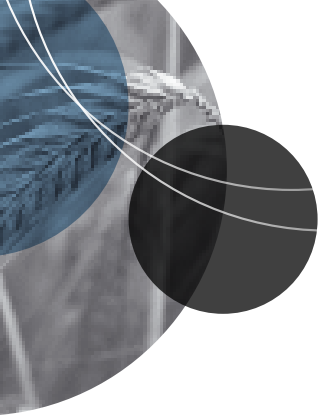

Agronomy – cereals

Effect of sowing date on phenology and grain yield of thirty-six wheat varieties – Wagga Wagga 2016

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Key findings

- It is critical to match sowing time with varietal phenology to optimise yield potential.
- Longer-season varieties were high yielding in 2016 due to the extended grain filling period due to adequate soil moisture and mild spring temperatures.
- There is a range of newer varieties with varied phenology with high yield potential.

Introduction

There is a range of varieties suited for sowing in southern NSW, these vary in phenology from slow-developing winter to fast-developing spring varieties. To achieve maximum grain yield potential, it is important to ensure varieties are sown according to their relative maturities so that flowering occurs at an optimum time. This experiment reports the effect of sowing time on the phenology, grain yield and quality of 36 wheat varieties.

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.
Fertiliser	100 kg/ha mono-ammonium phosphate (MAP) (sowing) 50 kg N/ha UAN (31 May)
Soil pH_{Ca}	5.1 (0–10 cm)
Mineral nitrogen at sowing (1.5 m depth)	142 kg N/ha
Weed control	Knockdown: glyphosate (450 g/L) 1.2 L/ha Pre-emergent: Sakura® 118 g/ha + Logran® at 35 g/ha
Disease management	Seed treatment: Hombre® Ultra 200 mL/100 kg Flutriafol-treated fertiliser (400 mL/ha) In-crop: Prosaro® 300 mL/ha at GS30 and GS37 to prevent and/or suppress rust infections
In-crop rainfall (April–October)	592 mm (long-term average is 355 mm)
Irrigation	9 mm applied 21 April to establish first sowing time only

Treatments

Thirty-six wheat varieties varying in maturity were sown on three sowing dates: 15 April, 3 May and 20 May 2016 (Table 1).

Table 1. Putative phenology types of the experimental varieties.

Phenology type	Varieties
Winter (W)	EGA Wedgetail$^{\Phi}$, LongReach Kittyhawk$^{\Phi}$
Very slow (VS)	EGA Eaglehawk$^{\Phi}$, LPB12-0648, Sunlamb$^{\Phi}$
Slow (S)	Bolac$^{\Phi}$, Cutlass$^{\Phi}$, Kiora$^{\Phi}$, LongReach Lancer$^{\Phi}$, Mitch$^{\Phi}$
Mid (M)	Coolah$^{\Phi}$, DS Darwin$^{\Phi}$, DS Pascal$^{\Phi}$, EGA Gregory$^{\Phi}$, Janz, LongReach Flanker$^{\Phi}$, LongReach Trojan$^{\Phi}$, Sunvale$^{\Phi}$, UQ01512, UQ01553
Mid-fast (MF)	Beckom$^{\Phi}$, Suntop$^{\Phi}$, LongReach Spitfire$^{\Phi}$
Fast (F)	Corack$^{\Phi}$, Emu Rock$^{\Phi}$, Livingston$^{\Phi}$, LongReach Reliant$^{\Phi}$ Mace$^{\Phi}$, Scepter$^{\Phi}$
Very fast (VF)	Condo$^{\Phi}$, LongReach Dart$^{\Phi}$, Hatchet CL Plus$^{\Phi}$, HTWYT_012, LPB12-0391, LPB12-0494, Sunmate$^{\Phi}$

Results

Phenology response to sowing time

The warmer winter temperatures in 2016 resulted in flowering starting 10–14 days earlier than in 2015 (Slinger et al. 2016), while the cooler spring temperatures extended the flowering period into early November (tables 2, 3 and 4). Detailed phenology measurements were recorded in 2016 to determine variation in phase duration among maturity groups in response to sowing date.

There were significant differences between varieties in the phasic duration from sowing to start of stem elongation (GS31), ear emergence (GS59) and flowering (GS65). The warmer temperatures early in the season resulted in many faster-developing spring varieties starting stem elongation quicker from the first sowing (15 April) compared with the later two sowing dates. In contrast, the slowest-developing spring variety (Sunlamb$^{\Phi}$) and winter varieties (EGA Wedgetail$^{\Phi}$ and LongReach Kittyhawk$^{\Phi}$), which have increasing responsiveness to vernalisation, had prolonged vegetative phases (Table 4).

Delayed sowing reduced the length of the growing season and the reproductive phase (GS31–GS59) was most affected. This corresponds to the period in which potential grain number is largely determined.

Differences in the phenology of varieties are largely controlled by response to vernalisation and photoperiod. Winter varieties are responsive to vernalisation and can be sown early, remaining vegetative until their vernalisation requirement is satisfied. Should a spring variety with minimal response to vernalisation be sown early (when temperatures are warmer and days longer), development progresses quickly, flowering occurs earlier than is optimal and grain yield potential is lower. For example, LongReach Dart$^{\Phi}$, sown on 15 April 2016 at Wagga Wagga, started stem elongation on 8 June and flowered on 30 August (Table 2). However, EGA Wedgetail$^{\Phi}$, sown on the same day, was slower to reach GS31 (20 July) and flowered on 8 October (Table 4).

Varieties differ in their response to photoperiod. In photoperiod-sensitive varieties, development is accelerated in response to longer days. However, there is variation in photoperiod response amongst Australian wheats with many insensitive to photoperiod. The slow maturity of Sunlamb$^{\Phi}$ is controlled largely through response to vernalisation coupled with photoperiod sensitivity. This is different from the winter types EGA Wedgetail$^{\Phi}$ and LongReach Kittyhawk$^{\Phi}$, which are relatively insensitive to photoperiod. This is observed through the shortened vegetative phase and extended reproductive phase of Sunlamb$^{\Phi}$ compared with the winter types (Table 4).

The accelerated development of fast spring varieties such as Hatchet CL Plus$^{\Phi}$ and LongReach Dart$^{\Phi}$ meant that when sown early, they were exposed to two frost events (26–27 August) at early ear emergence and had significantly lower yield (Table 5). These fast developing varieties produced high numbers of later tillers which resulted in varied maturity within plots, delayed harvest and varied grain quality (Table 5).

Table 2. Phase duration of very fast- to fast- (VF–F) maturing varieties at Wagga Wagga, 2016. Dates of key development stages: Sowing (S), start of stem elongation (GS31), ear emergence (GS59) and flowering (GS65). Sowing dates: 15 April (1), 3 May (2) and 20 May (3).

Variety	Sowing date	Date development stage reached			Duration of phase		
		GS31	GS59	GS65	S-GS31 (days)	GS31–59 (days)	GS59–65 (days)
Hatchet CL Plus	1	8 Jun	5 Aug	6 Sep	48	58	32
	2	4 Jul	27 Aug	13 Sep	63	53	17
	3	22 Jul	19 Sep	6 Oct	64	58	18
LongReach Dart	1	8 Jun	7 Aug	30 Aug	48	60	23
	2	30 Jun	29 Aug	14 Sep	58	60	16
	3	22 Jul	17 Sep	26 Sep	64	56	10
Sunmate	1	8 Jun	23 Aug	11 Sep	48	76	19
	2	11 Jul	13 Sep	25 Sep	69	64	13
	3	1 Aug	2 Oct	8 Oct	73	62	7
HTWYT_012	1	14 Jun	25 Aug	6 Sep	54	72	12
	2	7 Jul	14 Sep	23 Sep	65	69	9
	3	29 Jul	27 Sep	3 Oct	70	60	7
LPB12-0391	1	8 Jun	19 Aug	4 Sep	48	72	16
	2	4 Jul	7 Sep	20 Sep	62	65	14
	3	26 Jul	26 Sep	5 Oct	67	62	10
LPB12-0494	1	16 Jun	19 Aug	5 Sep	56	64	17
	2	11 Jul	10 Sep	23 Sep	69	61	13
	3	26 Jul	27 Sep	2 Oct	67	63	6
Condo	1	8 Jun	19 Aug	1 Sep	48	72	13
	2	11 Jul	7 Sep	16 Sep	69	58	9
	3	26 Jul	24 Sep	2 Oct	67	60	8
Corack	1	20 Jun	19 Aug	4 Sep	60	60	16
	2	11 Jul	7 Sep	19 Sep	69	58	12
	3	1 Aug	22 Sep	2 Oct	73	52	11
Emu Rock	1	8 Jun	5 Aug	3 Sep	48	58	29
	2	4 Jul	2 Sep	17 Sep	62	60	15
	3	26 Jul	26 Sep	4 Oct	67	62	8
Livingston	1	8 Jun	16 Aug	3 Sep	48	69	18
	2	4 Jul	4 Sep	22 Sep	62	62	18
	3	2 Aug	24 Sep	3 Oct	74	53	9
Mace	1	8 Jun	29 Aug	10 Sep	48	82	12
	2	12 Jul	12 Sep	22 Sep	70	62	10
	3	1 Aug	30 Sep	6 Oct	73	60	6
LongReach Reliant	1	27 Jun	30 Aug	11 Sep	67	64	12
	2	11 Jul	13 Sep	19 Sep	69	64	6
	3	1 Aug	27 Sep	6 Oct	73	57	9
Scepter	1	20 Jun	30 Aug	9 Sep	60	71	10
	2	11 Jul	11 Sep	25 Sep	69	62	15
	3	1 Aug	2 Oct	8 Oct	73	62	6
l.s.d. ($P<0.05$)					5.2	6.4	7.2

Table 3. Phase duration of mid-fast- to mid-slow- (MF–MS) maturing varieties at Wagga Wagga, 2016. Dates of key development stages: Sowing (S), start of stem elongation (GS31), ear emergence (GS59) and flowering (GS65). Sowing dates: 15 April (1), 3 May (2) and 20 May (3).

Variety	Sowing date	Date development stage reached			Duration of phase		
		GS31	GS59	GS65	S-GS31 (days)	GS31-59 (days)	GS59-65 (days)
LongReach Spitfire	1	14 Jun	18 Aug	6 Sep	54	65	19
	2	6 Jul	6 Sep	19 Sep	64	62	14
	3	26 Jul	26 Sep	6 Oct	67	62	10
Beckom	1	23 Jun	31 Aug	14 Sep	63	69	14
	2	11 Jul	14 Sep	23 Sep	69	65	10
	3	6 Aug	3 Oct	8 Oct	79	57	5
Suntop	1	8 Jun	30 Aug	15 Sep	48	83	16
	2	11 Jul	19 Sep	29 Sep	69	70	10
	3	5 Aug	4 Oct	9 Oct	77	60	6
Coolah	1	22 Jun	8 Sep	25 Sep	63	77	17
	2	15 Jul	13 Sep	25 Sep	73	60	12
	3	9 Aug	6 Oct	15 Oct	81	58	9
EGA Gregory	1	23 Jun	12 Sep	21 Sep	63	81	9
	2	15 Jul	21 Sep	30 Sep	74	67	9
	3	11 Aug	7 Oct	13 Oct	83	57	7
Janz	1	20 Jun	30 Aug	14 Sep	60	71	15
	2	13 Jul	16 Sep	28 Sep	71	65	13
	3	4 Aug	30 Sep	7 Oct	76	57	7
LongReach Flanker	1	27 Jun	5 Sep	19 Sep	67	70	14
	2	16 Jul	20 Sep	30 Sep	75	65	10
	3	9 Aug	4 Oct	11 Oct	81	56	7
Sunvale	1	27 Jun	5 Sep	17 Sep	67	70	12
	2	18 Jul	22 Sep	30 Sep	76	66	8
	3	11 Aug	7 Oct	15 Oct	83	57	8
LongReach Trojan	1	23 Jun	5 Sep	19 Sep	63	74	14
	2	13 Jul	18 Sep	30 Sep	71	67	12
	3	5 Aug	7 Oct	11 Oct	77	63	5
DS Darwin	1	20 Jun	28 Aug	9 Sep	60	69	12
	2	11 Jul	17 Sep	25 Sep	69	68	8
	3	4 Aug	3 Oct	6 Oct	76	60	3
DS Pascal	1	7 Jul	13 Sep	26 Sep	77	68	13
	2	22 Jul	25 Sep	6 Oct	81	64	11
	3	12 Aug	7 Oct	16 Oct	84	56	9
UQ01512	1	25 Jun	6 Sep	18 Sep	66	72	12
	2	18 Jul	20 Sep	27 Sep	76	64	8
	3	10 Aug	5 Oct	9 Oct	82	56	5
UQ01553	1	30 Jun	5 Sep	19 Sep	70	67	14
	2	18 Jul	18 Sep	29 Sep	76	62	11
	3	15 Aug	4 Oct	12 Oct	87	50	9
Mitch	1	20 Jun	9 Sep	18 Sep	60	81	9
	2	11 Jul	19 Sep	28 Sep	69	70	9
	3	8 Aug	4 Oct	17 Oct	80	57	13
l.s.d. ($P<0.05$)					5.4	6.4	7.2

Table 4. Phase duration of slow-winter (S–W) maturing varieties at Wagga Wagga, 2016. Dates of key development stages: Sowing (S), start of stem elongation (GS31), ear emergence (GS59) and flowering (GS65). Sowing dates: 15 April (1), 3 May (2) and 20 May (3).

Variety	Sowing date	Date development stage reached			Duration of phase		
		GS31	GS59	GS65	S-GS31 (days)	GS31–59 (days)	GS59–65 (days)
Bolac	1	30 Jun	5 Sep	22 Sep	70	67	17
	2	18 Jul	24 Sep	6 Oct	76	68	12
	3	10 Aug	7 Oct	16 Oct	82	58	10
Cutlass	1	23 Jun	14 Sep	23 Sep	63	83	9
	2	16 Jul	30 Sep	9 Oct	75	75	10
	3	11 Aug	7 Oct	18 Oct	83	57	12
Kiora	1	20 Jun	7 Sep	30 Sep	60	79	23
	2	11 Jul	20 Sep	4 Oct	69	71	14
	3	11 Aug	7 Oct	19 Oct	83	57	12
LongReach Lancer	1	23 Jun	9 Sep	20 Sep	63	78	11
	2	18 Jul	19 Sep	30 Sep	76	63	11
	3	9 Aug	9 Oct	18 Oct	82	61	10
EGA Eaglehawk	1	5 Jul	13 Oct	19 Oct	75	100	6
	2	18 Jul	19 Oct	25 Oct	76	93	6
	3	9 Aug	25 Oct	31 Oct	81	77	7
LPB12-0648	1	9 Jul	20 Sep	1 Oct	79	73	11
	2	26 Jul	23 Sep	2 Oct	84	59	9
	3	15 Aug	8 Oct	20 Oct	87	54	12
Sunlamb	1	11 Jul	17 Oct	21 Oct	81	98	4
	2	1 Aug	25 Oct	27 Oct	90	85	2
	3	18 Aug	28 Oct	31 Oct	90	71	4
LongReach Kittyhawk	1	16 Jul	3 Oct	5 Oct	86	81	2
	2	4 Aug	8 Oct	16 Oct	93	65	8
	3	22 Aug	18 Oct	23 Oct	94	57	6
EGA Wedgetail	1	20 Jul	2 Oct	8 Oct	90	74	6
	2	5 Aug	26 Sep	15 Oct	94	52	19
	3	18 Aug	16 Oct	22 Oct	90	59	6
l.s.d. ($P<0.05$)					5.2	6.4	7.2

Grain yield

The cooler spring temperatures favoured later-maturing varieties in 2016, which had reasonably stable yields across all three sowing dates due to the extended grain-filling period. The later sowing time (20 May) did not incur the grain yield penalties often associated with later heading dates (Figure 1). There was no significant difference in mean grain yield between the second and third sowing dates. The winter and longer-season varieties achieved similar grain yields across sowing dates (Table 5). Newly released winter wheat LongReach Kittyhawk$^{\Phi}$ yielded similarly to EGA Wedgetail$^{\Phi}$. It developed 3–4 days faster than EGA Wedgetail$^{\Phi}$ from stem elongation through to flowering (Table 4).

As expected, fast-maturing varieties such as Hatchet CL Plus$^{\Phi}$, LongReach Dart$^{\Phi}$, Condo$^{\Phi}$, Sunmate$^{\Phi}$, Emu Rock$^{\Phi}$, Corack$^{\Phi}$ and LongReach Reliant$^{\Phi}$ had a positive grain yield response with delayed sowing, achieving higher yields from the latest (20 May) sowing (Table 5). Some varieties such as Beckom$^{\Phi}$, Coolah$^{\Phi}$, Scepter$^{\Phi}$, LongReach Trojan$^{\Phi}$ and LongReach Lancer$^{\Phi}$ have shown flexibility in sowing date across 2015 and 2016, achieving above site mean grain yields consistently across sowing times.

Note: whilst all seasons are unique, it is important to consider long-term data to determine suitability of varieties based on matching phenology and sowing time for the growing environment.

Table 5. Grain yield and quality of 36 varieties across three sowing dates at Wagga Wagga, 2016.

Variety	Sowing date											
	15 April				3 May				20 May			
	Grain yield (t/ha)	Yield rank	Protein (%)	Screenings (%)	Grain yield (t/ha)	Yield rank	Protein (%)	Screenings (%)	Grain yield (t/ha)	Yield rank	Protein (%)	Screenings (%)
Beckom	6.35	6	11.9	3.5	7.46	2	10.1	2.0	7.67	5	9.7	4.8
Bolac	6.70	3	12.0	4.1	7.32	4	11.2	7.1	6.52	29	10.6	4.8
Condo	5.22	21	13.3	0.2	6.78	17	12.2	1.0	7.64	6	11.2	1.5
Coolah	6.91	2	12.2	1.1	7.13	8	11.2	1.3	7.68	3	9.9	2.3
Corack	3.92	32	14.1	0.8	5.85	28	13.4	0.7	6.91	18	11.0	0.1
Cutlass	5.30	19	12.1	0.2	7.28	5	11.1	1.4	7.73	2	9.6	1.3
DS Darwin	5.30	20	13.5	1.0	6.59	22	11.9	1.1	7.13	12	10.7	1.1
DS Pascal	6.38	5	12.1	0.7	6.90	14	11.3	2.2	7.51	7	10.3	4.1
EGA Eaglehawk	5.93	12	10.6	3.4	4.90	35	10.1	3.7	6.48	33	9.4	5.4
EGA Gregory	6.05	11	12.5	1.3	6.76	19	12.8	1.2	6.74	22	10.9	2.4
EGA Wedgetail	6.21	9	10.3	1.7	6.94	13	10.9	1.2	7.10	14	10.8	3.4
Emu Rock	4.46	30	15.3	1.2	6.34	25	13.3	1.4	6.85	21	11.5	3.4
Hatchet CL Plus	2.04	36	19.4	0.8	2.87	36	16.3	0.5	6.49	31	11.1	0.9
HTWYT_012	4.72	25	14.2	3.7	6.25	27	13.7	2.8	6.57	27	11.0	7.1
Janz	5.46	18	12.6	2.2	6.77	18	11.3	3.8	6.66	23	10.7	2.3
Kiora	6.17	10	12.7	2.6	7.56	1	11.4	5.7	7.31	9	11.1	6.4
Livingston	2.39	35	16.2	2.9	5.26	34	14.0	1.2	6.46	34	12.5	2.5
LongReach Dart	2.79	34	16.5	0.7	5.59	31	14.3	1.5	6.48	32	12.1	3.3
LongReach Flanker	5.63	17	11.9	1.0	7.01	11	10.9	1.5	7.37	8	9.5	1.6
LongReach Kittyhawk	6.42	4	10.8	2.5	7.12	9	11.1	3.0	6.65	24	9.2	3.4
LongReach Lancer	5.63	16	13.3	0.9	7.07	10	12.1	1.6	6.65	25	11.4	2.4
LongReach Reliant	4.55	28	14.5	0.7	5.43	33	12.9	1.6	6.05	36	11.0	1.5
LongReach Spitfire	3.51	33	15.2	1.4	6.30	26	12.6	0.7	7.13	13	11.4	3.3
LongReach Trojan	6.29	7	11.8	2.5	7.41	3	10.8	1.7	7.68	4	9.9	2.2
LPB12-0391	4.97	23	14.0	1.2	6.72	20	12.7	1.9	6.57	28	9.2	4.7
LPB12-0494	4.51	29	14.1	2.4	6.63	21	12.5	1.1	7.24	11	11.3	5.0
LPB12-0648	5.90	14	13.4	2.5	6.86	15	11.0	3.9	7.10	15	10.0	3.6
Mace	4.60	27	14.9	1.2	5.84	29	13.5	1.2	6.90	19	10.7	1.5
Mitch	7.22	1	10.8	2.4	7.21	6	10.4	4.0	7.31	10	9.2	2.0
Scepter	6.25	8	12.7	0.9	7.14	7	11.9	0.6	7.89	1	11.4	1.1
Sunlamb	5.75	15	10.8	3.9	6.48	23	10.6	6.6	6.87	20	53.8	10.9
Sunmate	4.41	31	13.9	0.0	6.40	24	11.8	1.1	6.52	30	10.3	1.5
Suntop	5.91	13	12.2	4.3	7.00	12	11.4	4.3	6.94	16	11.5	8.2
Sunvale	4.95	24	13.7	2.4	6.81	16	11.3	1.3	6.60	26	10.7	2.9
UQ01512	5.20	22	12.2	1.9	5.79	30	12.3	0.7	6.45	35	10.7	2.0
UQ01553	4.63	26	13.4	0.4	5.44	32	13.6	0.6	6.93	17	11.0	2.3
Mean (sowing date)	5.24		13.2	1.8	6.48		12.1	2.1	6.97		11.8	3.3
l.s.d. grain yield ($P<0.05$)	0.83 t/ha											
l.s.d. protein ($P<0.05$)	6.2											
l.s.d. screenings ($P<0.05$)	2.2											

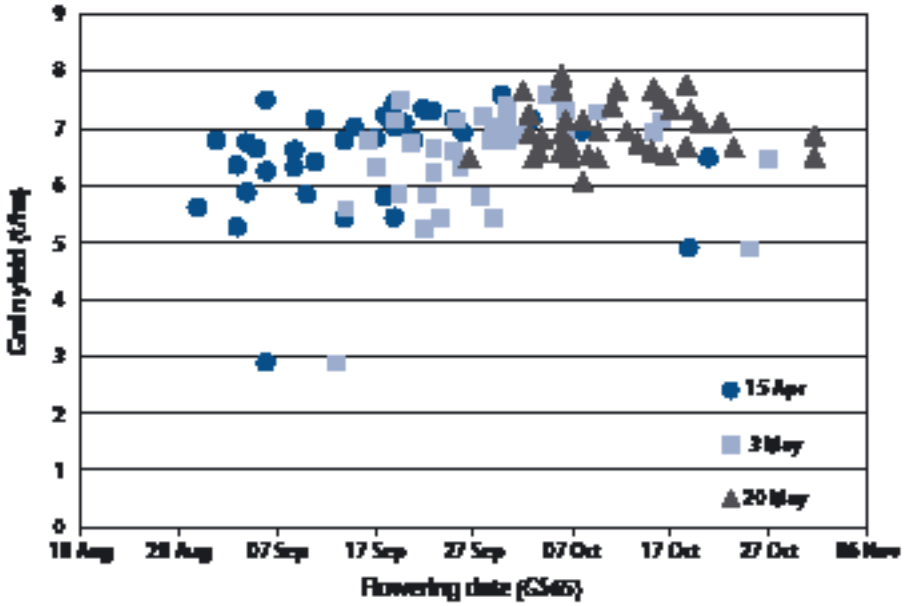

Figure 1. Flowering date and grain yield of 36 wheat varieties for three sowing dates at Wagga Wagga, 2016.

Summary

Varietal phenology is important when determining the effect of sowing time on grain yield potential. Longer-season varieties were high yielding with the extended grain-filling period in 2016. However, decisions should be based on results across a number of seasons. Winter wheats can be sown early (late February–April), with long-season spring wheats from mid April to early May, and main season spring wheats from late April onwards. Some of the newer varieties have been high-yielding and are worth consideration: LongReach Kittyhawk$^{\Phi}$ performed similarly to EGA Wedgetail$^{\Phi}$ and provides an alternative for earlier sowing; mid-maturing varieties Beckom$^{\Phi}$, Coolah$^{\Phi}$ and LongReach Trojan$^{\Phi}$ have shown some flexibility across sowing times, achieved high yields and are suited to main-season sowing; while faster-maturing varieties such as Scepter$^{\Phi}$, Condo$^{\Phi}$ and Cutlass$^{\Phi}$ achieved high yields from later sowing. Further research will be undertaken in 2017 to better understand the impact of phenology on grain yield formation.

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