Evaluating the importance of sowing rate, depth and time of sowing on emergence and yield – wheat and canola

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Key findings

- Despite observed differences in establishment between times of sowing (TOS) for wheat and canola, early sown crops resulted in higher yields due to improved water use efficiency (WUE) for biomass and grain production at Hart.
- With a dry subsoil there was no benefit of deep sowing canola or wheat. In general, similar yields were achieved from shallow and standard sowing depths.
- Increasing sowing rates to compensate for anticipated lower establishment did not increase yields of canola and wheat in most cases.
- Preliminary data from Hart suggests that soil moisture at sowing may be an indicator of plant establishment (%), with an approximate 2% reduction in establishment noticed for every 1% decline in soil moisture for both wheat and canola, regardless of TOS.

Background

An increase in the average farm size and variation in autumn rainfall means that it is becoming increasingly important for farmers to sow earlier in the season without significantly reducing production potential (Flohr et al. 2021). Despite recent cultivar development improving resilience to drought stress, significant risks remain when dry sowing. Poor establishment and uneven crop development associated with dry sowing, particularly into marginal soil moisture, may lead to significant issues such as poor weed control and a reduction in crop productivity.

Simulation modelling of the effects of dry sowing has suggested potential yield benefits of up to 35% compared to delayed sowing in wet conditions (Fletcher et. al. 2015). The greatest benefits were noticed at locations with lower annual rainfall, heavier soils and where there was a large cropping program (Fletcher et. al. 2015). By testing the impact of sowing depth on plant establishment in dry conditions, the risks associated with dry sowing can be quantified. In order to combat potential yield losses associated with poor establishment in dry conditions, the efficiency of increasing sowing rates was explored.

In 2023, trials were sown at three sites across the Mid-North of SA; Hart, Giles Corner and Bute. Trial objectives investigated techniques to improve the effectiveness of dry or early sowing by quantifying effects of sowing depth and rate on plant establishment, growth and yield under varying soil moisture conditions and times of sowing.

Methodology

Five replicated trials were sown across three sites; a calcareous clay-loam at Hart, dark grey vertosol at Giles Corner and a loam to clay-loam soil at Bute. At each site, crops were sown at three or four sowing dates between late April and early June, with three sowing depths and two or three plant densities. Sowing rates for Hart targeted 100%, 125% and 150% of the standard sowing rate. For canola, these rates were 45, 56 and 68 plants/m^2 respectively, and for wheat the rates were 180, 225 and 270 plants/m^2. Similar rates were targeted at Bute and Giles Corner sites (Table 1).

All trials were sown with a knife-point press wheel system. The same seeder was used at both Hart and Giles Corner sites, however very low bulk density of the vertosol soil at Giles Corner resulted in seeder wheels sinking. Tynes also caused variability in depth at Giles Corner due to soil clods. Clods are often present in high clay content soils and can range from 1-30 cm in size and caused a relatively large spread of seeding depth across the wheat trial. The canola trial at Giles Corner was sown on a bean stubble and had a slightly lower clay content compared to the wheat, which was reflected in more stable depths.

The number of plants/m^2 was measured to determine the effect of treatment on establishment. Soil moisture in the top 10 cm was recorded at sowing and monitored until final emergence of all TOS. Normalised Difference Vegetation Index (NDVI) was also measured frequently after emergence to track plant growth (higher NDVI values indicate less exposed soil and greener vegetation). Additionally, timing of key phenological events (e.g., flowering) were recorded for all plots to determine potential treatment effects on plant development. Data was analysed using REML spatial model (Regular Grid) in Genstat 23rd edition.

Table 1. Trial details for the three sites at Hart, Giles Corner and Bute.

Crop type	Hart	Giles Corner	Bute
Rockstar wheat	**TOS 1:** April 27 **TOS 2:** May 5 **TOS 3:** June 2 **Depth** 10 mm, 40 mm, > 50 mm **Sowing rates** 180, 225, 270 plants/m^2	**TOS 1:** April 21 **TOS 2:** May 5 **TOS 3:** June 2 **Depth** 20 mm, 35 mm 70 mm **Sowing rates** 180, 240 plants/m^2	**TOS 1:** April 21 **TOS 2:** May 5 **TOS 3:** May 19 **Depth** 35 mm, 46 mm, 56 mm **Sowing rates** 180, 270 plants/m^2
Enforcer CT canola	**TOS 1:** April 21 **TOS 2:** May 5 **TOS 3:** June 2 **TOS 4:** June 20 **Depth** 10 mm, 20 mm, 30 mm **Sowing rate** 45, 56, 68 plants/m^2	**TOS 1:** April 21 **TOS 2:** May 5 **TOS 3:** June 2 **Depth** 10 mm, 20 mm, 50 mm **Sowing rate** 50, 70 plants/m^2	

Results

Hart

Time of sowing

Plant establishment (%) differences were observed between all TOS at Hart in 2023 (Table 2).

Establishment results were consistent for wheat and canola, with sowing on June 2 (TOS 3) recording the highest establishment counts (plants/m^2). Crops sown on May 5 (TOS 2) into marginal soil moisture with little follow up rain recorded the lowest plant establishment.

Average plant establishment for canola (TOS 1 – 4) was 54%, 32%, 89% and 71% respectively. The corresponding values for wheat were 75%, 64% and 84%. This shows that plant establishment of canola was more sensitive to TOS and soil moisture at seeding than wheat. Although similar trends were noticed, canola had higher variation across TOS for plant establishment (%) than wheat (Figure 1). Establishment and soil moisture at seeding for both wheat and canola suggests a decrease of approximately 2% in establishment for every 1% decrease in soil moisture at sowing time at Hart, highlighting that soil moisture at sowing is a key indicator of plant establishment, regardless of time of sowing (Figure 1).

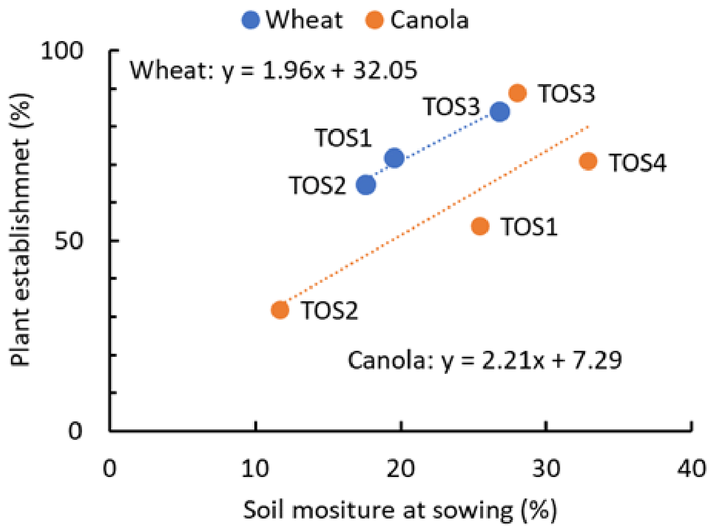

Figure 1. Plant establishment (%) and soil moisture (%) at sowing for each wheat and canola TOS.

Time of sowing had significant effects on grain yield in wheat and canola at Hart In 2023. In wheat and canola, the highest grain yields were achieved with the earliest sowing date (Figure 2 & 3).

TOS 1 shallow and standard sown wheat treatments performed best, averaging 4.3 and 4.4 t/ha respectively, while canola TOS 1 recorded the highest yield at 2.16 t/ha.

Table 2. Treatment effects on plant establishment (plants/m²) and establishment % for both wheat and canola. Significant differences in plant establishment between treatments are indicated by different letters after plant count (plants/m²). Shaded values indicate the treatments with the highest plant establishment.

Effects of sowing date			Effects of sowing depth			Effects of sowing rate		
CANOLA								
Sowing date	**Plants /m²**	**Establishment %**	**Depth mm**	**Plants /m²**	**Establishment %**	**Rate /m²**	**Plants /m²**	**Establishment %**
April 21 (TOS 1)	30b	54	**10**	40b	71	**45**	28a	62
May 5 (TOS 2)	18a	32	**20**	37b	66	**56**	37b	66
June 2 (TOS 3)	50d	89	**30**	27a	48	**68**	39b	57
June 20 (TOS 4)	40c	71						
WHEAT								
Sowing date	**Plants /m²**	**Establishment %**	**Depth mm**	**Plants /m²**	**Establishment %**	**Rate /m²**	**Plants /m²**	**Establishment %**
April 27 (TOS 1)	168b	75	**10**	190b	84	**180**	136a	75
May 5 (TOS 2)	145a	64	**40**	172b	76	**225**	168b	75
June 2 (TOS 3)	190c	84	**55**	142a	63	**270**	202c	75

Photo: Hart regional intern, Kaidy Morgan, presenting at the 2023 Hart Field Day.

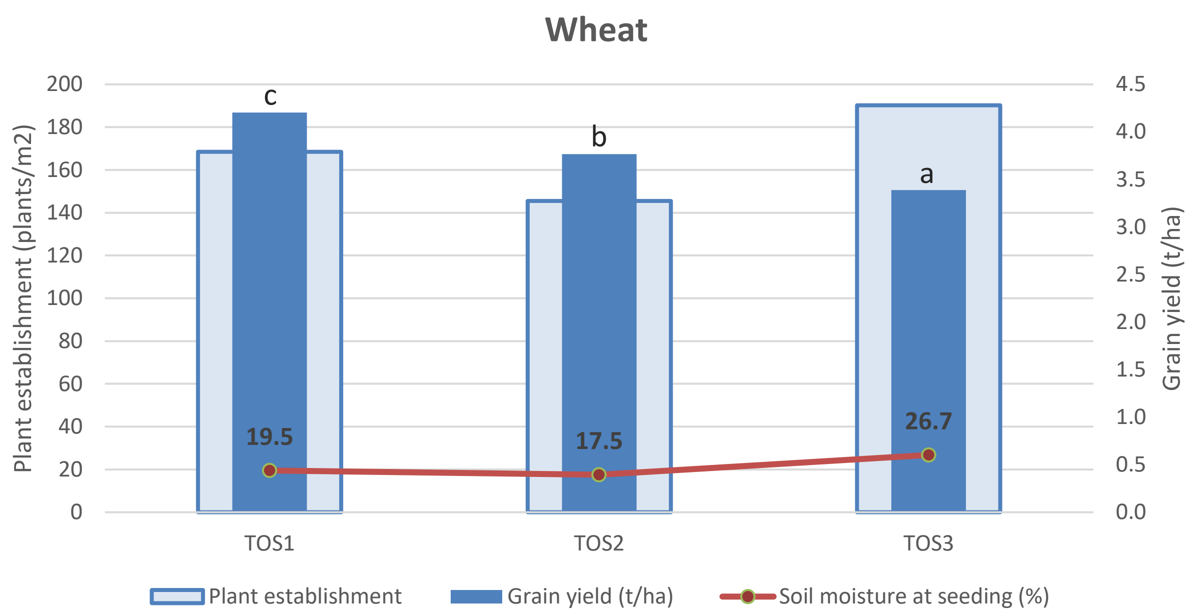

Figure 2. Plant establishment (plants/m^2), grain yield (t/ha) and soil moisture % (displayed) at seeding for wheat TOS at Hart. Time of sowing (TOS) with the same letter above yield are not significantly different.

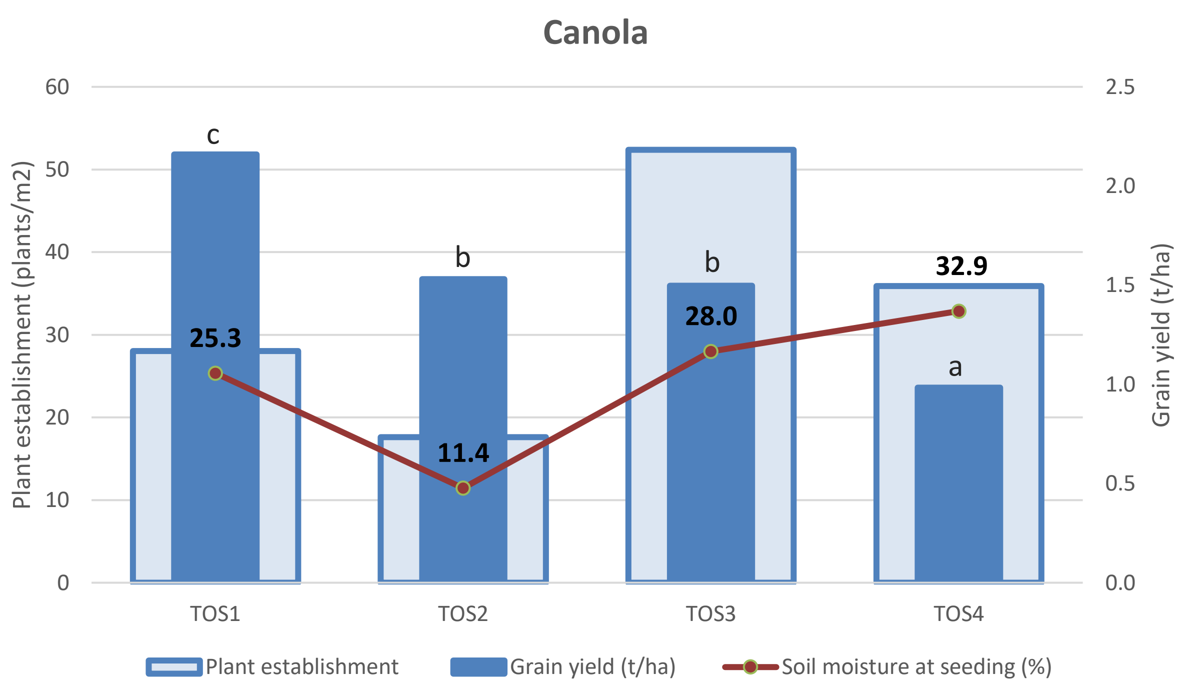

Figure 3. Plant establishment (plants/m2), grain yield (t/ha) and soil moisture % (displayed) at seeding for canola TOS at Hart. Time of sowing (TOS) with the same letter above yield are not significantly different.

Table 3. Time of sowing effect on 50% flowering date for canola at Hart.

TOS	50% flowering date
April 27	August 31
May 5	September 11
June 2	September 25

Sowing depth

Deep sowing reduced plant establishment for both wheat and canola, with shallow sown treatments achieving approximately 20% higher establishment than deep sowing for both crop types. (Table 2).

Sowing depth influenced wheat yield with shallow sown treatments yielding higher than standard and deep. Plant establishment for canola ranged from 27 - 40 plants/m^2 across three depths, however the ability of canola plants to branch out and fill space resulted in no yield differences despite variation in establishment (Figures 4a and 4b).

Sowing rate

Sowing at the standard rate resulted in the lowest plant density for both canola (target 45 plants/m^2) and wheat (target 180 plants /m^2), achieving 28 and 136 plants/m2, respectively (Table 2). Seeding rates targeting 125% and 150% increased plants/m^2, however there was no yield benefit from a higher plant density, either in canola or wheat. Despite differences in plants/m^2 for sowing rates, establishment % of both wheat and canola remained relatively consistent at 75% for wheat and 57% – 66% for canola.

These results suggest that increasing sowing rate above grower standard practice may improve crop establishment, but this does not result in grain yield increases.

Grain quality

Oil content for all canola treatments was high, with both TOS 2 and TOS 4 exceeding 42%, therefore receiving oil content premiums (Table 5). Although TOS 1 had the highest yield, it had a lower oil content than TOS 4 which yielded only 0.99 t/ha. This may indicate a relationship between oil content and grain yield in dry spring conditions. Previous studies have found a positive link between yield (t/ha) and oil content (%), however this was not evident in this trial (McBeath et. al., 2020).

Differences in wheat grain protein (%) were small and ranged from 10.1% to 10.7% (Table 6). Protein for TOS 1 and 2 was below the 10.5% minimum for APW1 receival standards, while TOS 3 recorded 10.7% protein and therefore met APW1 protein receival standards.

Test weight for all wheat treatments exceeded 76 kg/hL, ranging from 82.8 to 85.1 kg/hL, therefore meeting maximum receival standards (Table 6).

Limited rainfall in the second half of the growing season resulted in high screenings for all treatments, however a trend between TOS and screenings was noticed (Table 6). Earlier sown treatments that were better able to utilise early GSR had lower screenings than later sown treatments where season length and therefore access to early season rainfall was limited.

Flowering dates were impacted by TOS, with canola 50% flowering date ranging from August 11 to September 18 (Table 3). Wheat 50% flowering date ranged from August 31 to September 25 across three TOS (Table 4). The extended flowering window of TOS 1 wheat and canola prior to water and heat stress towards the end of the season is likely a contributing factor for higher yields and reduced screenings from early sown treatments.

Time of sowing had a larger effect on wheat protein, screenings and test weight than sowing depth and sowing rate, with TOS 1 performing best for both screenings and test weight (Table 6).

Table 4. Time of sowing effect on 50% flowering date for wheat at Hart.

TOS	50% flowering date
April 21	August 11
May 5	August 31
June 2	September 11
June 20	September 18

Table 5. Oil content in comparison to yield data for canola TOS trial at Hart in 2023. Significant differences in oil content and yield are indicated by different letters. Shaded values indicate the best performing TOS.

TOS	Oil content (%)	Yield (t/ha)
April 21	41.9^{b}	2.16^{c}
May 5	42.2^{b}	1.53^{b}
June 2	41.1^{a}	1.50^{b}
June 20	44.5^{c}	0.99^{a}

Table 6. Quality data for the wheat trial at Hart in 2023. Significant differences in quality between TOS, depth and sowing rate are indicated by different lettering. Shaded values indicate the best performing treatments.

Treatment	Grain Protein (%)	Screenings (%)	Test Weight (kg/hL)
April 27	10.4^{b}	4.6^{a}	85.1^{c}
May 5	10.1^{a}	6.4^{b}	84.1^{b}
June 2	10.7^{c}	7.4^{c}	82.8^{a}
10 mm	10.5^{b}	6.6^{b}	83.7^{a}
40 mm	10.3^{a}	5.8^{a}	84.2^{b}
55 mm	10.4^{ab}	5.9^{a}	84.1^{b}
180/m^{2}	10.4	6.3^{b}	83.9^{a}
225/m^{2}	10.4	6.12^{b}	84.0^{ab}
270/m^{2}	10.4	5.7^{a}	84.3^{b}

Figure 4 (a,b). These images show the differences in canola development between TOS at Hart. Figure 4a was taken in August, with Figure 4b taken one month later.

Results from other sites

At Giles Corner, canola establishment was lowest (approx. 60%) at the first two sowing dates (April 21 and May 5) compared to June 2 date (80%). However, despite the low establishment, yields were highest at the first two sowing times, while delaying sowing until June 2 resulted in a yield penalty of 20%. Increasing sowing rate had no effect on yield, except when canola was sown deep at 50 mm. At each time of sowing, varying sowing rates and depths to alter plant establishment had little to no effect on canola yield.

In the wheat trial, establishment with sowing on April 21 and May 5 was 55% and 45% respectively and increased to 87% when sown on June 2. These differences reflected the rainfall and soil moisture at sowing. Sowing at 70 mm reduced establishment to 44% compared to 80% with 20 mm sowing depth. The response to time of sowing depended on the sowing depth (Table 7). When sown at 20 mm, yields declined with later sowing, whereas when sown at 35 mm or 70 mm the lowest yields occurred with sowing on May 5, when the emergence was lowest due to dry conductions.

Yield reductions of delaying sowing from April 21 to May 5 were 5% at 20 mm, 9% at 35 mm and 16% at 70 mm. There was only a single significant fall of rain in the two weeks following sowing on May 5 and the shallow sowing may have been better able to utilise this moisture for faster germination and establishment. Compared to canola, wheat was more responsive to changes in plant density.

Established plant densities ranged from approximately 50 plants/m^2 up to 225 plants/m^2 and yield responded to increased plant density up to about 125 plants/m^2. Increasing the sowing rate by a third from 180 seeds/m^2 to 240 seeds/m^2 resulted in a 6% yield increase.

Table 7. The effects of sowing depth on the grain yield of wheat at Giles Corner. Grain yields followed by the same letter are not significantly different. Shaded values indicate the best performing treatments.

Grain yield (t/ha)			
Sowing date	**Depth**		
	20 mm	**35 mm**	**70 mm**
April 21	6.99[a]	6.47[abc]	5.81[d]
May 5	6.67[ab]	5.90[cd]	4.89[e]
June 2	6.19[bcd]	6.36[a-d]	5.99[bcd]

At Bute, the average wheat establishment was 74%, but ranged from 48% – 100% among individual treatments. Establishment varied little across TOS and the most consistent effect was a reduction in establishment with deep sowing and an increase in plants/m2 with a higher sowing rate.

Table 8. The effects of sowing date on the grain yield of wheat at Bute. Grain yields followed by the same letter are not significantly different. Shaded values indicate the best performing treatments.

Sowing date	Grain yield (t/ha)
April 21	1.83[b]
May 5	2.26[a]
May 19	1.89[b]

Time of sowing and sowing depth affected wheat grain yield at Bute in 2023.

The highest yields were achieved at the second TOS with the first and last sowing dates producing equivalent yields (Table 8). A significant frost event on September 9 caused damage to wheat at Bute, with the April 21 sown treatment affected more than later sowing dates. Frost damage to the early sown crop may be a factor contributing to lower yields when compared to the May 5 sowing.

There was a small (5%) but significant reduction in grain yield when wheat was sown at 53 mm with no difference between 35 mm and 46 mm sowing depths. Despite a wide range in crop establishment among the treatments, there was no significant effect of sowing rate on yield.

Summary

Despite lower establishment from late-April to early-May sowing in wheat and canola at Hart and canola at Giles Corner, these sowing times produced the highest yields due to better utilisation of earlier growing season rainfall for biomass production. Wheat at Giles Corner and Bute was less sensitive to time of sowing in 2024.

Deep sowing showed no benefit in either plant establishment or yield. This is most likely because soil moisture was still low at the deepest sowing depth. Sowing deep into dry soil to promote germination and improve establishment may be a risky tactic.

Increasing sowing rates to compensate for anticipated reductions in crop establishment from sowing into dry soil did not improve yields in most experiments and using standard recommended sowing rates may be adequate.

Further investigation into the relationship between soil moisture at sowing, crop establishment and yield potential will be explored in future years of this project. This trial is in its first of two seasons and final results will be published following the conclusion of the project to provide a more comprehensive investigation across multiple seasons and sites.

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