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Deep sown wheat experiment – Riverina 2024

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Key findings

- Calibre⦶ sown at 4 cm on 27 May was the highest yielding treatment with 6.26 t/ha.
- Sowing time was a key factor in achieving higher yields with the earlier sowing date (27 May) producing 23–24% higher average yields than the later sowing date (17 June).
- Sowing depth was also a significant factor in achieving higher yields with the shallow sowing depth (4 cm) producing 12–13% higher average yields than the deeper sowing depth (12 cm).
- Calibre⦶ was the highest yielding variety sown at 12 cm on 27 May (5.24 t/ha) and was significantly higher yielding than Mace18 (4.63 t/ha) and statistically similar to Magenta13 (4.84 t/ha).
- The 2 new experimental long coleoptile varieties derived from Mace⦶ and Magenta⦶ demonstrated no significant yield advantage over the 4 commercial varieties for any sowing time or any sowing depth. However, the long coleoptile genetics did improve establishment and achieved the highest plant density from the deep sowing (12 cm), particularly for the optimum sowing window (27 May).

Keywords Wheat, variety, grain yield, sowing depth, sowing time, coleoptile

Introduction

Sowing wheat is often postponed in seasons when the autumn break is delayed due to the lack of adequate soil moisture at the normal 4–5 cm depth. The delay in sowing often leads to yield loss with the longer the delay in sowing, the greater the yield loss at harvest. To reduce yield loss due to late sowing, growers might consider the option to sow their wheat deeper at 12 cm in search of adequate soil moisture and therefore be able to sow in the correct sowing window. We asked the question: should growers adopt longer coleoptile varieties to improve establishment and yield by sowing deeper in the correct sowing window? To help answer this question, we compared 4 commercial wheat varieties against 2 new experimental varieties derived from Magenta⦶ and Mace⦶ that differ in the gene expression of the semi-dwarfing genes (*Rht13* or *Rht18* respectively) and *Rht2* gene. The experiment evaluated 6 wheat varieties at 2 sowing depths and 2 sowing times.

Materials and method

Site details

Location	Leeton Field Station (LFS)
Soil type	Self-mulching medium clay
Previous crop	Field pea
Soil starting nitrogen (N)	140 kg N/ha (60 cm)
Starter fertiliser	100 kg/ha of mono-ammonium phosphate (MAP) (10 kg N/ha)
Time of sowing (TOS)	• TOS1: 27 May 2024 • TOS2: 17 June 2024
Row spacing	350 mm
Target plant density	180 plants/m^2
In-season rainfall	• Autumn: 73 mm • Winter: 86 mm • Spring: 64 mm
Fungicides	• Soprano (125 g/L epoxiconazole) at 125 mL/ha • Prosaro 420 (210 g/L prothioconazole and 210 g/L terbuconazole) at 300 mL/ha
Herbicides	• Trilogy (480 g/L trifluralin) at 1.7 L/ha • Boxer Gold (800 g/L prosulfocarb and 120 g/L S-metolachlor) at 2.5 L/ha • Achieve (400 g/kg tralkoxydim) at 500 g/ha • Axial Xtra (50 g/L pinoxaden and 12.5 g/L cloquintocet-mexyl) at 600 mL/ha • L.V.E. Agritone (570 g/L MCPA present as the 2-ethylhexyl ester) at 1.8 L/ha
Harvest date	2 December 2024

Treatments

The experiment was a split-split-plot design with main plots as time of sowing (TOS), then split for sowing depth and genotype (Table 1). Each interaction (TOS × sowing depth × genotype) had 3 replicates across the experiment area. With 3 replicates of 6 varieties × 2 sowing depths × 2 sowing times, there were a total of 72 plots. All plots were 1.4 m wide (4 rows at 35 cm apart) and 12 m long. The experiment was sown using a cone seeder for both seed placement and base fertiliser application.

Table 1 Treatments (time of sowing, target sowing depth and genotype) evaluated in the 2024 LFS deep sown wheat (DSW) experiment.

Treatment	Comment
Time of sowing (TOS)	
TOS1: 27 May	Middle of the sowing window for the Riverina
TOS2: 17 June	Late in the sowing window for the Riverina
Target sowing depth	
4 cm	Actual depth averaged 3.8 cm
12 cm	Actual depth averaged 10.3 cm
Genotype	
Scepter⁽ᴾ⁾	AGT spring variety released in 2015
Calibre⁽ᴾ⁾	Scepter type with longer coleoptile released in 2021
Magenta⁽ᴾ⁾	Intergrain commercial spring variety released in 2007
Mace⁽ᴾ⁾	AGT spring variety released in 2008
Mace18	Mace variety containing experimental long coleoptile *Rht2* gene
Magenta13	Magenta variety containing experimental long coleoptile *Rht2* gene

Measurements

All plots were sown with a target density of 180 plants/m². Plots were sown 12 m long and cut back to 10 m before harvest. Plant density counts were conducted after all plants emerged (3–5 weeks after sowing). The 10 m plots were harvested using a Kingaroy plot header with all 4 rows harvested to determine grain yield. Subsamples from the machine harvest were collected and used to determine grain quality with yield calculated at 12% grain moisture.

Results

Plant density

TOS2 sown at 4 cm achieved the highest average plant density with 170.0 plants/m² and was statistically similar to TOS1 sown at 4 cm with 160.1 plants/m² (Table 2). TOS2 at 12 cm had the lowest density with 107.2 plants/m² and was statistically similar in density to TOS1 at 12 cm with 107.5 plants/m².

Table 2 Effect of 2 times of sowing on establishment (plants/m²) at 2 sowing depths for the 2024 DSW experiment at LFS.

	Time of sowing: establishment (plants/m²)	
Sowing depth	**TOS1**	**TOS2**
4 cm	160.1 [a]	170.0 [a]
12 cm	107.5 [b]	107.2 [b]

Values followed by the same letter are not significantly different at the 95% confidence level.

For TOS1, Magenta⁽ᴾ⁾ sown at 4 cm achieved the highest plant density with an average of 202.6 plants/m² (Table 3). Magenta⁽ᴾ⁾ sown at 4 cm had a significantly higher plant density than all other varieties sown at 4 cm including the 2 new experimental lines of Magenta13 and Mace18.

For TOS1 at the deeper 12 cm sowing depth, Mace18 and Magenta13 achieved the highest plant density with 133.3 and 130.9 plants/m² respectively and were statistically similar in density to Magenta⁽ᴾ⁾ and Calibre⁽ᴾ⁾.

TOS1 often induces high mortality given it is a more difficult environment for the plants to emerge due to slightly higher temperatures compared with TOS2. The '4 cm vs 12 cm -establishment percentage' comparison is used to demonstrate which varieties are more suitable when searching for deeper soil moisture. The results show that both Mace18 and

Magenta13 performed very consistently between sowing depth treatments with a 95.6 and 81.7 establishment percentage, respectively, which is much better than the other commercial varieties. Furthermore, both Mace18 and Magenta13 performed the best out of all the varieties when comparing the 12 cm sowing depth to the target population of 180 plants/m² with a 74.1 and 72.7% establishment rate, respectively.

Table 3 Effect of 2 sowing depths on establishment (plants/m²) for TOS1 in the 2024 DSW experiment at LFS.

	TOS1	Sowing depth: establishment (plants/m²)		Establishment percentage – 4 cm vs 12 cm	Percentage of target population (180 plants/m²)	
	Variety	4 cm	12 cm	4 cm vs 12 cm	4cm	12 cm
1	Calibre	161.9 b	110.2 ef	68.1	89.9	61.2
2	Scepter	156.2 bcd	96.0 f	61.5	86.8	53.3
3	Magenta	202.6 a	104.8 ef	51.7	112.6	58.2
4	Mace	143.4 bcd	64.5 g	45.0	79.7	35.8
5	Mace18	139.5 bcd	133.3 cde	95.6	77.5	74.1
6	Magenta13	160.3 bc	130.9 de	81.7	89.1	72.7

Values followed by the same letter are not significantly different at the 95% confidence level.

For TOS2, Magenta⦶ sown at 4 cm achieved the highest plant density with an average of 207.4 plants/m² (Table 4) and was statistically similar to Magenta13.

For TOS2 at the deeper 12 cm sowing depth, Magenta⦶, Magenta13 and Mace18 achieved the highest plant density with 131.4, 129.3 and 119.0 plants/m² respectively. For TOS2 at the deeper sowing depth of 12 cm, Magenta⦶ and Magenta13 were significantly higher in plant density than Mace⦶, Calibre⦶ and Scepter⦶.

For TOS2, Mace18 demonstrated a 90.4% establishment percentage in the 4 cm depth compared with the 12 cm depth, which was much better than all the other genotypes in terms of establishment consistency (Table 4). Mace18, Magenta⦶, and Magenta13 were relatively consistent at the TOS2 sowing depth when compared with the target population of 180 plants/m².

Table 4 Effect of 2 sowing depths on establishment (plants/m²) for TOS2 in the 2024 DSW experiment at LFS.

	TOS2	Sowing depth: establishment (plants/m²)		Establishment percentage – 4 cm vs 12 cm	Percentage of target population (180 plants/m²)	
	Variety	4 cm	12 cm	4 cm vs 12 cm	4cm	12 cm
1	Calibre	160.5 c	97.9 ef	61.0	89.2	54.4
2	Scepter	161.7 c	71.0 f	43.9	89.8	39.4
3	Magenta	207.4 a	131.4 d	63.4	115.2	73.0
4	Mace	173.6 bc	98.3 ef	56.6	96.4	54.6
5	Mace18	131.7 d	119.0 de	90.4	73.2	66.1
6	Magenta13	194.5 ab	129.3 d	66.5	108.1	71.8

Values followed by the same letter are not significantly different at the 95% confidence level.

Grain yield

Grain yield averaged 4.60 t/ha across all variety, sowing time and sowing depth treatments. TOS1 sown at 4 cm achieved the highest average grain yield with 5.58 t/ha and was significantly higher yielding than all other sowing time and sowing depth combinations (Table 5). TOS2 sown at 12 cm had the lowest grain yield with 3.73 t/ha and was significantly lower in yield than all other sowing time and sowing depth combinations.

Table 5 Effect of 2 times of sowing on yield (t/ha) at 2 sowing depths for the 2024 DSW experiment at LFS.

	Time of sowing: yield (t/ha)	
Sowing depth	TOS1	TOS2
4 cm	5.58 [a]	4.25 [c]
12 cm	4.83 [b]	3.73 [d]

Values followed by the same letter are not significantly different at the 95% confidence level.

There was a significant interaction between varieties, sowing time and sowing depth treatments. For TOS1, grain yield averaged 5.20 t/ha across both sowing depths. Calibre⁽ᴰ⁾ sown at 4 cm achieved the highest grain yield with an average of 6.26 t/ha and had a significantly higher yield than all other varieties sown at 4 cm (Table 6). For TOS1 at the deeper 12 cm sowing depth, Calibre⁽ᴰ⁾ also achieved the highest grain yield with 5.24 t/ha and was significantly higher yielding than Mace⁽ᴰ⁾ and Mace18.

For TOS2, grain yield averaged 3.99 t/ha across both sowing depths. Calibre⁽ᴰ⁾ sown at 4 cm achieved the highest grain yield with an average of 4.51 t/ha and was statistically similar in yield to Scepter⁽ᴰ⁾, Magenta⁽ᴰ⁾, Mace⁽ᴰ⁾ and Mace18 (Table 6). For TOS2, at the deeper 12 cm sowing depth, Calibre⁽ᴰ⁾ achieved the highest grain yield with 3.94 t/ha and was statistically similar in yield to all other varieties sown at 12 cm.

Table 6 Average grain yield (t/ha) for all varieties for both times of sowing and both sowing depth treatments in the 2024 DSW experiment at LFS.

	Variety	Sowing depth (cm)	Time of sowing	Yield (t/ha)
1	Calibre	4	1	6.26 [a]
2	Scepter	4	1	5.65 [b]
3	Magenta	4	1	5.63 [b]
4	Mace	4	1	5.35 [bcd]
5	Mace18	4	1	5.55 [bc]
6	Magenta13	4	1	5.01 [cdef]
1	Calibre	12	1	5.24 [bcd]
2	Scepter	12	1	5.03 [cde]
3	Magenta	12	1	4.86 [defg]
4	Mace	12	1	4.38 [gh]
5	Mace18	12	1	4.63 [efg]
6	Magenta13	12	1	4.84 [defg]
1	Calibre	4	2	4.51 [efgh]
2	Scepter	4	2	4.44 [fgh]
3	Magenta	4	2	4.04 [hij]
4	Mace	4	2	4.33 [ghi]
5	Mace18	4	2	4.44 [fgh]
6	Magenta13	4	2	3.71 [j]
1	Calibre	12	2	3.94 [hij]
2	Scepter	12	2	3.66 [j]
3	Magenta	12	2	3.62 [j]
4	Mace	12	2	3.74 [j]
5	Mace18	12	2	3.65 [j]
6	Magenta13	12	2	3.78 [ij]

Values followed by the same letter are not significantly different at the 95% confidence level.

Summary

When averaged across the 6 varieties, sowing time had no effect on plant density at either the 4 cm or 12 cm sowing depths. However, sowing depth did have a significant effect on plant density for both sowing times. For TOS1, there was an average reduction in plant density of 33% when the sowing depth was increased from 4 cm to 12 cm and in TOS2 the average reduction in plant density was 37% when the sowing depth was increased.

In terms of any varietal effect, both the long coleoptile varieties for TOS1 established very consistently between both sowing depth treatments. This is especially important as TOS1 will be the target date for sowing the long coleoptile varieties. Also, Mace18 and Magenta13 had the highest establishment percentage for TOS1 at the 12 cm depth, which is important when sowing deeper in search of adequate soil moisture.

There was a significant yield penalty associated with delaying sowing at both the 4 cm and 12 cm sowing depths. There was an average yield penalty across all varieties of 1.33 t/ha (24%) at the 4 cm sowing depth and an average yield penalty of 1.10 t/ha (23%) at 12 cm when sowing was delayed from 27 May to 17 June.

There was also a significant yield penalty when the sowing depth was increased for both sowing times. For TOS1, there was an average yield penalty across all varieties of 0.75 t/ha (13%) when the depth was increased from 4 cm to 12 cm. For TOS2, the increase in sowing depth resulted in an average yield penalty of 0.88 t/ha (12%).

The highest yielding treatment across the whole experiment was the commercial variety Calibre$^{\phi}$ sown at 4 cm on 27 May (TOS1). This treatment yielded 6.26 t/ha and was significantly higher yielding than all other treatments. Other high yielding treatments above 5.60 t/ha included the varieties Scepter$^{\phi}$ and Magenta$^{\phi}$, all sown at 4 cm on 27 May (TOS1). This result demonstrates confidence in sowing commercial varieties at the recommended sowing time when there is adequate soil moisture at 4 cm.

When there is insufficient soil moisture at 4 cm, growers can consider sowing wheat deeper at 12 cm in search of adequate soil moisture to avoid any delay in sowing. In this experiment we can directly compare the 2 options of 'sowing deeper to avoid delayed sowing' or 'delaying sowing until there is adequate shallow moisture'. For TOS1 sown at 12 cm deep, the 2 new experimental long coleoptile varieties of Mace18 and Magenta13 achieved a grain yield of 4.63 and 4.84 t/ha respectively. For TOS2 the highest yielding commercial varieties achieved a yield of 4.51 and 4.44 t/ha, which was statistically similar in yield to the 2 new experimental long coleoptile varieties. This result demonstrated that there was no benefit in adopting the new long coleoptile varieties over existing commercial varieties under the better than average seasonal conditions at Leeton in 2024. Perhaps more modern varieties with the long coleoptile genetics would better emphasise the potential benefits of deep sowing in terms of yield as opposed to older varieties such as Mace$^{\phi}$ and Magenta$^{\phi}$ (released 2007 and 2009 respectively) compared with Calibre$^{\phi}$ (released 2021).

In this experiment we can also directly compare the new experimental long coleoptile varieties to the existing commercial varieties at both shallow and deep sowing depths. At the shallow depth (4 cm), Calibre$^{\phi}$ was significantly higher yielding for TOS1 than either Mace18 or Magenta13, and in TOS2 at 4 cm, Calibre$^{\phi}$ was significantly higher yielding than Magenta13 but statistically similar in yield to Mace18. At the deeper depth (12 cm), Calibre$^{\phi}$ was significantly higher yielding for TOS1 than Mace18 and statistically similar in yield to Magenta13. For TOS2 sown at 12 cm, Calibre was statistically similar in yield to both Mace18 and Magenta13. This result demonstrated that there is no benefit in adopting any of the new long coleoptile varieties at either sowing time (27 May and 17 June) or at either sowing depth (4 cm and 12 cm).

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