Time of sowing, depth and rainfall interactions on wheat and barley establishment and yield

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Key findings

- Germination of wheat occurred with 10 mm of simulated rainfall; however significant emergence required at least 20 mm on a loam soil.
- Seed can remain viable and achieve a high rate of emergence after 3-4 weeks in dry soil.
- Early emergence was more important than achieving a high plant density: higher yields were achieved with dry sowing despite lower crop establishment compared to delaying sowing until after the break.
- Sowing at a depth of 40 mm reduced seedling emergence and grain yield.
- Increasing sowing rate to compensate for poorer establishment gives inconsistent results and generally provides little benefit.

Introduction

The run of dry autumns in recent years coupled with an increase in cropped area on farms has meant that dry sowing has become more common. This may be a long-term trend because in parts of southern Australia, the autumn opening rains are occurring later in the season. There are still some potential risks from dry sowing, including poor establishment and low plant densities due to germination in dry soil as well as the risk of seedling loss from false breaks. A question that is often asked is how much rainfall is required to allow germination and emergence of crops to occur. Soil type has a major effect on this, with much less rainfall required on sandy and light textured soil compared to loams and clay loams.

Dry seeding experiments over the last two years at three sites in the Mid North and upper Yorke Peninsula have found:

(i) There has been little to no benefit to yield of wheat and canola from delayed sowing until after opening rains. The grain yield of canola and wheat sown dry in late April-early May has generally produced higher yields than crops sown with rainfall events later in May and June. Yields of some dry sown crops of wheat that have emerged in late April–early May have been affected by frost damage, which highlights the need to match maturity to sowing time.

(ii) On loam and clay loam soils there has been no benefit from sowing deeper than the standard sowing depth in dry soil. Seedlings take longer to emerge and often the early vigour of these crops is reduced. Yields can be reduced because of the later emergence and the lower plant density. The adverse effect of deep sowing can be exacerbated in cereals with short coleoptiles. Sandy soils are more forgiving of deep sowing.

(iii) Increasing plant density to compensate for lower establishment has had variable effects. Increasing sowing rates by 25% or 50% above the normal rate, often has no significant effect on yield but there have been instances where there has been some benefit. Responses to increased plant density will generally be more likely with crops that are sown or emerge late rather than with early-emerging crops.

(iv) Seed can remain viable in dry soil without compromising emergence for considerable periods of time. Pot studies have indicated that seed can remain in dry soil for six weeks without affecting emergence and this was supported by experimental results at Hart in 2024.

Two experiments were established at Hart in 2025. In experiment 1, different amounts of water were applied to dry-sown wheat to simulate the effects of rainfall events on germination and emergence. The aim was to examine the sensitivity of emergence and seedling survival to different rainfall events

In the second experiment, wheat and barley were sown dry or after rainfall in June at two different depths and plant densities. The aim was to examine the effects of dry sowing on emergence, growth and yield and if changes in sowing depth and plant density could mitigate any adverse effects of dry sowing.

Methodology

Experiment 1: Effect of rainfall events after dry sowing on wheat germination and emergence

Calibre wheat was sown at a depth of ~40 mm on April 24 into dry soil using a 6-row knifepoint press wheel plot cone seeder on 23 cm row spacings. Seeding depth was variable due to dry conditions causing the soil to be hard and producing clods during sowing, however a standard depth was targeted. There were six replicate plots of 10 m x 1.75 m. Within each plot, five watering treatments equivalent to 5, 10, 15, 20 and 25 mm, plus a dry control (0 mm) were randomly allocated in microplots (4 rows x 1 m per plot). A buffer area of one metre was allowed between microplots to prevent any lateral movement of water between treatments. The experiment was designed as a randomised complete block.

The watering treatments were applied to dry soil on April 29. Water was added using a watering can in 5 mm increments. Measurements of soil water content in the surface 60 mm was measured one hour after completion of watering, 24 hours later and then 8, 15, 22 and 27 days after watering.

Seedling emergence was assessed in 50 cm x two central rows in each microplot. Seeds were recovered from each microplot 8 and 22 days after watering. The seed was categorised as (i) not germinated, (ii) emerged and (iii) germinated but not emerged.

Experiment 2: Effects of time of sowing, sowing depth and sowing rate on emergence and yield

This experiment was sown to examine the effect of time of sowing, sowing depth and sowing rate on emergence of wheat and barley. Two wheat varieties and one barley variety with different coleoptile lengths were sown at shallow and standard sowing depths. Two sowing rates were also tested: standard sowing rate and 25% higher than the standard sowing rate (Table 1).

Table 1. Treatments used in Experiment 2 at Hart, 2025.

Sowing dates	Varieties (coleoptile length)	Sowing depth	Sowing rates
Dry: April 24 (Emerged June 2)	RockStar wheat (short)	Shallow: 10 mm	Wheat: 180 & 225 plants/m^2
	Calibre wheat (long)	Standard: 40 mm	
After rain: June 27 (Emerged July 7)	Neo CL barley (moderate)		Barley: 150 & 188 plants/m^2

Results and discussion

Experiment 1: Effect of rainfall events after dry sowing on wheat germination and emergence

At sowing the moisture content in the surface 60 mm was about 3% without additional water and it remained dry in the three weeks after the watering treatments were applied due to the lack of rain in May (Figure 1). The largest decline in soil moisture after watering occurred within the first few days and there was little change after 10 days. At 21 days after watering, soil moisture ranged from approximately 3% (dry soil) to 10% (25 mm treatment) and by this time the amount of water lost (mainly by evaporation) was up to 100% of the water applied (Table 2).

Less than 5 mm of rainfall was received in the three weeks after watering and the first significant rainfall (~9 mm) occurred 29 days after the plots were watered after which time all treatments showed similar soil moisture contents (Figure 1).

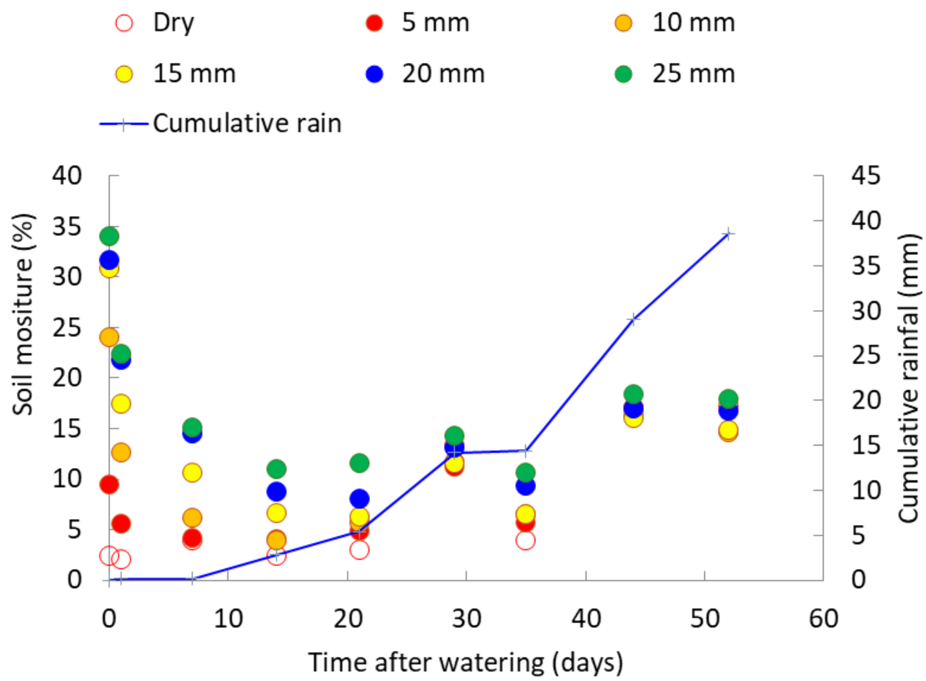

Figure 1. The changes in seed bed soil moisture content after receiving the rainfall equivalent of 5-25 mm of rainfall and the cumulative rainfall in the seven weeks after watering.

Table 2. Estimated loss of soil moisture from the surface 60 mm in the 20 days after watering.

	Rainfall equivalent (mm)					
	Dry	**5**	**10**	**15**	**20**	**25**
Loss (mm)	0	2.8	11	14.8	14.2	13.5
% of amount applied		56	100	99	71	54

Three weeks after watering with the equivalent of 10 mm of rainfall, 90% of the seeds had germinated, however none had emerged. It required the equivalent of 15 mm of rainfall to achieve at least 50% emergence, and maximum emergence was observed after the equivalent of 25 mm (Figure 2). There was a four-week period of dry weather after the watering treatments were applied, during which seedlings became severely stressed if less than 15-20 mm had been applied (Figure 3). Consequently, a number of seedlings died and as a result, final plant populations were low (Table 3). Plant establishment ranged from 6 plants/m^2 (3% establishment) to 103 plants/m^2 (57% establishment). Very dry soil (clay loam) and poor surface structure resulted in a very cloddy seedbed leading to poor seed-soil contact in many plots, which contributed to the poor seedling establishment.

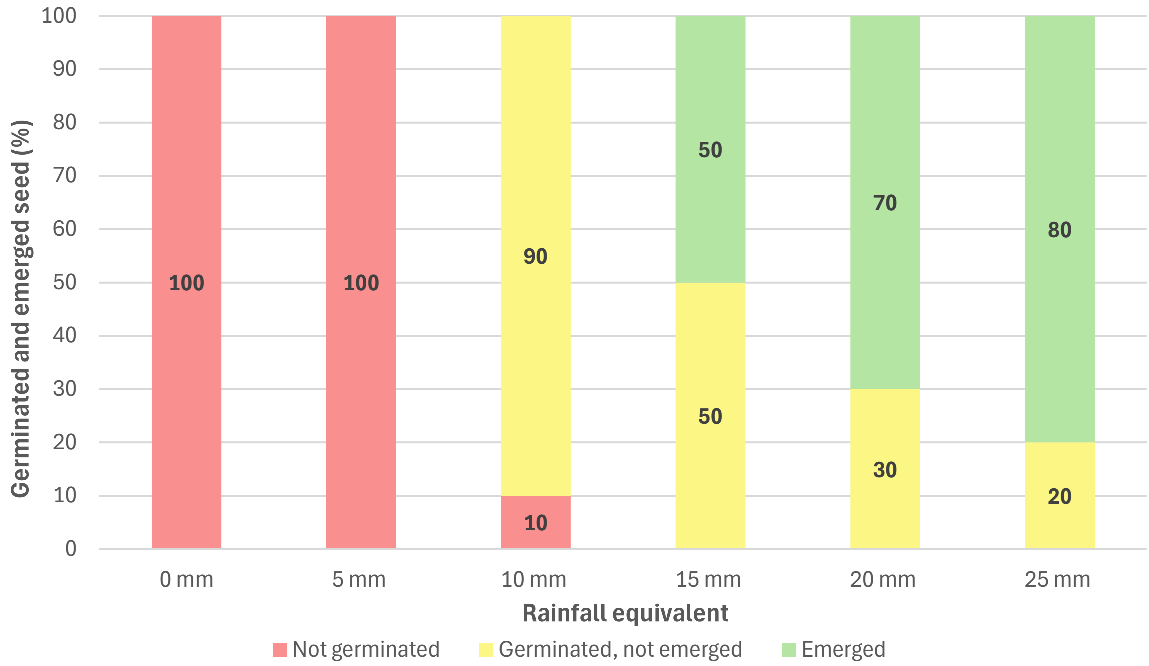

Figure 2. The effect of different amounts of water on the percentage of seed that had not germinated, germinated, but not emerged and emerged at 22 days after watering.

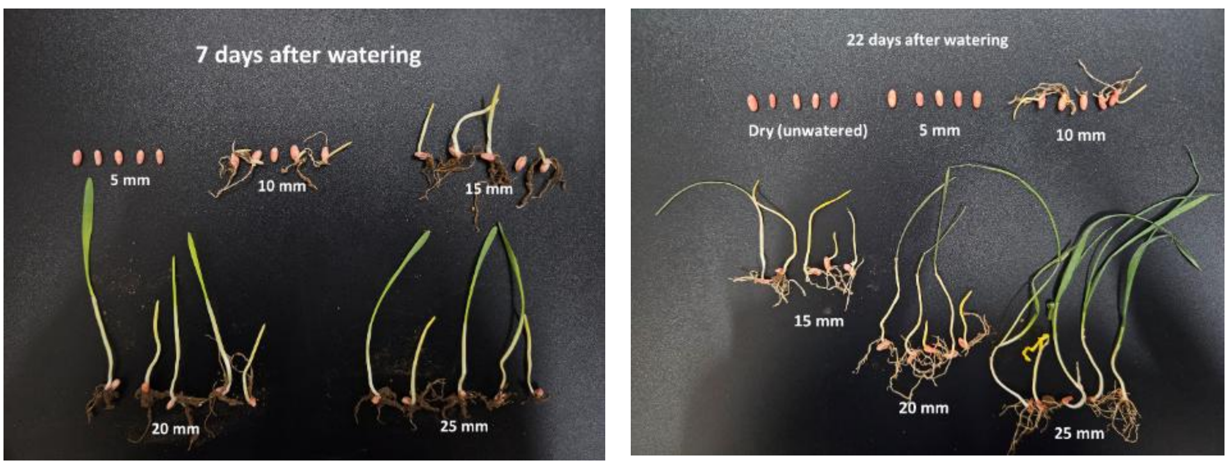

Figure 3. Images of wheat seed recovered from the plots 7 and 22 days after water was applied. By 22 days after water, seedlings were showing symptoms of water stress, and some seedling death had occurred in lower rainfall treatments.

Table 3. Final plant establishment in watered microplots. Values of plants/m^2 followed by the same letter are not significantly different. Shaded values indicate treatments with highest crop establishment. Counts were conducted on July 11 (73 days after watering).

	Rainfall equivalent (mm)				
	5	**10**	**15**	**20**	**25**
Plants/m^2	13^{ab}	15^{ab}	6^{a}	49^{bc}	103^{c}
Establishment (%)	8	8	3	27	57

The low rainfall in May after the watering treatments were applied in late April essentially simulated a 'false break' resulting in seedling death and low establishment. High seed mortality was observed in treatments with lower amounts of simulated rainfall. In Experiment 2 (see below), much higher (>80%) establishment was observed after dry sowing at a depth of 10 mm at the end of April. Improved establishment in the dry, 10 mm sown treatments in Experiment 2 when compared to high simulated rainfall treatments in Experiment 1 were likely caused by consistently dry conditions prior to the season break and reduced clods (improved seed-soil contact) from shallow sowing which reduced emergence time once the season break had occurred. Similarly, in a trial conducted at Hart in 2023, canola and wheat dry sown in late April with no follow-up rain for 57 days achieved establishment rates of 85% in canola and 70% in wheat. While germination and emergence can occur after relatively small amounts of rainfall (10-15 mm), follow up rains are critical to achieve high rates of establishment.

Experiment 2: Effects of time of sowing, sowing depth and sowing rate on emergence and yield

Emergence from April sowing occurred on June 2 (49 days after sowing) and June sowing on July 7 (10 days after sowing). Plant establishment was lower with dry sowing and with sowing at a depth of 40 mm. Reduced plant population was observed with dry sowing (145 plants/m^2) when compared to sowing after the break (173 plants/m^2). However, the establishment rate (established plants/m^2 relative to the number of seeds/m^2 sown) was still high at 78%, which is consistent with results from 2023 when wheat sown into dry soil in late April achieved establishment rates of 70% after being in dry soil with no rain for 57 days. The critical factor in both years was likely that the soil remained dry after sowing rather than receiving a 'false break' that caused the seed to germinate (see Experiment 1).

Based on the results from Experiment 1, if it is assumed that between 10 and 20 mm of rainfall is sufficient to cause germination but not full emergence (i.e. a 'false break') the long-term rainfall data can be used to estimate the probability of a 'false break' with early sowing (Figure 4). During April to mid-May, 10-20 mm was received in the week after sowing between 10% and 20% of the years and this rose to 25% after mid-May. This suggests on average a 'false break' can occur once in every 5-10 years with April to mid-May sowing.

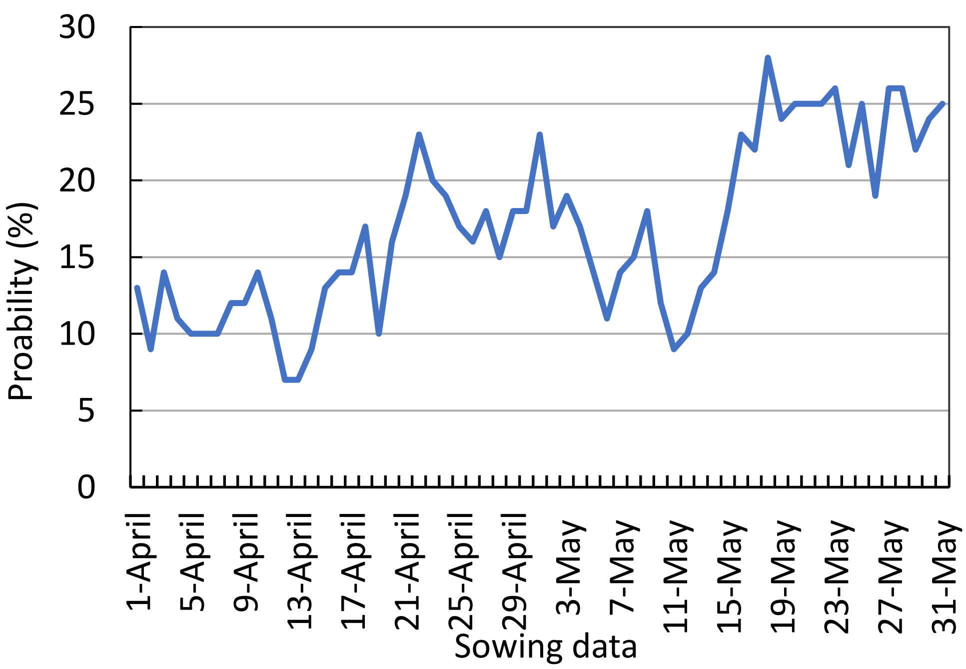

Figure 4 The probability of receiving between 10 mm and 20 mm of rainfall in a 7-day period after sowing between April 1 and May 31 at Blyth. Values are the percentage of years this amount of rainfall was received between 1970 and 2025. (Data were derived from CliMATE https://climateapp.net.au)

Sowing at a depth of 40 mm significantly reduced emergence in all varieties and at both sowing times, however the biggest reduction occurred from dry sowing. At both sowing times, at a depth of 10 mm, average established plant density was 187 plants/m^2 however, this was reduced to 103 plants/m^2 when dry-sown at 40 mm and to 159 plants/m^2 when sown after rain. Genetic differences in coleoptile length did not affect emergence from 40 mm sowing depth. Calibre (long coleoptile) and RockStar (short coleoptile) had similar average plant densities (159 plants/m^2 and 167 plants/m^2, respectively) and both were significantly higher than Neo CL (intermediate coleoptile length; 150 plants/m^2). All varieties showed a similar reduction in establishment from deep sowing; 30% for RockStar and Neo CL and 40% for Calibre.

The main factors influencing grain yield were the interactions between sowing date, sowing depth and variety. Grain yield was reduced by 40 mm sowing depth at both times of sowing with the larger reduction occurring with the early, dry sowing (Table 4). A greater yield loss (43% reduction) was observed from 40 mm, dry sowing on April 24 when compared to delaying and sowing into moisture.

Table 4. The effects of time of sowing and depth of sowing on the average yield (t/ha) of wheat and barley. Shaded values in each column indicate best performing treatments.

	Sowing date	
Sowing depth	April 24	June 27
10 mm	1.9	1.33
40 mm	1.05	1.08
P-value	**<0.001**	
LSD (5%)	**0.161**	

Among the three varieties, the highest average yield was achieved by Neo CL (1.42 t/ha) and Calibre (1.40 t/ha) both of which were higher yielding than RockStar (1.19 t/ha) (Table 5). Increasing the sowing rate by 25% had no effect on yield; the same yield (1.34 t/ha) was achieved at both sowing rates despite a significantly higher plant density at the higher sowing rate (136 plants/m^2 compared with 113 plants/m^2; $p<0.001$). This is not an uncommon occurrence because plasticity in growth in cereal can compensate for differences in plant density.

The average grain size was small, and screenings were high in all treatments, reflecting the dry spring. There was a significant interaction between sowing date, sowing depth and variety for 1000 grain weight and screenings (Table 5). The early, 40 mm, dry sowing, treatment resulted in smaller grain and higher screenings, however at the later sowing date there was no significant effect of sowing depth on either 1000 grain weight or screenings. Neo CL barley had the highest grain weight but also high screenings while RockStar recorded lower screenings than the other varieties.

Table 5. The effects of time of sowing and sowing depth on the 1000 grain weight and screenings % in three cereal varieties. Shaded values in each column indicate best performing treatments.

Variety	Sowing depth (mm)	Yield (t/ha)		1000 grain weight (g)		Screenings (%)	
		April 24	June 27	April 24	June 27	April 24	June 27
Calibre	10	1.95^{de}	1.34^{b}	23.5^{bc}	21.7^{ab}	11.3^{ab}	21.5^{cd}
	40	1.10^{ab}	1.21^{ab}	20.2^{a}	21.2^{ab}	27.9^{e}	22.3^{bcde}
Rockstar	10	1.69^{cd}	1.17^{ab}	25.1^{cd}	24.4^{cd}	10.3^{a}	9.4^{a}
	40	0.94^{a}	0.98^{a}	22.5^{abc}	24.9^{cd}	16.5^{bc}	9.2^{a}
Neo CL	10	2.06^{e}	1.49^{bc}	26.2^{cde}	29.8^{f}	39.1^{f}	24.2^{de}
	40	1.09^{ab}	1.05^{a}	31.4^{f}	29.7^{def}	23.3^{de}	27.3^{de}
P-value		**NS**		**<0.001**		**<0.001**	
LSD (5%)		**0.278**		**3.1**		**5.83**	

Conclusions

In 2025, 10 mm of rainfall was sufficient to germinate seeds, however 20-25 mm was required for seedling emergence. Receiving between 10 and 20 mm allowed the seed to germinate, but on the loamy soil at Hart, germination was patchy and the coleoptile did not fully elongate making the seedling susceptible to dry conditions. Long-term rainfall data for Blyth suggests the chance of a 'false break' with a mid-April to early May sowing is 10-20% (one in every 5-10 years).

The experiment with wheat and barley largely verified past results at Hart. Higher yields were achieved with early, dry sowing compared to waiting to sow until the break despite a lower plant population. While good establishment is a desirable aim, it is not a prerequisite for high yields and delaying sowing until the seed bed is wet does not necessarily 'de-risk' sowing.

Sowing deep into dry soil is not recommended on this soil type. The responses to deeper sowing was similar to past experiments conducted at Hart in canola and wheat. Deeper sowing reduced plant establishment and grain yield. In 2025, the effect of 40 mm sowing was more severe than a 2-month delay in sowing.

Acknowledgement

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