Benefits of long coleoptile wheat

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Key findings

- Marginal summer rainfall leading into the 2022 season at Hart resulted in dry conditions, and marginal soil moisture at depth.
- Commercial wheat varieties with longer coleoptiles had improved crop establishment when sown deep, with Bale (133 plants/m^2) and Calibre (130 plants/m^2) having better crop establishment when compared to Scepter (118 plants/m^2).
- Results show that pre-breeding line Mace18 had reduced yield when sown at standard depth (40 mm) after the season break on May 30. This result was also observed at other trial locations (Rebetzke et al 2022) with the reason currently unknown.
- Yield losses were observed for Mace and Scout when sown deep, showing that the Rht18 gene in these varieties provides benefits, allowing growers to sow deeper.
- In years where small and infrequent rainfall events occur, standard sowing (40 mm) may reduce establishment when crops are sown early in drier conditions. Long coleoptile wheats can reduce this risk by deeper sowing into subsoil moisture when conditions are favourable.

Introduction

Deep sowing is a technique that can be used by growers to place seeds into soil moisture lower in the profile or improve pre-emergent herbicide crop safety (Porker & Wheeler 2012). Most commercially available wheat varieties have shorter coleoptile lengths (5-7 cm) and reduced establishment can result if sown too deep (Pumpa et al 2013). Wheats with longer coleoptile sheaths have the ability to protect the seedling when sown deeper (>50 mm), resulting in a reduction of crop establishment. Long coleoptile wheat varieties could allow growers to sow seed further away from pre-emergent herbicide bands without reducing crop establishment (Porker & Wheeler 2012) or risking potential yield loss.

Two trials were conducted at Hart in 2022:

1. Comparing crop safety and yield impacts of current wheat varieties with varying coleoptile lengths.
2. Assessing the performance of current and pre-breeding wheat lines from CSIRO (+/- Rht18 gene) when sown at standard depth (40 mm) or deep (120 mm).

Methodology

Plot size	1.75 m x 10.0 m	**Fertiliser**	Seeding: DAP (18:20) Zn 1% + Impact @ 80 kg/ha
Seeding date	June 10, 2022		July 22: Easy N (42.5:0) @ 70 L/ha
Location	Hart, SA		August 17: Easy N (42.5:0) @ 60 L/ha
Harvest date	December 15, 2022		
2021 crop	Mulgara Oaten Hay		

Trial 1 was a split-split plot design with three replicates, three wheat varieties, three pre-emergent herbicides and two sowing depths. Varieties selected for this trial were based on their variation in coleoptile length (Table 1); Scepter (medium – short), Calibre (medium – long), and LRPB Bale (long). The pre-emergent herbicides used in this trial were Sakura®, Luximax® and Overwatch®. Assessments for this trial include plant establishment (plants/m^2), NDVI (Normalised Difference Vegetation Index), grain yield (t/ha), and grain quality. Data was analysed using a split-split plot ANOVA model in Genstat 22nd edition.

Trial 2 was a split plot design with three current commercial varieties, three pre-breeding lines (+Rht18 breeding gene) and two sowing depths (Table 2). Assessments include plant establishment (plants/m^2), NDVI (Normalised Difference Vegetation Index), plant height (cm), grain yield (t/ha), and grain quality. Data was analysed using a split-split plot ANOVA model in Genstat 22nd edition.

Table 1. Treatments for Trial 1; variety x herbicide x sowing depth sown at Hart in 2022.

Variety	Pre-emergent herbicide	Sowing depth
Scepter	Sakura	40 mm (standard)
Calibre	Luximax	120 mm (deep)
LRPB Bale	Overwatch	

Table 2. Treatments for Trial 2; new genetics x sowing depth sown at Hart in 2022. Mace18, Scout18 and Yitpi18 contain the Rht18 dwarfing gene.

Variety	Sowing depth
Mace	40 mm (standard)
Mace18	120 mm (deep)
Scout	
Scout18	
Yitpi	
Yitpi18	

Results and discussion

2022 Sowing conditions

Due to a late season break (May 30) and minimal rainfall over summer and autumn months, trials were sown in June. Long coleoptile wheats allow growers to sow earlier into subsoil moisture, however as the Hart site has a heavy soil type (clay loam), dry conditions were not favourable to sow deep and would have resulted in poor seed-soil contact.

Results from Trial 2 primarily show the effects of sowing pre-breeding wheat (+Rht18 genes) at a standard sowing time at two depths compared to commercial varieties Mace, Scout and Yitpi.

Variety x herbicide x sowing depth

There was a plant establishment penalty observed across all varieties sown at depth when compared to standard sowing depth, however, less so for those with a longer coleoptile. Bale and Calibre performed best at depth with plant establishment of 133 and 130 plants/m^2, respectively. Crop establishment between all varieties sown at standard sowing depths was similar.

Grain yield was not affected by sowing depth, with the trial averaging 3.95 t/ha (Table 3).

Scepter was expected to display yield losses when sown at depth. Previous growth chamber research conducted at Waite, SA (Bruce 2017) showed that coleoptile length can increase under cold conditions (peak length at 15 degrees), so results highlight the possibility that coleoptile length can increase in cold environments.

Grain quality was variable among treatments with differences in protein (%), test weight (kg/hL) and screenings (%). Protein was higher when crop was deep sown, averaging 10.3%, while standard depth sowing averaging 9.1% (Table 3). Screenings were affected by variety selection, with the awnless variety Bale recording the highest level of screenings. Screenings were also high for Bale when sown deep. Test weight was variable between treatments with varying responses amongst varieties.

Table 3. Grain yield and quality of wheat varieties at standard or deep sowing for the variety x herbicide x sowing depth trial. Shaded values indicate best performing treatments. Values with the same letters are not significantly different.

Sowing Depth	Variety	Yield (t/ha)	Protein (%)	Test Weight (kg/hL)	Screenings (%)
Standard	Scepter	4.31	8.8	85.5[d]	3.2[a]
	Calibre	4.48	8.7	82.9[b]	3.3[a]
	Bale	3.84	9.9	82[b]	4.9[b]
Deep	Scepter	3.69	10.2	86.2[d]	2.9[a]
	Calibre	3.92	9.6	84.0[c]	3.6[ab]
	Bale	3.47	11.00	79.1[a]	6.4[c]
LSD (P≤0.05)		**NS**	**NS**	**1.03**	**1.39**

Pre-emergent herbicide selection had little effect on crop establishment or grain yield at Hart in 2022 and no crop damage was observed in any treatment.

Grain yield was positively influenced by pre-emergent herbicide treatment; with plots treated with Overwatch and Luximax recording high yields of 3.97 and 3.98 t/ha, respectively. Plots treated with Sakura were lower yielding with yields of 3.91 t/ha. The lower yields were likely not due to herbicide damage from Sakura. Herbicide damage is more likely to occur when crops are sown at a standard depth and no damage was observed at Hart.

New genetics x sowing depth

The inclusion of the new dwarfing gene Rht18 improved crop establishment at deep sowing for Mace18 and Scout18 (Figure 2). Yitpi18 was observed to have similar establishment to commercial wheat Yitpi without the Rht18 gene, when sown deep. This is a result of Yitpi having a longer coleoptile and would emerge better when sown deep compared to other varieties. Differences would likely be observed if deeper seeding depth was trialed.

At a standard sowing depth of 40 mm, emergence between varieties +/- Rht18 gene was similar.

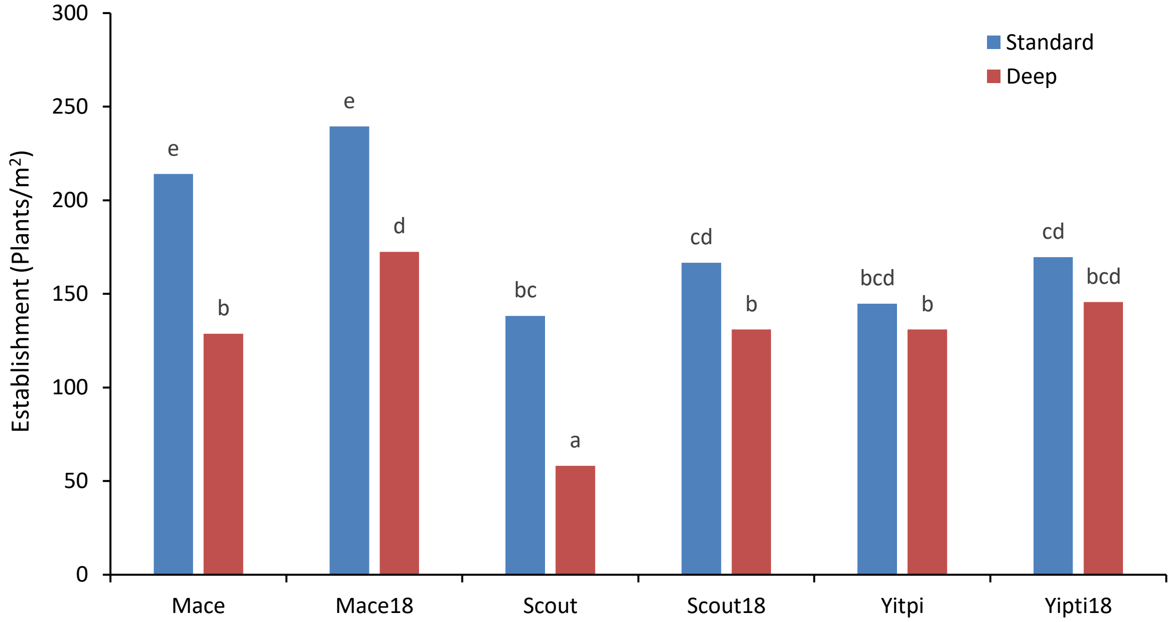

Figure 2. Establishment (plants/m^2) of wheat varieties trialed in the variety x sowing depth. Varieties with the same letter are not significantly different.

When sown at standard depth, Mace, Scout, Yitpi and Yitpi18 were the highest yielding wheats with an average yield of 4.09 t/ha (Figure 3).

Scout18 and Mace18 provided yield benefits over commercial varieties Mace and Scout when sown deep. This was not observed for Yitpit18 which yielded similarly to commercial variety Yitpi. This is a result of this variety having a longer coleoptile. Yield differences may be observed if Yitpi and Yitpi18 were sown deeper than 120 mm.

Pre-breeding wheat lines of Scout18 and Yitpi18, with the Rht18 gene, were sown at a standard depth, achieving similar yield outcomes to commercial varieties Yitpi and Scout. This suggests that if seasonal conditions that allow early sowing into subsoil moisture are not met, growers can still sow these varieties in May in favourable seeding conditions with no yield penalty.

Results show that pre-breeding line Mace18 had reduced yield when sown at standard depth (40 mm) after the season break on May 30. This result was also observed at other trial locations (Rebetzke et al 2022) with the reason currently unknown. Yield losses were observed for Mace and Scout when sown deep, showing that the Rht18 gene in these pre-breeding varieties provides benefits, allowing growers to sow deeper. In years where small and infrequent rainfall events occur; standard sowing (40 mm) may reduce establishment when crops are sown early in drier conditions. Long coleoptile wheats can reduce this risk by deeper sowing into subsoil moisture when conditions are favourable.

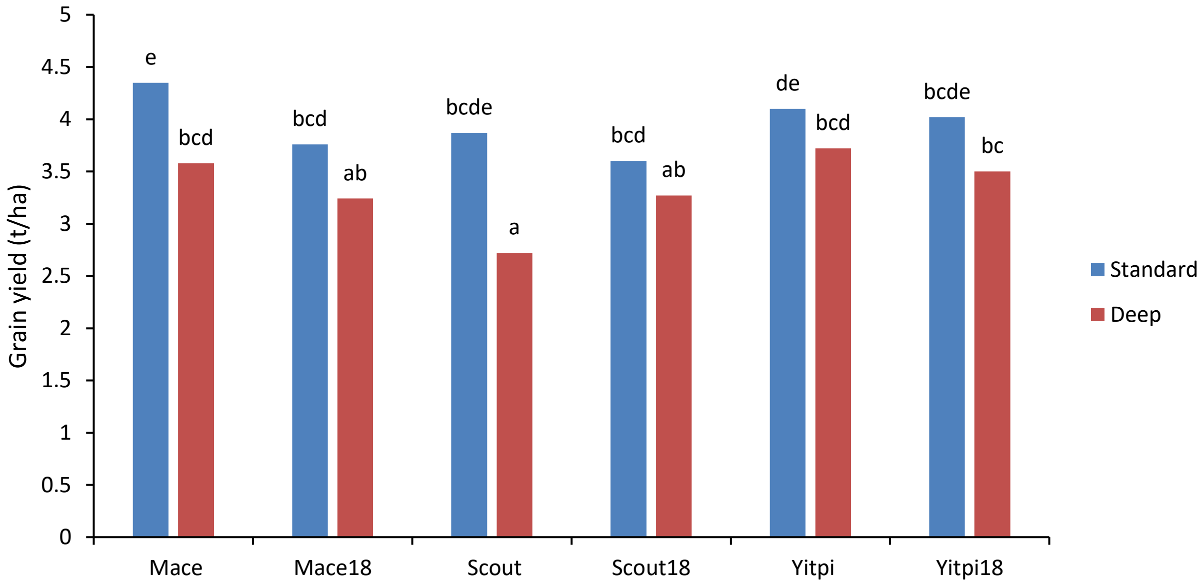

Figure 3*. Grain yield at standard or deep sowing for the new genetics x sowing depth trial. Values with the same letters are not significantly different.*

When assessing new pre-breeding genetic lines across two sowing depths, differences were observed for protein (%), test weight (kg/hL) and screenings (%).

Protein increased slightly when sown deep, averaging 11.1%, compared to 10% at standard sowing (Table 4). The increase in grain protein from deep sowing resulted in a higher receival grade of APW, when compared to the ASW receival grade at standard sowing. Screenings were also higher at deep sowing averaging 3.2% when compared to 2.7% for standard sowing. Variety selection affected test weight and screenings across sowing depths, with only select varieties experiencing changes in test weight and screenings (Table 4).

Table 4. Grain quality of wheat varieties at standard or deep sowing for the new genetics x sowing depth trial. Shaded values indicate best performing treatments. Values with the same letters are not significantly different.

Sowing Depth	**Variety**	**Protein** (%)	**Test Weight** (kg/hL)	**Screenings** (%)
Standard	Mace	9.9	85.6^{g}	2.4^{ab}
	Mace18	10.2	83.2^{ef}	1.9^{a}
	Scout	9.1	83.5^{ef}	3.2^{cde}
	Scout18	11.1	78.6^{b}	2.0^{a}
	Yitpi	9.7	83.1^{e}	3.6^{e}
	Yitpi18	9.8	81.2^{cd}	3.0^{cd}
Deep	Mace	11.0	85.5^{g}	2.8^{bc}
	Mace18	11.4	83.9^{ef}	2.3^{a}
	Scout	10.7	84.3^{f}	4.5^{f}
	Scout18	11.4	76.0^{a}	2.3^{ab}
	Yitpi	11.2	81.6^{d}	3.5^{de}
	Yitpi18	10.8	80.2^{c}	3.7^{e}
LSD (P≤0.05)		**NS**	**1.13**	**0.52**

Coleoptile length between varieties

Variation in coleoptile lengths between wheat varieties is highlighted below in Figure 4. The first wheats released with the Rht18 gene were LRPB Bale and LRBP Dual with Bale recording the longest coleoptile length (120 mm). Dual also contains the Rht12 gene for dwarfing, explaining the difference in coleoptile length between the two. Yitpi is also known for having a long coleoptile length, recording 116 mm.

Under laboratory conditions, commonly grown wheat varieties Scepter and Vixen have shorter coleoptile lengths of 90 mm and 86 mm. Other varieties that produced short coleoptiles were Sunblade CL Plus and Beckom with lengths of 61 mm and 74 mm respectively.

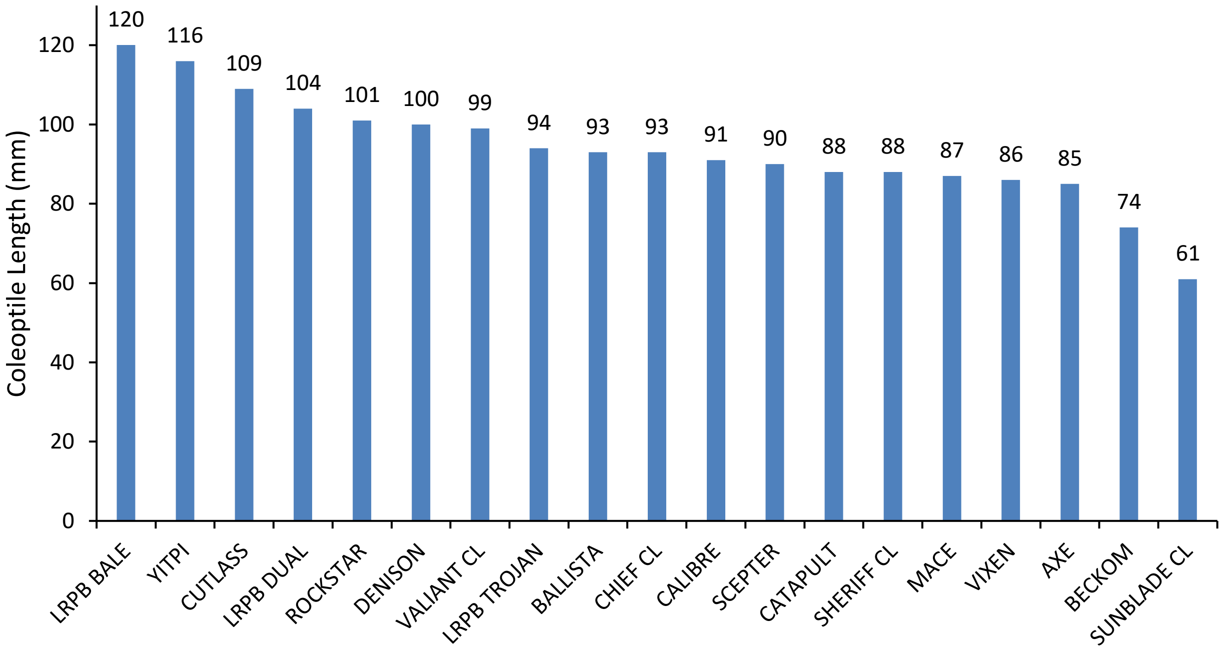

Figure 4. Summary of lab recorded wheat coleoptile lengths (mm) at 200°Cd. Data was supplied by Mitchell Eglinton and Longreach Plant Breeders as part of their coleoptile screening data. Data has not been analysed.

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References

Bruce D, Noack S and Porker K 2017, 'Comparing coleoptile length in wheat varieties' https://www.hartfieldsite.org.au/pages/resources/trials-results/2017-trial-results.php