Evaluating long coleoptile wheat performance in clay-loam soils

Kaidy Morgan and Rebekah Allen
Hart Field-Site Group

Key findings

- Plant establishment and grain yield (t/ha) was not improved through the selection of a long coleoptile wheat at Hart across two seasons (2022 - 2023).
- Early sowing resulted in higher yields for all varieties at three depths, despite greater plant establishment for later sown treatments sown at 40 and 80 mm.
- Observed yield trends for all varieties were consistent with expected yield potential and were not influenced by sowing depth or TOS in conditions where good starting soil moisture was present.

Introduction

Changes in climatic conditions and rainfall patterns noticed on a national and global scale have highlighted the importance of building resilient seeding practices to ensure adaptability to adverse conditions, including crop moisture stress. In addition to an increasing prevalence of drier cropping conditions, an increase in land size has resulted in many farm businesses having larger cropping programs (Stummer et. al., 2023). Farming methods that reduce risks associated with dry or early sowing allow farmers to sow a larger proportion of their farm earlier, with reduced impacts to grain yield, particularly in years where autumn rainfall is limited.

To maximise crop yield, it is essential that germination and establishment occur in a uniform and timely manner to utilise growing season rainfall, reduce weed pressure and increase the photoperiod of cash crops (Rebetzke et. al., 2022).

Through the development of long coleoptile wheat varieties, opportunities for dry sowing have potentially increased, allowing crops to access moisture stored deeper in the soil profile.

The coleoptile is a sheath that protects the emerging leaf of a germinating seed as it moves through the soil (Figure 1) (Meiklejohn, 2021). Varieties with a long coleoptile have improved emergence and vigour when sown at depth compared to varieties with shorter coleoptiles that are unable to protect the emerging plant until it reaches the soil surface (Stummer et. al., 2023).

This trial investigated the performance of three wheat varieties with various coleoptile lengths to determine benefits of improved establishment and yield for a long coleoptile variety on a calcareous dark reddish-brown clay-loam soil.

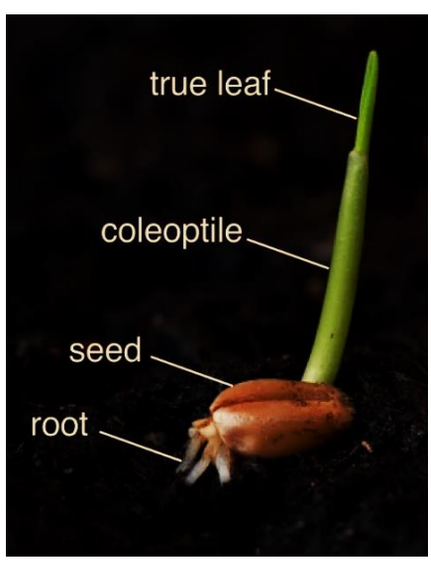

Figure 1. Germinating wheat seed showing coleoptile. Figure sourced from Salomé P, 2017 (Plants: the green starfish of the world, published in Plant Cell Extracts).

Methodology

A trial was implemented at Hart, SA as a split-split plot design with three replicates and 18 treatments. Treatments included two times of sowing (TOS) (Table 1), three sowing depths and three wheat varieties with different coleoptile lengths including Sunblade (61 mm), Scepter (90 mm) and Bale (120 mm). This trial was managed with the application of pesticides to ensure a weed, insect and disease-free canopy.

Table 1. Site details for the 2023 long coleoptile wheat trial at Hart, SA.

Plot size	1.75 m X 10.0 m	**Fertiliser**	Seeding: DAP Zn 1% + Flutriafol @ 80 kg/ha
Seeding date (TOS 1)	April 21, 2023		
Seeding date (TOS 2)	June 2, 2023		June 15 (TOS 1): 36.5 units N
Harvest date (TOS 1)	November 14, 2023		July 5 (TOS 2): 36.5 units N
Harvest date (TOS 2)	November 20, 2023		
Location	Hart, SA		
Previous crop	Mulgara Oaten Hay		

All wheat varieties were sown at a standard target plant density of 180 plants/m^2 at shallow (10 mm), standard (40 mm) and deep (80 mm) treatments. Soil moisture (%) at each TOS was measured to determine any influence of soil moisture at sowing on crop establishment. Soil moisture was measured regularly until crop emergence was complete and plant establishment counts (plants/m^2) were conducted. Normalised Difference Vegetation Index (NDVI) was also measured every two weeks until flowering, as an indicator of crop biomass production. Final wheat grain yield (t/ha) and grain quality as protein (%), screenings (%) and test weight (kg/hL) was measured, and all data was analysed using a REML spatial model (Regular Grid) in Genstat 23rd edition.

Results and discussion

2023 sowing conditions

Significant rainfall in mid-April (26 mm) resulted in 25.4 % soil moisture within the top 10 cm at TOS 1 on April 21. Although there was limited follow up rainfall in May, TOS 1 germinated from existing soil moisture and was able to utilise growing season rainfall (GSR) early in the season.

Following significant rainfall at the end of May, TOS 2 was sown on June 2 into 28% soil moisture and therefore had good emergence at all seeding depths (Figure 2). As there was minimal variation in soil moisture at seeding between TOS 1 and TOS 2 (Table 3), season length was likely the determining factor for yield response between the two times of sowing (Figure 2).

Plant establishment and soil moisture

The average plant establishment for wheat was improved at TOS 2 when sown deep at 80 mm and standard at 40 mm, however TOS 1 had higher establishment when sown shallow at 10 mm (Figure 2). Warmer soils from a late April sowing in addition to damp morning conditions retaining moisture within the soil surface are likely causes of this result.

Plant establishment was not improved through the selection of a long-coleoptile wheat, such as Bale, at Hart in 2023. A contributing factor to this result was favourable moisture present at both TOS across April and June. Results show that a long-coleoptile variety did not improve crop establishment when compared to Scepter sown at any depth (10 – 80 mm) in favourable moisture conditions.

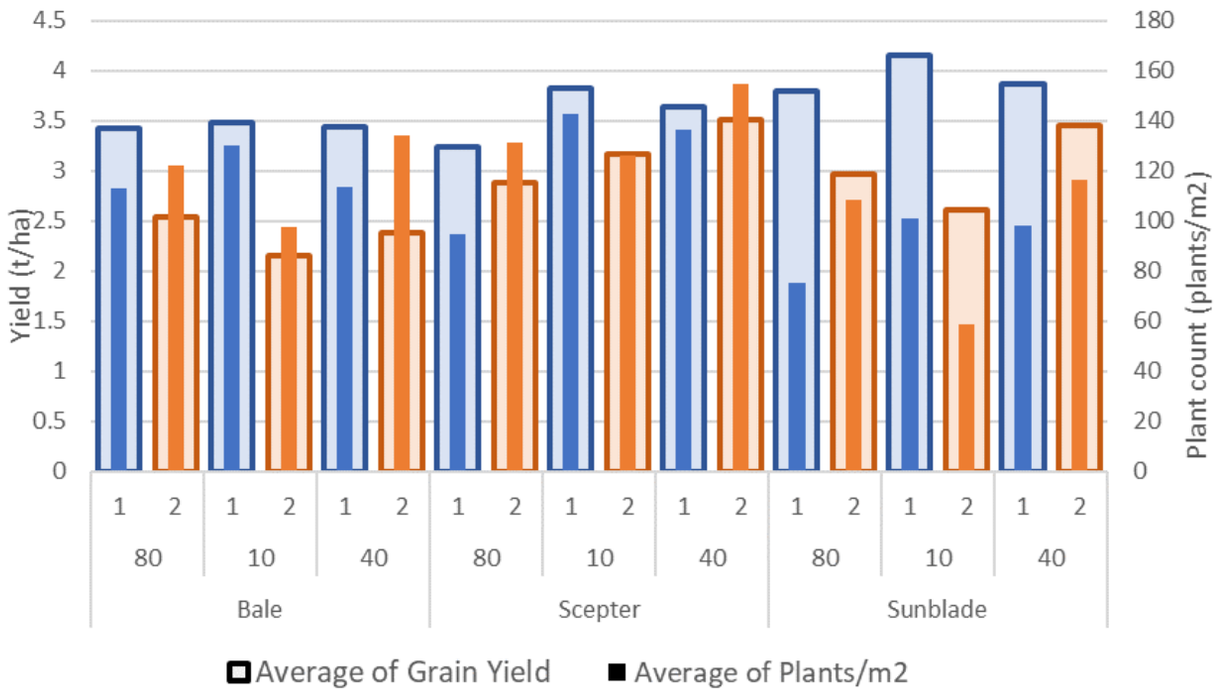

Figure 2. Comparison of plant establishment (plants/m^2) and grain yield (t/ha) for Bale, Scepter and Sunblade when sown at three depths and two TOS. The first time of sowing (TOS 1) is indicated by blue boxes (yield) and bars (plant establishment), while TOS 2 data is shown by orange boxes (yield) and bars (plant establishment).

Grain Quality

Neither protein or test weight were influenced by TOS or sowing depth, however as expected, there were differences noticed between varieties (Table 2). Bale recorded the highest protein of 12.3%, while Scepter and Sunblade performed similarly to each other. Scepter had the lowest screenings and highest test weight at 4.2% and 85.6 kg/hL, respectively. Shallow sown (10 mm) treatments recorded the lowest screenings, while increasing depth to standard (40 mm) or deep (80 mm) resulted in higher screenings.

Table 2. Yield and quality results for the long coleoptile wheat trial at Hart in 2023. Values shaded in blue indicate the best performing treatments, values with the same letters or no letters indicate that there was no differences between results.

	Yield (t/ha)	Predicted protein (%)	Screenings (%)	Test weight (kg/hL)
TOS 1	3.65^{b}	11.3	5.0	85.7
TOS 2	2.85^{a}	11.4	5.3	83.6
10 mm	3.23^{a}	11.3	4.7^{a}	84.8
40 mm	3.38^{b}	11.4	5.3^{b}	84.7
80 mm	3.14^{a}	11.4	5.4^{b}	84.6
Sunblade	3.48^{b}	10.8^{a}	6.3^{c}	84.7^{b}
Scepter	3.38^{b}	11^{a}	4.2^{a}	85.6^{c}
Bale	2.90^{a}	12.3^{b}	4.9^{b}	83.7^{a}

Grain yield

All treatments in TOS 1 resulted in higher grain yield, despite better plant establishment at TOS 2. This was a result of earlier germination increasing the season length for crops.

No yield benefits were observed for long coleoptile variety selection at Hart in 2023. Similar results were observed in a trial at the Hart field site in 2022 showing that Scepter sown at a standard depth (40 mm) or deep at 120 mm performed similarly to longer coleoptile varieties Calibre and Bale (Anderson et.al., 2022). Previous growth chamber research conducted at Waite, SA (Bruce, 2017) also shows that coleoptile length can potentially increase under cold conditions, with peak length at 15°C (Anderson et.al., 2022). Results across field trials at Hart in 2022 and 2023 highlight the possibility of coleoptile length increasing in cold environments.

The importance of season length is evident in yield results (Figure 2). Yield data shows that season length is, to an extent, able to compensate for reduced establishment as a result of plants being better able to utilise growing season rainfall early in the season. In a year where spring rainfall is limited, early sowing can significantly improve yield potential by increasing growing season length of crops.

As the Hart field site has a clay loam soil type, short-term deep water penetration is limited, with the majority of rainfall being stored in the upper horizons of the soil profile. This, along with below average summer rainfall reduced the potential benefits of deep sowing, as it is most successful in situations where there is soil moisture at depth. In conditions where there is no moisture benefit at depth, the efficiency of deep sowing to improve yield potential is likely to be reduced.

As expected, there were overall yield effects resulting from variety selection with Bale recording the lowest yield of 2.90 t/ha. Scepter and Sunblade performed similarly, yielding 3.36 and 3.45 t/ha, respectively.

Long coleoptile technology is gaining increasing attention for its potential yield benefits when sown deep. Data from this trial suggests that soil moisture and soil type will play a critical role in determining suitability of deep sowing and long-coleoptile variety selection as a beneficial management decision.

Summary

Although there are potential benefits of long coleoptile technology improving yield for deep sowing, it is important to consider seasonal conditions, soil type and variety selection. If there is no moisture benefit of deep sowing in a particular season, variety selection based on coleoptile length alone is unlikely to result in significant yield increases. The 2023 season was unfavourable to test the potential of long coleoptile varieties at depth, as there was adequate soil moisture at all sowing times and depths. The performance of long coleoptile varieties should be explored further across numerous sowing depths and soil types under different moisture constraints.

Acknowledgements

The Hart Field-Site Group would like to acknowledge the generous support of our sponsors who provide funding that allows us to conduct this trial. Proceeds from Hart's ongoing commercial crop also support Hart's research and extension program.

We would like to thank AGT, LongReach Plant Breeders and Kybunga farmer and Hart board member, Rob Dall, for providing seed to conduct this trial.

References

Stummer, B., Flohr, B., Rebetzke, G., Meiklejohn, R., Ware, A., Haskins, B., Whitworth, R., McBeath, T., (2023). Long coleoptile genotype and soil texture interactions determine establishment success and early growth parameters of wheat sown at depth, *Environmental Research Communications*, Vol. 5

Rebetzke, G., Kirkegaard, J., McBeath, T., Stummer, B., Flohr, B., Fletcher, A., Rich, S., Lamond, M., Haskins, B., Whitworth, R., Bechaz, K., Gullifer, L., Aisthorpe, D., Ware, A., Meiklejohn, R., (2022). Early learnings from multi-site, multi-system assessment of new long-coleoptile genetics for deep sowing of wheat. *Murray Bridge South Australia GRDC Updates*.

Anderson, D., Allen, R (2022). Benefits of long coleoptile wheat. *2022 Hart Trial Results Book.* Available at: *www.hartfieldsite.org.au*

Meiklejohn, R., (2021). New long coleoptile wheat trialed on the EP for first time, *AIR EP Ag Innovation & Research Eyre Peninsula*

Photo: Long coleoptile wheat trial at the Hart field site, 2023.