Lessons learnt in canola establishment

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Take-home messages

- Select **high-vigour seed (≥1.8 mm)** and adjust sowing rate based on seed size
- Ensure **seed-bed moisture remains above wilting point for ~4 days post-sowing** and be mindful of rapid dry-back
- **Sow shallow whenever possible**; if deeper sowing is required, use **large seed** and **reduce press-wheel pressure**
- **Separate seed and fertiliser**, particularly nitrogen-containing products
- Match **stubble load and soil moisture** with seeder capacity and opener type (e.g. tynes generally perform better than discs in wet soils)
- Manage **sowing speed** and monitor when conditions are conducive to pests such as slugs and slaters.

Introduction

Research and field surveys consistently show that growers often establish only around **half of the canola seed sown**. Canola seeds are small and have limited energy reserves compared with crops such as wheat, making them particularly vulnerable to poor establishment. This risk is increasing as sowing windows move earlier and establishment conditions become more marginal.

This paper summarises key lessons from a range of **GRDC-funded projects** aimed at improving canola establishment and reducing risk under challenging conditions.

Checklist of key factors to improve canola establishment

1. Seed vigour and seed rate

Factors influencing seed vigour

a) *Seed size*
Larger canola seeds produce bigger cotyledons and have greater energy reserves than small seeds, leading to improved establishment and early biomass. While the largest seed generally performs best, most of the establishment benefit occurs once seed diameter reaches ≥1.8 mm (approximately >4 g per 1000 seeds or <256,000 seeds/kg). Seed weight increases by around 40% for every 0.2 mm increase in seed diameter. Smaller seeds exhibit higher rates of abnormalities and electrolyte leakage, indicating poorer cell membrane integrity (Appendix 1).

b) *Seed-crop (parent crop) management*
Large seed size alone does not guarantee high vigour. Poor management or stress during seed fill (e.g. frost or heat) can substantially reduce seed quality. Producing high-vigour seed requires favourable, extended seed-filling conditions, slow seed moisture dry-down, and adequate phosphorus uptake. Best practice includes matching variety phenology to sowing time, targeting higher plant densities to maximise main-stem seed yield, ensuring adequate P nutrition, and allowing crops to mature naturally (McMaster *et al.,*2023).

c) *Genetic selection*
Breeding programs (CSP2307-002RTX) are targeting traits such as longer hypocotyls and early vigour. International germplasm has shown promising gains in these traits, which may improve establishment under marginal conditions. Stay tuned.

Factor seed size into sowing rate

Larger seeds have higher thousand-seed weights and therefore **fewer seeds per kilogram**. If sowing rates are set solely on a kg/ha basis, larger seed will result in **lower plant density**. Sowing rates should be adjusted for seed size to achieve target plant populations. Table 1 matrix illustrates expected plant densities across seed sizes, sowing rates and establishment percentages.

Table 1. Canola plant density (p/m^2) for various sowing rates (kg/ha), seed size (small, medium, large and extra-large) and establishment (25%, 50% and 75%) percentage.

Sow rate (kg/ha)	Small seed 1.6 – 1.8 mm ~301,654 seeds/kg			Medium seed 1.8 – 2.0 mm ~242,365 seeds/kg			Large seed 2.0 – 2.2 mm ~192,289 seeds/kg			Extra-large seed >2.2mm ~150,000 seeds/kg		
	25%[a]	50%[a]	75%[a]	25%[a]	50%[a]	75%[a]	25%[a]	50%[a]	75%[a]	25%[a]	50%[a]	75%[a]
1.5	11	23	34	9	18	27	7	14	22	6	11	17
2.0	15	30	45	12	24	36	10	19	29	8	15	23
2.5	19	38	57	15	30	45	12	24	36	9	19	28
3.0	23	45	68	18	36	55	14	29	43	11	23	34
3.5	26	53	79	21	42	64	17	34	50	13	26	39
4.0	30	60	90	24	48	73	19	38	58	15	30	45

2. Seed-bed moisture

Recent research shows canola requires **soil moisture at or above the wilting point for approximately four days after sowing** for successful emergence. Wilting point varies with soil type, typically ranging from 1.5–3.5% for sand, 3.5–6.0% for sandy loam, 6.0–10% for loam and 15–20% for clays.

Figure 1 demonstrates the strong relationship between seed-bed moisture and establishment at Condobolin and Canowindra in 2025. Emergence did not occur until moisture reached the wilting point and declined sharply once moisture fell below this threshold.

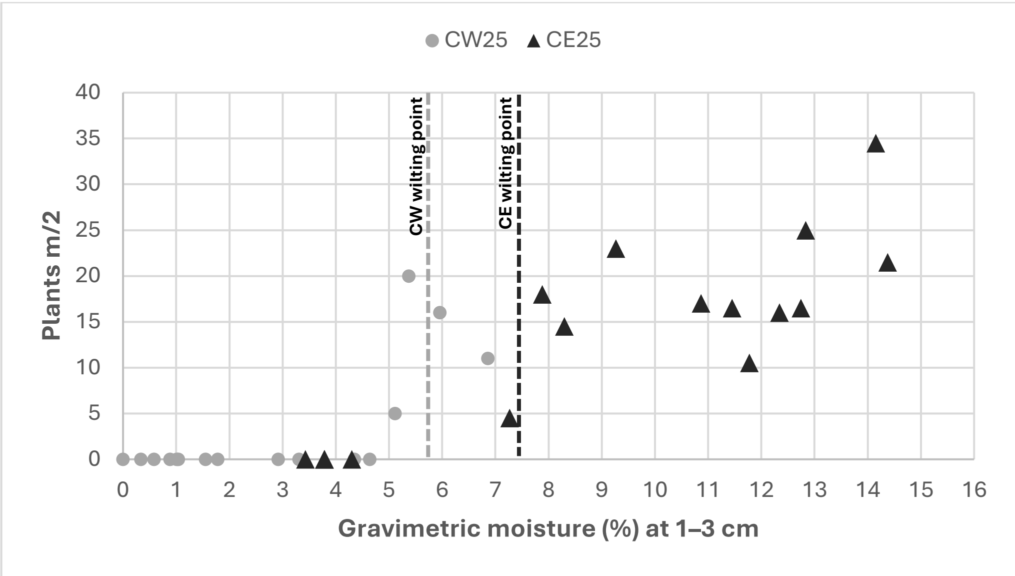

Figure 1. Effect of gravimetric seed-bed moisture content on canola establishment at Condobolin (CW25) and Canowindra (CE25) in 2025. Wilting point was 5.9% at Condobolin and 7.4% at Canowindra.

Excessive soil moisture can also reduce establishment, particularly with disc openers. Establishment declined by **11 percentage points** as gravimetric moisture increased from 12% to 19%, due to poor slot closure under wet conditions. Where soils are too wet to close effectively, delaying sowing to allow slight drying can improve emergence. Understanding opener limitations under different moisture conditions is critical.

Wet soils are also cooler soils. Following 20 mm of irrigation, soil temperature at 2.5 cm depth declined by approximately 7 °C ($P<0.05$) at both Condobolin (from 40 to 33 °C) and Canowindra in 2025 (from 34 to 27 °C). This demonstrates how increased soil moisture can reduce seed exposure to damaging high temperatures during germination. Soil temperatures exceeding 35–40 °C can restrict canola germination, conditions that typically occur when air temperatures approach ~32 °C (Porker *et al.,* 2024).

Seed-bed moisture dry-back

Moisture dry-back (seed-bed evaporation) during the first five days after sowing was greatest in wetter soils (Figure 2). Seed-bed moisture declined by **0.1, 1.0, 1.8, 2.7, 3.5 and 4.4 percentage points** when initial moisture was 4, 6, 8, 10, 12 and 14%, respectively. Wetter soils lose moisture more rapidly because water is present at the soil surface, allowing evaporation to occur readily under wind and heat. As soils dry, water movement to the surface becomes increasingly restricted by pore structure, slowing the rate of evaporation. As a result, soils at 12–14% moisture dry far more rapidly than soils at 4–6% moisture under identical weather conditions.

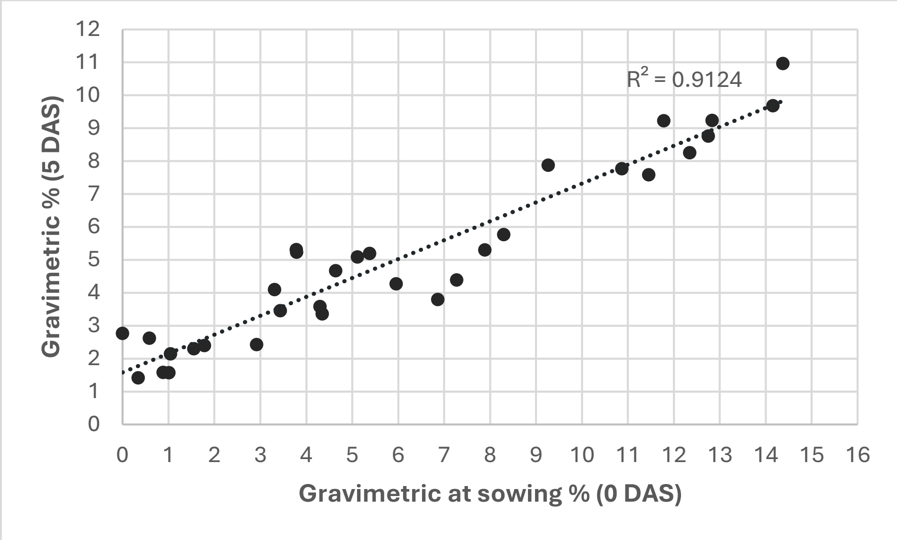

Figure 2. Relationship between gravimetric soil moisture (1–3 cm depth) at sowing and five days after sowing at Condobolin and Canowindra in 2025 (0 DAS = sowing; 5 DAS = five days after sowing).

Does soil moisture increase with seed depth and/or stubble?

Whilst not always, both stubble retention and deeper sowing can increase or stabilise seed-bed moisture in some seasons. Figure 3 illustrates how stubble increased surface (2.5 cm) moisture by **2.4 percentage points**, while moisture increased by 2.9 and 3.6 percentage points at the 4–6 cm and 7–10 cm depths compared with the 2.5 cm depth (Figure 3).

However, deeper sowing carries greater establishment risk. At Canowindra in 2025, sowing at 5 cm reduced establishment by **16 percentage points** compared with 2 cm, while retained stubble (7.5 t/ha) had no adverse effect when using a modern single-disc seeder (Appendix 2).

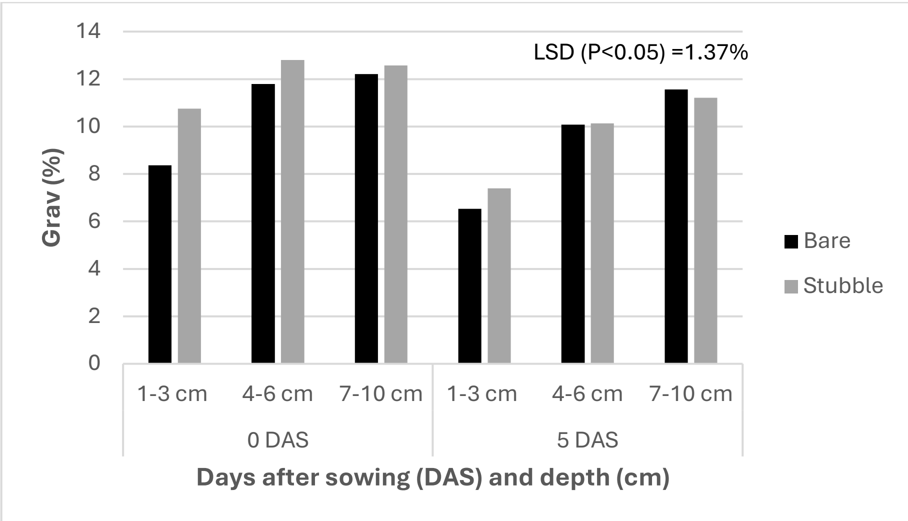

Figure 3. Effect of stubble cover and seed depth on gravimetric soil moisture at sowing and five days post sowing at Canowindra 2025. Stubble load was 7.5 t/ha, and the bare treatment had stubble removed 7 days prior to sowing (simulating a late burn).

Estimated rainfall required for canola to emerge in central/southern NSW

Emergence is most likely when seed-bed moisture remains at or above the wilting point for approximately four days after sowing. Whether this occurs depends on soil type, rainfall amount and timing, sowing date and local conditions. To maintain adequate soil moisture during this period, rainfall in the days following sowing must exceed evaporative demand (ETo).

Cumulative ETo over a 4- or 7-day period provides a practical estimate of the minimum rainfall required for establishment in lighter and heavier soils. Table 2 illustrates five locations in central and southern New South Wales; rainfall required to offset evaporation was greatest in early April (12–23 mm) and declined to 7–14 mm by mid-May as temperatures and evaporative demand decreased. Consequently, larger germinating rainfall events are typically required for early autumn sowing compared to late autumn sowing.

Table 2. Rainfall (mm) required to offset evaporative demand (4- or 7-day cumulative ETo) across 4 sites at 4 dates in central/southern NSW.

	Rainfall (mm)							
Location	**1-Apr**		**15-Apr**		**1-May**		**15-May**	
	4 day[a]	7 day[b]	4 day[a]	7 day[b]	4 day[a]	7 day[b]	4 day[a]	7 day[b]
Condobolin	13	23	12	21	10	17	8	14
Parkes	12	22	12	20	9	16	8	13
Canowindra	12	21	11	20	9	15	7	13
Wagga Wagga	12	20	10	18	8	15	7	12

a) 4-day sum exceeds evaporation - minimum requirement for germination and early emergence under ideal conditions (shallow sowing, light soils)
b) 7-day sum - conservative criteria for heavier soil or challenging conditions

3. Seed depth and press-wheel pressure

Across **29 Australian experiments**, sowing deeper than 3 cm reduced canola emergence by an average of **22%** (Fletcher *et al.,* 2024). In eight NSW experiments (Appendix 4), increasing depth reduced establishment at five sites, but improved establishment at two sites where surface moisture was below wilting point (Figure 4).

These results confirm that **shallow sowing is the most reliable strategy**, but deeper sowing may be justified when surface soils are too dry or moisture dry-back is rapid. When deep sowing is required, **reducing press-wheel pressure** (Figure 5) and using **large, high-vigour seed** (Appendix 3) can be essential to minimise losses. The critical determinant is **soil strength** above the seed, which varies with soil type, stubble cover and rainfall intensity following sowing and during the pre-emergence period. Lab studies identified that soil strength greater than 2.5 kg/cm^2 (penetrometer) can limit establishment at 5 cm depth.

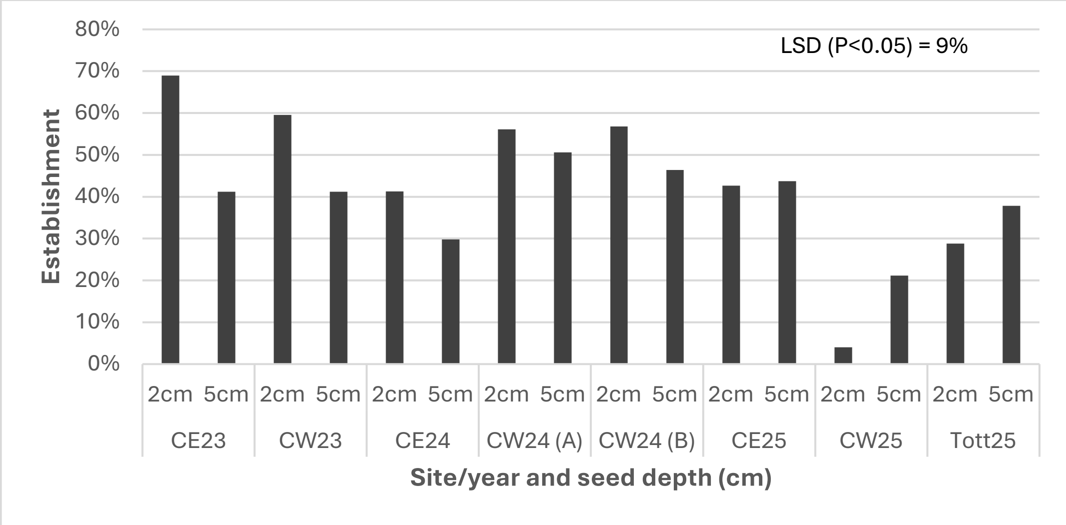

Figure 4. Effect of seed depth on canola establishment across eight site years in central NSW. (CE=Canowindra, central east; CW = Condobolin, central west; Tott = Tottenham)

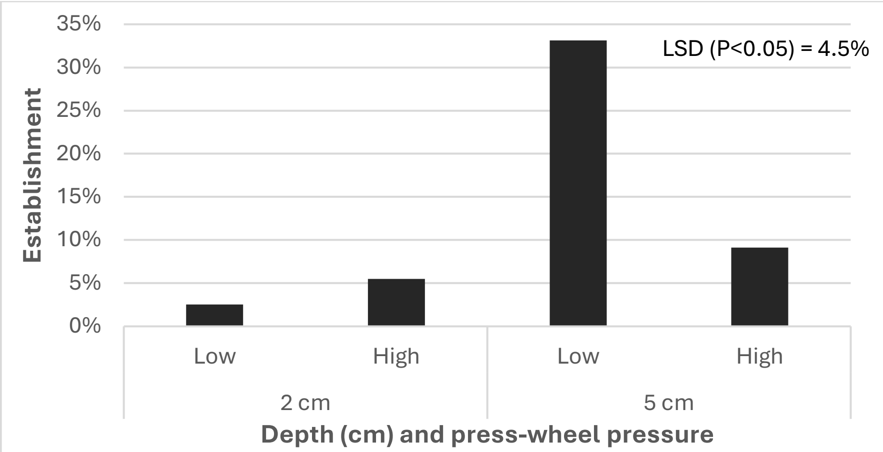

Figure 5. Effect of seed depth and press wheel pressure on canola establishment at Condobolin in 2025.

4. Fertiliser placement

Fertiliser placed close to canola seed can reduce establishment by up to **60%**, due to osmotic stress, pH effects and ammonia toxicity. Starter fertilisers such as MAP and DAP can cause damage through their phosphorus (P) and nitrogen (N) components.

Application of N is far riskier than P and can be applied at other timings or using alternative methods. Safe phosphorus rates depend on row spacing, opener width and fertiliser concentration. Wide rows and narrow openers carry the highest risk, and even **10 kg P/ha** placed with the seed has reduced establishment.

Where seed is inexpensive (grower retained), higher sowing rates may partially offset losses. However, for expensive hybrid seed, protecting establishment through **fertiliser separation** (banding below seed, broadcasting or split applications) is critical (Street and O'Brien 2021).

Managing cumulative risks is important. Sowing into excessively wet soil, small seed, and fertiliser placed with the seed can compound losses, whereas improvements in slot closure (Figure 6) and seed size (Figure 7) each increased establishment by around **10 percentage points**, providing a buffer against fertiliser damage.

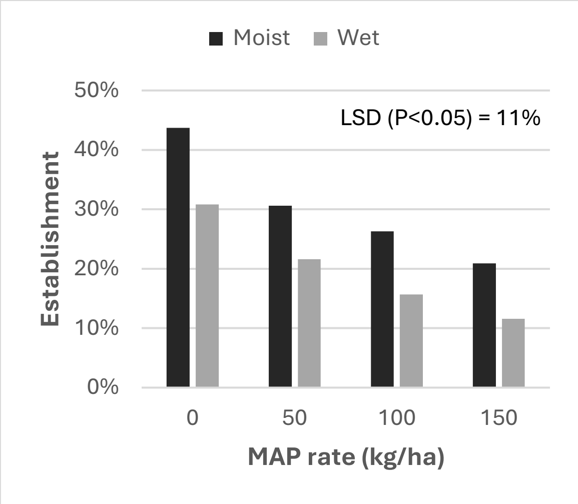

Figure 6. Effect of seed-bed moisture (gravimetric:11% moist; 17% wet) and MAP fertiliser rate on canola establishment using a disc opener.

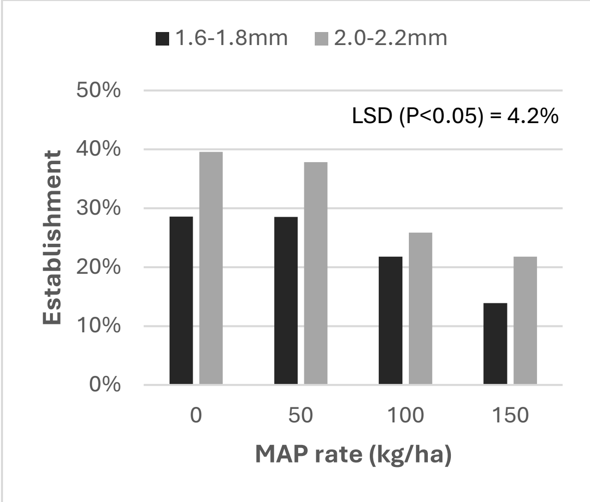

Figure 7. Effect of seed size and MAP fertiliser rate on canola establishment.

5. Other factors

Reducing sowing speed from 13–17 km/h to 6–8 km/h increased establishment by **16 percentage points** in central NSW, largely due to improved seed depth control (McMaster *et al.*, 2019).

Stubble can reduce establishment by **0–30%**, depending on seeder capability and conditions. Residue may conserve moisture but can hinder seed placement or increase pest pressure. Openers must cut residue effectively, maintain seed–soil contact and clear the row. Stubble can increase slug and slater risk, and further details can be found in GRDC publication '[Insect pests in establishing canola in NSW]'.

Conclusion

Improving canola establishment requires integrating **seed quality, soil moisture management and sowing system capability**. High-vigour seed (≥1.8 mm) consistently improves emergence and early biomass, while sowing rates should be adjusted to seed size and target density.

Maintaining seed-bed moisture above wilting point for at least four days post-sowing is critical. Shallow sowing remains the lowest-risk strategy, with deeper sowing justified only when necessary, and then combined with reduced press-wheel pressure and large seed. Fertiliser placement remains a major risk, best managed by separating seed and fertiliser.

By reducing cumulative establishment risks, growers can increase the likelihood of achieving adequate plant populations and improve yield potential under variable seasonal conditions.

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Appendix 1. Effect of canola seed size on electrical conductivity (EC) and proportion of abnormal seedlings (%)

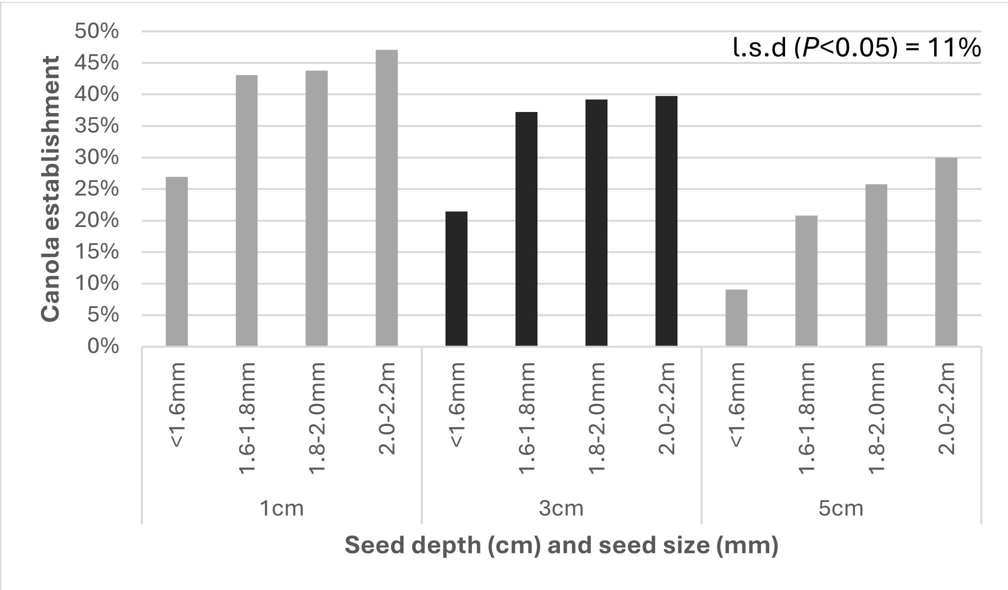
Seed size (mm)	EC reading[a] (uS cm-1g-1)	Abnormal seedlings[b] (%)
<1.6	547	0.40
1.6–1.8	207	0.13
1.8–2.0	140	0.07
2.0–2.2	136	0.05
P value	<.001	<.001
LSD (P<0.05)	47	0.053

a. The EC seed vigour test measures how much electrolyte leakage occurs from seeds when soaked in water, which indicates the strength and quality of their membranes and overall vigour. High vigour seed is less than that measured from low vigour seed.
b. Abnormal seedlings = a seedling that does not have all the essential structures or is damaged, deformed or decayed to such an extent that normal development is prevented.

Appendix 2. Effect of stubble and seed depth on canola establishment, leaf coverage, grain yield and oil at Canowindra 2025.

Stubble treatment	Depth (cm)	Plants (m^2)	Establishment (%)	Leaf coverage (%)	Yield (kg/ha)	Oil (%)
Stubble	2 cm	28.5	0.43	38.9	3360	46.2
	5 cm	19.0	0.28	20.4	3378	46.5
Bare	2 cm	27.2	0.41	28.4	3295	46.5
	5 cm	15.8	0.24	25.6	3434	46.2
LSD (P<0.05)						
	Stubble	ns	ns	ns	ns	ns
	Depth	7.1	0.1	7.0	ns	ns
	Stubble x depth	ns	ns	9.9	ns	0.4

Appendix 3. Effect of seed size and seed depth on canola establishment averaged across Canowindra, Wagga Wagga and Griffith 2022.



Appendix 4. Effect of opener, seed depth and press-wheel pressure across 8 sites in central/southern NSW between 2023 and 2025.

Opener, depth and press wheel pressure	Establishment %								Cross site analysis
	CE23	CW23	CE24	CW24 (A)	CW24 (B)	CW25	Tott25	CE25	
Disc[a]	0.52	0.59	0.31	0.49	0.47	0.12	0.30	0.41	0.40
2cm	0.73	0.70	0.46	0.52	0.56	0.04	0.37	0.37	0.47
Low[c]	0.67	0.64	0.51	0.46	0.54	0.01	0.31	0.37	0.44
High[d]	0.78	0.75	0.42	0.58	0.59	0.07	0.42	0.36	0.50
5cm	0.32	0.48	0.16	0.47	0.37	0.21	0.23	0.45	0.34
Low[c]	0.31	0.48	0.11	0.43	0.37	0.32	0.24	0.39	0.33
High[d]	0.33	0.49	0.20	0.51	0.38	0.10	0.23	0.51	0.34
Tyne[b]	0.58	0.42	0.40	0.57	0.56	0.13	0.37	0.45	0.44
2cm	0.65	0.49	0.36	0.61	0.57	0.04	0.21	0.49	0.43
Low[e]	0.72	0.45	0.34	0.63	0.49	0.04	0.24	0.41	0.41
High[f]	0.59	0.54	0.39	0.59	0.65	0.04	0.18	0.56	0.44
5cm	0.51	0.34	0.44	0.54	0.56	0.21	0.52	0.42	0.44
Low[e]	0.59	0.39	0.43	0.58	0.54	0.34	0.54	0.44	0.48
High[f]	0.43	0.29	0.45	0.50	0.57	0.08	0.51	0.41	0.41
Average	0.55	0.50	0.36	0.53	0.52	0.13	0.33	0.43	0.42
P value									
Opener	0.389	0.003	0.103	0.069	0.015	0.004	0.05	0.205	0.038
Depth	<.001	0.002	0.05	0.193	0.01	0.152	0.011	0.752	<.001
Pressure	0.554	0.616	0.739	0.637	0.106	0.19	0.92	0.112	0.745
Opener x depth	0.066	0.592	0.002	0.805	0.027	0.013	<.001	0.052	<.001
Seeder x pressure	0.15	0.52	0.702	0.066	0.405	0.1	0.135	0.895	0.076
Depth x pressure	0.669	0.193	0.518	0.59	0.251	<.001	0.558	0.712	0.024
Opener x depth x pressure	0.858	0.642	0.373	0.964	0.525	0.329	0.231	0.047	0.386

a. *Excel single disc with rubber firm wheel and scalloped closing wheel*
b. *DBS tyne and press wheel*
c. *Seed firming wheel was on lowest pressure adjustment (1st setting)*
d. *Seed firming wheel was on highest pressure adjustment (3rd setting)*
e. *Press wheel was on lowest pressure adjustment (1st setting)*
f. *Press wheel was on highest pressure adjustment (4th setting)*