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Influence of sowing date on wheat phenology and grain yield – Wagga Wagga 2017

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Key findings

- Frost significantly influenced flowering date and grain yield in 2017.
- High grain yields can be achieved from a range of genotype × sowing date combinations.
- Whilst flowering time is important in maximising grain yield potential, timing pre-flowering phases was also found to significantly influence grain yield.

Introduction

There is a range of commercial cultivars suited for sowing across the northern grains region (NGR), which vary in phenology from slow-developing winter types to fast-developing spring types, providing growers with flexibility in their sowing window. Wheat's yield potential depends on matching a variety's phenology and sowing time to ensure flowering and grain formation occurs at an optimal time. In southern NSW, the optimal flowering window is bound by decreasing frost risk, and increasing water and heat stress.

In 2017, field experiments were conducted across eight NGR environments (located throughout central and southern QLD, northern, central and southern NSW) to determine phenology's influence on grain yield responses for a core set of wheat genotypes. This paper presents results from the Wagga Wagga site (southern NSW) and discusses the influence of sowing date on the phenology and grain yield responses of a core set of 36 wheat genotypes.

Site details

Location	Wagga Wagga Agricultural Institute
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$_{Ca}$	4.5 (0–10 cm)
Mineral nitrogen (N)	145 kg N/ha at sowing (1.8 m depth)
Fertiliser	80 kg/ha mono-ammonium phosphate (MAP) (sowing) 42 90 L/ha urea ammonium nitrate (UAN) (2 July)
Weed control	Knockdown: glyphosate (450 g/L) 1.2 L/ha Pre-emergent: Sakura® 118 g/ha + Logran® 35 g/ha In-crop: Precept® 500 mL/ha + Lontrel™ 40 g/ha (12 July) LVE MCPA (570 g/L) 400 mL/ha + Paradigm™ 25 g/ha (9 August)
Disease management	Seed treatment: Hombre® Ultra 200 mL/100 kg Flutriafol-treated fertiliser (400 mL/ha) In-crop: Prosaro® 300 mL/ha (6 July, 9 August)
In-crop rainfall	222.8 mm (April–October) (long-term average – 355 mm)

Treatments

Thirty-six wheat genotypes, varying in maturity were sown on four sowing dates: 10 April, 20 April, 5 May and 18 May 2017 (Table 1.)

Table 1. Expected phenology responses of the 2017 experimental genotypes.

Phenology type	Genotypes
Winter (W)	Longsword$^{(\mathrm{b}}$ (Fast), LongReach Kttyhawk$^{(\mathrm{b}}$, EGA Wedgetail$^{(\mathrm{b}}$, RGT Accroc$^{(\mathrm{b}}$ (Slow), Manning$^{(\mathrm{b}}$ (Slow)
Very slow (VS)	Sunlamb$^{(\mathrm{b}}$, EGA Eaglehawk$^{(\mathrm{b}}$, Sunmax$^{(\mathrm{b}}$
Slow (S)	Cutlass$^{(\mathrm{b}}$, Kiora$^{(\mathrm{b}}$, Suntime$^{(\mathrm{b}}$
Mid–slow (S–M)	Mitch$^{(\mathrm{b}}$, LongReach Lancer$^{(\mathrm{b}}$, Coolah$^{(\mathrm{b}}$, DS Faraday$^{(\mathrm{b}}$, DS Pascal$^{(\mathrm{b}}$, EGA Gregory$^{(\mathrm{b}}$, LongReach Trojan$^{(\mathrm{b}}$
Mid (M)	Janz, Beckom$^{(\mathrm{b}}$, Sunvale$^{(\mathrm{b}}$, Suntop$^{(\mathrm{b}}$, DS Darwin$^{(\mathrm{b}}$, V09063-56,
Fast (F)	Scepter$^{(\mathrm{b}}$, Corack$^{(\mathrm{b}}$, LongReach Reliant$^{(\mathrm{b}}$, Mace$^{(\mathrm{b}}$, LongReach Mustang$^{(\mathrm{b}}$, LongReach Spitfire$^{(\mathrm{b}}$, RAC2388, V08025-18
Very fast (VF)	Condo$^{(\mathrm{b}}$, LongReach Dart$^{(\mathrm{b}}$, H45, Tenfour

Results

Phasic development

Optimum grain yield is achieved when genotypes are matched with sowing date to ensure flowering occurs at an appropriate time. Generally, flowering date is a strong predictor of yield, with genotype and sowing date combinations that flower in early to mid-October at Wagga Wagga capable of achieving the highest grain yields. In 2017, the flowering window spanned 4–19 October, with significant variation in grain yields for genotype × sowing date combinations that flowered on the same day (Figure 1). Early stem frost damage directly influenced the flowering window at Wagga Wagga in 2017, which resulted in significant tiller death and late tiller regrowth in faster-developing genotypes, consequently affecting maturity uniformity in the plots. Flowering dates are expressed as 50% of emerged spikes with visible anthers. Many of the recorded flowering dates reflect late tiller regrowth and do not account for early tiller losses. Faster developing genotypes had lower tiller survival (proportion of tillers that produced a spike) at early sowing dates, whilst the slower-developing genotypes, which remained vegetative for longer, were exposed to less frost and were able to maintain tillers and stabilise flowering time.

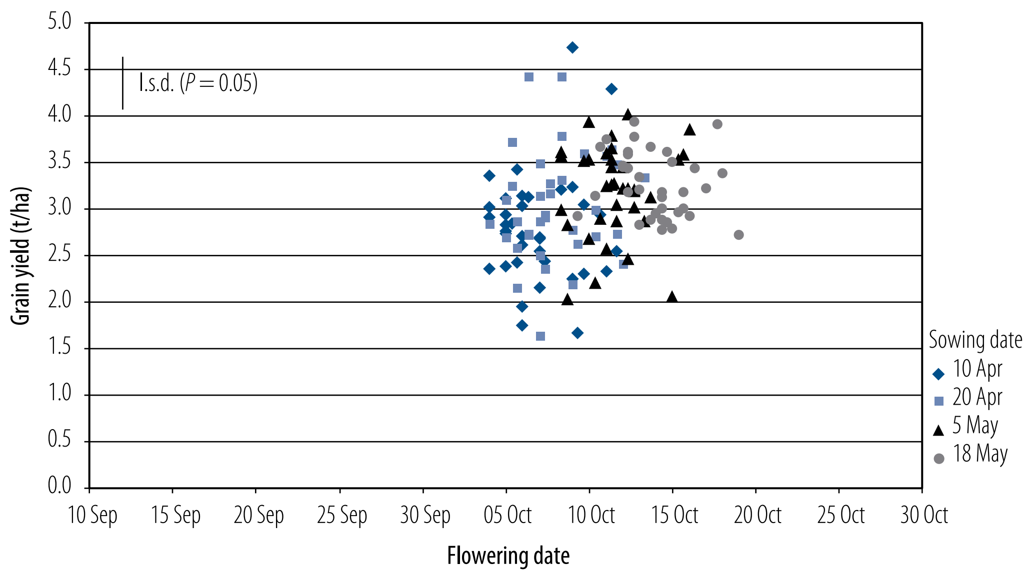

Figure 1. Relationship between flowering date and grain yield for 36 genotypes sown on 10 April, 20 April, 5 May and 18 May at Wagga Wagga, 2017.
Note: Flowering dates for Wagga Wagga were significantly affected by early stem frost damage.

Genotypes varied significantly in pre-flowering stage timing with respect to sowing time, which influenced the flowering grain yield responses shown in Figure 1. As phasic development is largely controlled by responses to vernalisation and photoperiod, these responses had a significant influence on pre-flowering phases timing and subsequently the genotypes' grain-filling phase in 2017 (Figure 2).

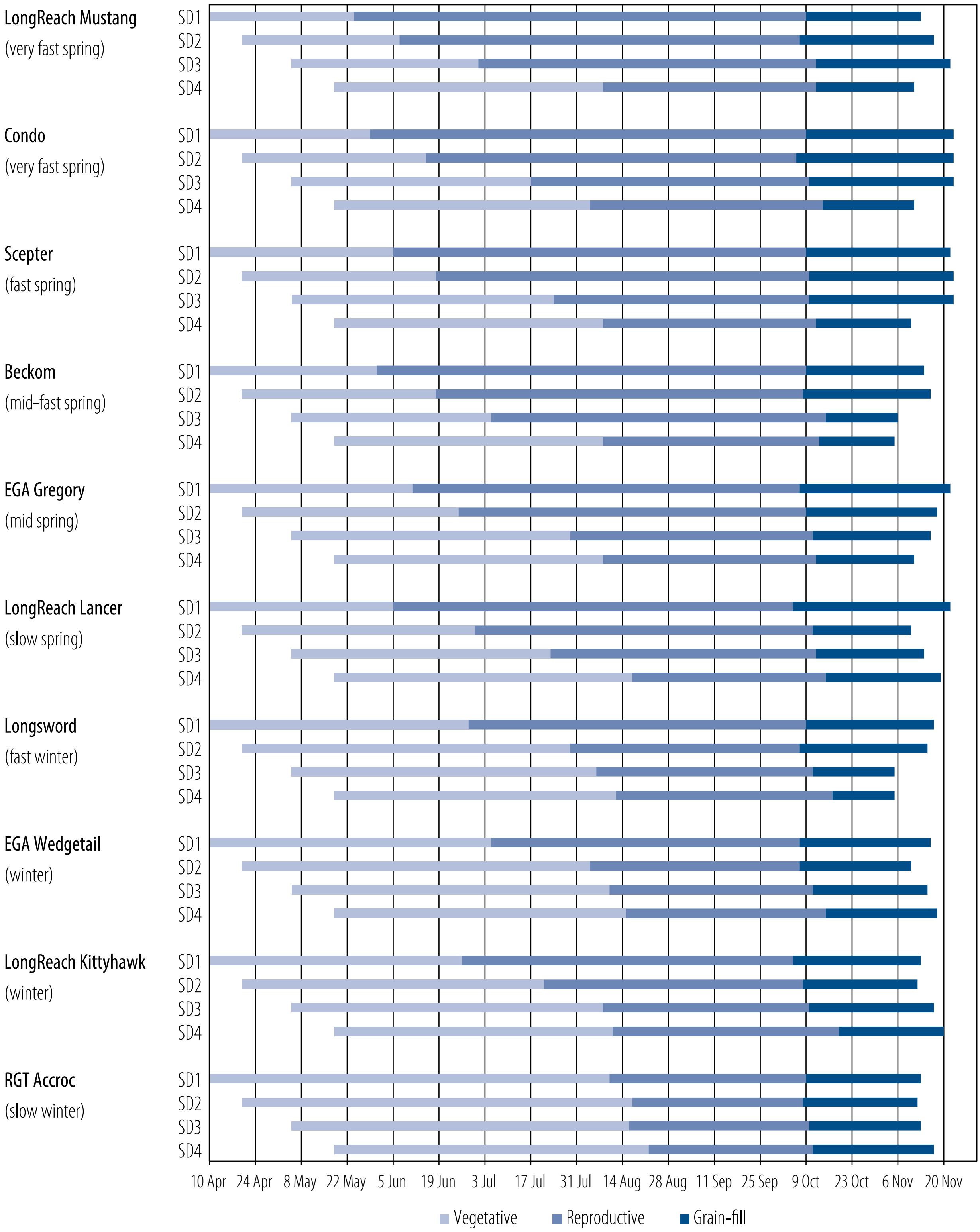

Figure 2. Influence of sowing date on phasic development of selected genotypes sown 10 April (SD1), 20 April (SD2), 5 May (SD3) and 18 May (SD4) at Wagga Wagga, 2017. Vegetative phase (sowing to GS30); reproductive phase (GS30 to flowering); grain-fill phase (flowering to maturity).

Faster-developing spring types (with minimal response to vernalisation), sown early (when temperatures are warmer and days longer), progressed quickly. For example, Condo⁽ᵖ⁾ sown on 10 April 2017 at Wagga Wagga, started stem elongation (GS30) on 29 May. However, winter type EGA Wedgetail⁽ᵖ⁾ sown on the same day (10 April), had a prolonged vegetative phase, due to its vernalisation requirement, reaching GS30 on 5 July (Figure 2).

Frost incidence significantly influenced phasic development, with Wagga Wagga recording 92 days below 0 °C (64 days below −2 °C) from late May to early September. The spring varieties' (e.g. LongReach Mustang⁽ᵖ⁾, Condo⁽ᵖ⁾) rapid development meant that when sown early, they were exposed to more severe frosts from early stem elongation to ear emergence. This resulted in significant tiller losses and late regrowth, which led to varied plant maturity within plots, and as such, delayed recorded flowering date and prolonged the grain-filling phase compared with later sowing dates (Figure 2). In contrast, the winter types had minimal stem frost damage, and had relatively uniform maturity across all sowing dates with the exception of the faster winter type Longsword⁽ᵖ⁾. Longsword⁽ᵖ⁾ had a prolonged vegetative phase (afforded by its vernalisation response), though progressed quickly thereafter, and some stem frost damage was recorded (and delayed maturity) in the earlier two sowing dates (Figure 2).

Grain yield

Winter and long-season genotypes achieved high yields from early sowing and were relatively stable across all sowing dates at the Wagga Wagga site (Table 2). This is likely due to the extended vegetative phase (afforded by vernalisation responses), which reduced exposure to frosts during early reproductive development and resulted in flowering at an optimal time. In contrast, faster developing genotypes were exposed to several frosts during stem elongation through to flowering when sown early, which significantly reduced yield.

There was variation in genotype yield responses across the four sowing dates (Figure 3). Generally, slow-developing genotypes had the highest yields when sown early (indicated by negative slope), for example, Manning⁽ᵖ⁾ (winter type, strong vernalisation response) and LongReach Kittyhawk⁽ᵖ⁾ (winter type). In contrast, many faster developing, spring genotypes had the greatest yields from later sowing times (indicated by positive slope), for example Scepter⁽ᵖ⁾. Despite the extreme frost conditions, some spring genotypes were able to maintain relatively stable grain yields across many sowing dates (indicated by flatter slope), for example EGA Gregory⁽ᵖ⁾ and Beckom⁽ᵖ⁾.

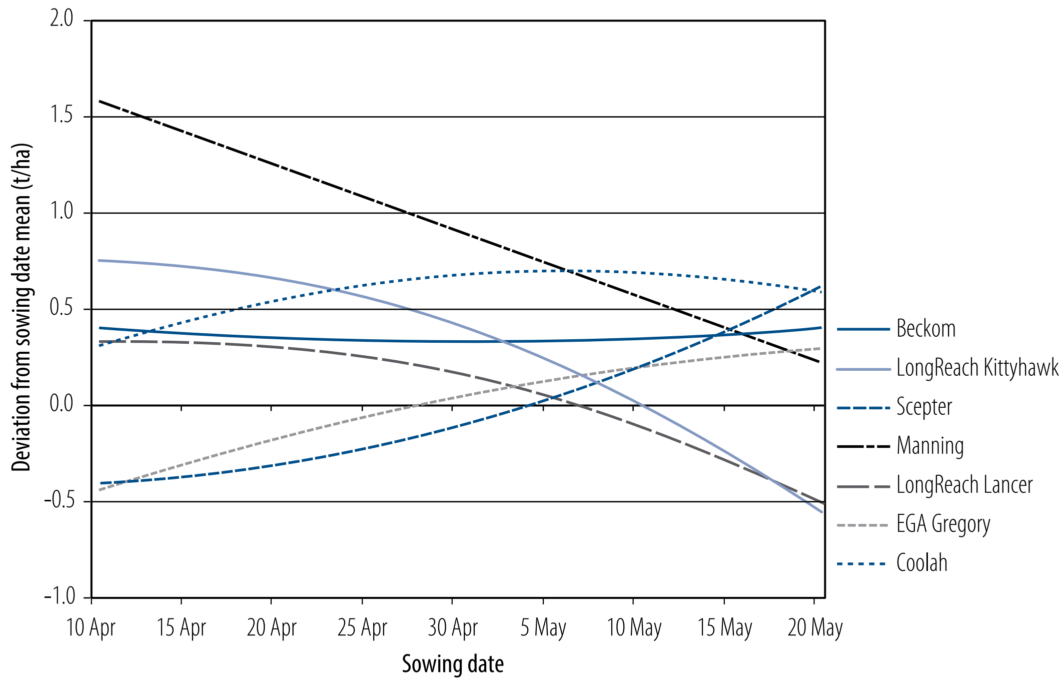

Figure 3. Genotype by sowing date response in 2017 for selected genotypes. Response is presented as deviation from sowing date mean across four sowing dates at Wagga Wagga. Sowing date mean: 10 April 2.79 t/ha; 20 April 3.03 t/ha; 5 May 3.20 t/ha; 18 May 3.26 t/ha.

Table 2. Grain yield of genotypes across four sowing dates (SD) at Wagga Wagga in 2017. Percentage of sowing date mean in parentheses.

Genotype	Grain yield (t/ha)							
	SD1: 10 April		SD2: 20 April		SD3: 5 May		SD4: 18 May	
Beckom	3.24	(116)	3.32	(110)	3.54	(111)	3.67	(113)
Condo	1.66	(60)	2.74	(90)	2.21	(69)	2.78	(85)
Coolah	3.04	(109)	3.61	(119)	4.02	(126)	3.79	(116)
Corack	1.95	(70)	2.16	(71)	2.06	(64)	3.35	(103)
Cutlass	3.12	(112)	3.11	(102)	3.54	(111)	3.50	(107)
Dart	2.16	(77)	2.36	(78)	2.47	(77)	2.96	(91)
DS Darwin	2.95	(106)	2.85	(94)	3.38	(106)	3.19	(98)
DS Faraday	2.74	(98)	3.34	(110)	3.60	(112)	3.67	(113)
DS Pascal	2.42	(87)	2.91	(96)	3.52	(110)	2.97	(91)
EGA Eaglehawk	2.92	(104)	3.15	(104)	3.46	(108)	2.89	(89)
EGA Gregory	2.44	(87)	2.63	(87)	3.60	(112)	3.44	(105)
EGA Wedgetail	2.70	(97)	3.28	(108)	3.28	(103)	3.00	(92)
H45	2.39	(86)	2.73	(90)	2.87	(90)	3.46	(106)
Janz	2.69	(96)	2.78	(92)	3.61	(113)	3.21	(98)
Kiora	2.77	(99)	3.73	(123)	3.27	(102)	3.01	(92)
LongReach Kittyhawk	3.42	(123)	3.8	(125)	3.54	(111)	2.72	(84)
LongReach Lancer	2.94	(105)	3.58	(118)	3.22	(101)	2.79	(86)
LongReach Mustang	2.61	(94)	2.87	(95)	3.02	(94)	3.38	(104)
LongReach Reliant	3.05	(109)	2.94	(97)	3.20	(100)	3.62	(111)
LongReach Trojan	2.71	(97)	2.72	(90)	3.86	(121)	3.46	(106)
Longsword	2.25	(81)	2.51	(83)	3.05	(95)	3.23	(99)
Mace	2.35	(84)	2.41	(80)	2.58	(81)	3.19	(98)
Manning	4.30	(154)	4.43	(146)	3.79	(119)	3.59	(110)
Mitch	2.83	(102)	3.25	(107)	3.58	(112)	2.86	(88)
RGT Accroc	4.74	(170)	4.43	(146)	3.95	(123)	3.75	(115)
Scepter	2.31	(83)	2.99	(99)	2.90	(91)	3.95	(121)
LongReach Spitfire	2.33	(83)	2.20	(72)	2.69	(84)	3.13	(96)
Sunlamb	3.22	(115)	3.17	(105)	2.88	(90)	2.88	(88)
Sunmax	3.14	(113)	3.48	(115)	3.46	(108)	3.01	(92)
Suntime	2.55	(91)	2.70	(89)	2.83	(88)	2.84	(87)
Suntop	3.36	(120)	3.50	(115)	3.66	(114)	3.18	(98)
Sunvale	2.85	(102)	3.65	(120)	3.23	(101)	2.93	(90)
Tenfour	1.75	(63)	1.64	(54)	2.03	(63)	3.44	(105)
Mean	2.79	(100)	3.03	(100)	3.2	(100)	3.26	(100)
l.s.d.								
sowing date	0.29							
genotype	0.08							
sowing date × genotype	0.58							

Summary

Genotypes vary in their phenology, which influences early development phases as well as flowering time. The extreme frost conditions in 2017 had a significant effect on flowering date and grain yield, as well as amplifying the effect of the timing and length of pre-flowering development phases on yield. Whilst matching variety and sowing time to achieve flowering at an appropriate time for each growing environment is the most effective management strategy to optimise grain yields, future research will also investigate the contribution of pre-flowering phases to yield development.

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