 February, 2018, Dubbo, Australia https://grdc.com.au/resources-and-publications/grdc-update-papers/tab-content/grdc-update-papers/2018/02/understanding-drivers-of-phenology-to-increase-grain-yield-of-wheat

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