

# Final Technical Report for Online Farm Trials

## Stubble residue management for optimising canola establishment in the Wimmera

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## KEY MESSAGES

- In the paddocks surveyed, average canola plant density was 34 plants/m<sup>2</sup>. Poor establishment was usually associated with patchiness, bare areas and uneven emergence.
- For modern hybrid canola, densities of 20 to 30 plants/m<sup>2</sup> generally supported high yield potential, but targeting the upper end is preferred where establishment risk is high.
- Stubble load alone did not explain canola establishment and was not a reliable predictor of establishment or yield. Burning or removing stubble did not consistently improve outcomes and should be applied strategically.
- MAP placed with canola seed can significantly reduce establishment. The risk was greatest under dry conditions post-sowing.
- Canola establishment under retained stubble is a farming systems issue. Successful establishment depends on matching machinery setup, seed placement, residue flow, soil moisture, seasonal conditions, pest and herbicide risk, fertiliser placement and target plant density.

## SUMMARY

High stubble loads after recent high-yielding seasons are making canola establishment more difficult in the Wimmera. Burning is commonly used to reduce this risk, but it also reduces ground cover, soil organic matter and nutrient retention, and increases erosion risk.

This project tested whether retained stubble directly limits canola establishment and identified practical ways to improve establishment without defaulting to burning.

The results showed that stubble load alone was not a reliable predictor of establishment or yield. Poor establishment was more often linked to patchiness, uneven emergence and local interactions between residue distribution, machinery performance, dry soil, pests and fertiliser placement.

Most surveyed paddocks achieved adequate average plant densities. Trials showed that 20 to 30 plants/m<sup>2</sup> generally supported high yield potential, but targeting the upper end is preferred where establishment risk is high.

Fertiliser placement was a clear establishment risk. MAP placed with canola seed reduced establishment, especially when seed remained in dry soil for two to three weeks before germination. Conversely, varying press-wheel pressure (within the limits of the machinery available) had limited impact on seed depth or establishment under the conditions tested.

Overall, the results indicated that retained stubble can be supported where paddock conditions and machinery setup allow reliable crop establishment.

## BACKGROUND AND OBJECTIVES

Stubble retention practices in the Wimmera following recent high production years is leading to issues with canola establishment in subsequent years. Growers are utilising burning to manage these high stubble residue loads preventatively; however, this leads not only to loss of organic matter and nutrients (NPKS), and reduced water infiltration but also increases the risk of soil erosion. Where high stubble loads are retained, establishment is being impacted by stubble effects on seeding operations, affecting seed depth, shadowing of emerging seedlings retarding early growth/ vigour, chemical tie up and the harbouring of pests and diseases among other factors.

Growers are interested in understanding the optimal stubble load that can balance these risks and what tools can be used to manage stubble after high production years. The other component of this issue relates to situations where optimal establishment is not achieved, including reduced density (<5 plants/m<sup>2</sup>) and staggered germination, and growers are unsure when to cut their losses and resow with a different crop.

This project was designed to deliver a series of field trials and associated communications and extension which demonstrate the impact of differing stubble loads on the establishment of canola in the subsequent year under a range of local farming systems sowing practices.

The target outcome of this project was to provide growers and advisers access to information to inform critical decision making around the management of stubble residues under different farming systems to minimise impact on establishment of canola in the following season. During 2024 and 2025, additional trials were incorporated to investigate the impacts of fertiliser placement and press-wheel pressure on canola establishment in addition to experiments to assess critical plant densities.

## TRIAL LOCATIONS

| Trial (year)                                                            | Year | Nearest town |
|-------------------------------------------------------------------------|------|--------------|
| Stubble management × seeding systems for canola establishment           | 2023 | Douglas      |
|                                                                         | 2024 | Douglas      |
|                                                                         | 2025 | Douglas      |
| Effect of press-wheel pressure on canola establishment                  | 2024 | Douglas      |
|                                                                         |      | Kalkee       |
|                                                                         | 2025 | Douglas      |
| Effect of fertiliser placement at sowing on canola establishment        |      | Minyip       |
|                                                                         | 2024 | Douglas      |
|                                                                         | 2025 | Douglas      |
| Critical plant densities to maintain canola productivity in the Wimmera |      | Minyip       |
|                                                                         | 2024 | Douglas      |
|                                                                         |      | Kalkee       |
|                                                                         | 2025 | Douglas      |
|                                                                         |      | Minyip       |

## METHODS

### Surveying current approaches to canola establishment and establishment rates in the Wimmera

Field surveys were conducted across the Wimmera in 2022 and 2023 to benchmark canola establishment under a range of stubble management and seeding systems.

A total of 30 paddocks were surveyed for canola establishment (Figure 1). Each paddock was assessed using a broad U-shaped transect designed to capture the main variation across the paddock.

Plant counts were taken at a minimum of 5 points per paddock, with an average of 16 points per paddock. At each survey point, plants were counted over 1 m of two adjacent crop rows. Survey points were selected randomly to reduce operator bias, and counts were converted to plant density using row spacing.

Most surveyed paddocks were sown using tyne-based seeders, reflecting their common use in the Wimmera. Of the 30 sites, 22 used tyne-based seeders. Only two sites were sown into cereal stubble without prior residue management, such as burning or mulching.

A substantial proportion of paddocks were sown into legume stubbles. This was more common in the northern Wimmera, where legumes are more frequently included in crop rotations.

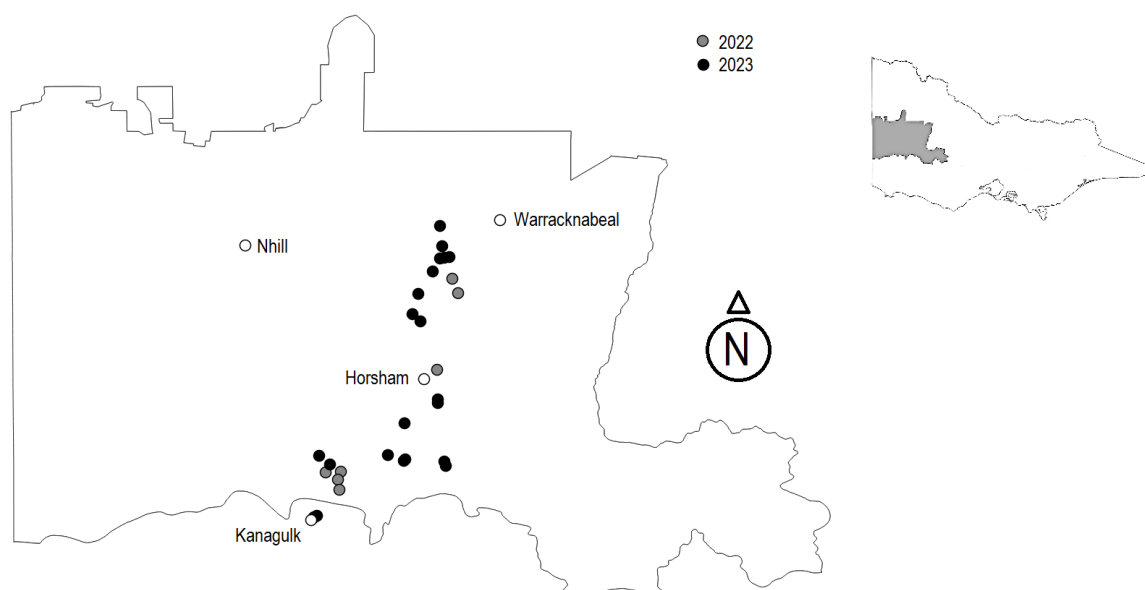


**Figure 1:** Canola establishment survey sites across the Wimmera Catchment for 2022 and 2023

In addition to field surveys of canola establishment, data from the Wimmera Catchment Management Authority's annual land management survey were analysed. This survey captures information on land use and management practices, including stubble management and crop rotation, through annual roadside assessments. It covers approximately 86,000 ha and records data at the paddock scale within a GIS database, providing a unique longitudinal dataset. By linking paddock observations across seasons, it is possible to quantify the proportion of canola sown into cereal versus non-cereal phases and assess the likelihood of cereal stubble requiring management (burning, mulching, cultivation or straw removal) prior to canola compared with other crops.

### **Field trials to understand interactions between stubble management and seeding system on canola establishment**

Between 2023 and 2025, a series of field experiments were conducted at Douglas in the southern Wimmera to investigate interactions between stubble management and seeder type on canola establishment. Experiments were initiated at harvest in the preceding year, where wheat crops were cut at different heights to create plots with varying stubble loads and characteristics. Prior to sowing in autumn, additional treatments (burning or mulching) were applied.

Experiments were established as split-plot designs with four replicates, where stubble treatment formed the main plot and seeder type was the subplot. While the overall experimental framework remained consistent across seasons, treatments were adjusted each year to reflect grower practices and to investigate related issues.

Across all trials, the canola variety InVigor® LR 4540P was used. Herbicides, fertiliser, insecticides and fungicides were applied to minimise pest and disease pressure and optimise crop performance. Pre-emergent herbicides were selected to ensure compatibility with low disturbance (disc-based) seeders. Target sowing depth for all treatments was 15 mm. Measurements included emergence timing, plant establishment, sowing depth, biomass, grain yield and yield components.

### **Year: 2023**

A wide range of stubble management treatments were established, including wheat stubble harvested at three heights (control 25 cm, low 10 cm and high 35 cm), burnt stubble, mulched stubble (flail mulcher), baled stubble and an additional treatment where baled straw was redistributed to simulate very heavy, lodged stubble. Stubble load and height (including standing stubble and chaff) were measured prior to sowing. Three seeders were used:

- knife-point tyne seeder with 70 mm press wheels sown as 6 × row plots at 0.3 m row spacing
- prototype single-disc seeder (20 inch blade, 7° angle, depth wheel, press-wheel and closing wheel) sown as 6 × row plots at 0.3 m row spacing
- single-disc seeder (as above) with a residue manager

The residue manager was designed to clear residue from the furrow to reduce hair-pinning.

Experiments were sown at two times (24 April and 24 May). A seed boot was added to the disc seeder in an attempt to separate seed and fertiliser and reduce toxicity risk. Fertiliser was applied as single superphosphate at 120 kg/ha. Target plant density was 50 plants/m<sup>2</sup> based on estimated field establishment of 80%.

### **Year: 2024**

Stubble treatments were simplified to two harvest heights (25 cm and 35 cm) and burnt stubble. Plots were sown at a single time using the same three seeders as 2023 but configured as 5 × row plots at 0.3 m row spacing.

To investigate performance under different soil moisture conditions, three irrigation treatments were applied:

- nil irrigation
- 20 mm pre-sowing
- 20 mm post-sowing

Pre-sowing irrigation was designed to test the performance of disc versus tyne seeders under wet conditions, while post-sowing irrigation acted as a positive control. Due to space constraints, irrigated and nil treatments were applied only to tyne and disc seeders, while the disc plus residue manager treatment included pre- and post-sowing irrigation only.

Experimental design remained a split-plot, with stubble as the main plot and seeder type × irrigation as the subplot. Sowing occurred on 10–11 May. Fertiliser was applied as MAP at 80 kg/ha, following operational issues with superphosphate in 2023. Target plant density was 50 plants/m<sup>2</sup> based on estimated field establishment of 80%.

### **Year: 2025**

Stubble treatments included two harvest heights (25 cm and 35 cm) and mulched stubble. Plots were sown on 14–15 May using the same seeders and configuration as 2024.

Two seed rates were included to target plant densities of 20 and 40 plants/m<sup>2</sup>, based on results from 2024 indicating critical densities within this range. Seed rates were calculated using germination data and an assumed 65% field establishment. Fertiliser applications were as per 2024.

### **Field trials to measure the effect of press-wheel pressure on canola establishment**

Trials were conducted at Douglas (2024 and 2025), Kalkee (2024) and Minyip (2025) to assess the effects of press-wheel pressure and seeding depth on emergence, establishment and yield.

All trials used a knife-point tyne seeder fitted with 70 mm press wheels. Three pressure settings were tested:

- lifted (nil pressure)
- standard (single spring)
- high (additional spring)

Seeding depth targets were 15 and 30 mm in 2024 and 15 and 40 mm in 2025. Target plant density was 50 plants/m<sup>2</sup> in 2024 and 40 plants/m<sup>2</sup> in 2025 with assumed field establishment of 80% and 65% respectively.

Trials were established as spatially optimised, randomised, complete block factorial designs with three replicates.

The variety used was InVigor® LR 4540P. Sowing occurred in May at each site. MAP was applied at 80 kg/ha below the seed. Pest, disease and weed management were applied as required and data collection was conducted as per the stubble management experiments outlined above with the addition of sowing depth measurement.

### **Field trials to measure the effect of fertiliser placement on canola establishment**

Trials were conducted at Douglas (2024 and 2025) and Minyip (2025) to assess the effect of fertiliser rate and placement on canola establishment and yield.

In 2024, a single-disc seeder with limited capacity to separate seed and fertiliser was used. An additional seed boot was added behind the fertiliser boot in an attempt to separate seed from fertiliser. In 2025, a tyne-based seeder with twin boots allowed clear separation of seed and fertiliser. Target plant density was 50 plants/m<sup>2</sup> in 2024 and 40 plants/m<sup>2</sup> in 2025 with assumed field establishment of 80% and 65% respectively.

Fertiliser (MAP) was applied:

- with the seed
- below the seed
- on the soil surface after sowing
- split (50:50) between seed and surface (2025 only)

Two rates were tested:

- 2024: 60 or 100 kg/ha
- 2025: 80 or 120 kg/ha

Split applications involved partial placement with the seed and the remainder was surface applied. Trials were designed as randomised complete block designs with three replicates.

Agronomic management and measurement protocols matched those used in the press-wheel trials, except sowing depth was not measured.

## Revisiting critical plant densities for modern, hybrid canola grown in the Wimmera

Trials were conducted at Douglas (2024 and 2025), Kalkee (2024) and Minyip (2025) to determine yield responses to plant density. Target densities were 10, 20, 30, 40, 50 and 70 or 80 plants/m<sup>2</sup>. Seed rates were calculated using germination data and assumed establishment of 80%, revised to 65% after lower establishment in 2024. Trials used a tyne seeder and were established as randomised complete block designs with four replicates. Agronomic management and measurements were consistent with previous trials.

### Soil characteristics of field trial sites (2023-2025)

Soils at Douglas were sandy clay loam over clay, with non-wetting characteristics when dry. Topsoil pH was acidic, increasing to alkaline at depth. Phosphorus, organic carbon and mineral nitrogen levels were moderate to high. At Kalkee and Minyip, soils were Wimmera grey clay and red clay loam, respectively. Topsoils were neutral to alkaline, with increasing alkalinity at depth. Nutrient levels were lower than at Douglas. The Minyip site had high phosphorus fixation potential (PBI 150 at 0-10 cm).

**Table 1:** Soil chemical characteristics measured prior to sowing for field experiment sites from 2023-2025

| Site                | Depth (cm) | NO <sub>3</sub> -N (mg/kg) | NH <sub>4</sub> -N (mg/kg) | Colwell P (mg/kg) | Organic C (%) | pH (CaCl <sub>2</sub> ) |
|---------------------|------------|----------------------------|----------------------------|-------------------|---------------|-------------------------|
| <b>2023 Douglas</b> | 0-10       | 14.8                       | 5.3                        | 44                | 1.6           | 4.7                     |
|                     | 10-20      | 3.3                        | 3                          |                   |               | 5.0                     |
|                     | 20-40      | 2.3                        | 3.5                        |                   |               | 6.2                     |
|                     | 40-60      | 2.3                        | 4.8                        |                   |               | 7.4                     |
| <b>2024 Douglas</b> | 0-10       | 3.0                        | 19.3                       | 33                | 1.4           | 5.2                     |
|                     | 10-20      | 2.0                        | 5.3                        |                   |               | 5.8                     |
|                     | 20-40      | 0.0                        | 4                          |                   |               | 6.6                     |
|                     | 40-60      | 0.0                        | 2.8                        |                   |               | 8.2                     |
| <b>2024 Kalkee</b>  | 0-10       | 1.3                        | 7.0                        | 13                | 1.1           | 7.7                     |
|                     | 10-20      | 1.0                        | 2.0                        |                   |               | 7.7                     |
|                     | 20-40      | 1.0                        | 3.0                        |                   |               | 8.1                     |
|                     | 40-60      | 1.0                        | 3.0                        |                   |               | 8.1                     |
| <b>2025 Douglas</b> | 0-10       | 8.5                        | 44.8                       | 60.75             | 1.5           | 4.9                     |
|                     | 10-20      | 3                          | 10.8                       |                   |               | 4.7                     |
|                     | 20-40      | 3.25                       | 6                          |                   |               | 6.4                     |
|                     | 40-60      | 2.5                        | 4.8                        |                   |               | 6.7                     |
| <b>2025 Minyip</b>  | 0-10       | 2.7                        | 71.3                       | 22.3              | 1.0           | 7.0                     |
|                     | 10-20      | 2.0                        | 35.7                       |                   |               | 7.7                     |
|                     | 20-40      | 1.5                        | 15.7                       |                   |               | 7.8                     |
|                     | 40-60      | 1.0                        | 6.3                        |                   |               | 7.9                     |

## Rainfall across field trial sites (2023-2025)

Annual rainfall across the field trial sites from 2023 to 2025 was generally below average, with the exception of Douglas in 2023 (Table 2). Rainfall at Douglas (southern Wimmera) was consistently higher than at the northern sites, ranging from 341 to 482 mm compared with 287–319 mm at Kalkee and Minyip.

In both 2024 and 2025, the onset of seasonal rainfall was delayed across all sites (Figure 2). At Douglas in 2024, sowing occurred on 9 May, but no significant rainfall was received until 31 May (12 mm). A similar pattern occurred at Kalkee, where sowing on 14 May was followed by limited rainfall until 31 May (9 mm).

In 2025, trials at Douglas were sown on 14 May, with the first rainfall event occurring on 27 May (7 mm). At Minyip, sowing was later (29 May), with follow-up rainfall occurring on 7 June (7 mm).

In contrast, seasonal conditions in 2023 were wetter with an earlier autumn break. At Douglas, the first sowing (24 April) was followed by rainfall from 27 April (6 mm). The second sowing (24 May) was followed by rainfall on 25 May, with regular rainfall events continuing through to mid-June.

**Table 2:** Monthly and annual rainfall totals across all field trial sites between 2023 and 2025. Values presented in parentheses indicate decile relative to the long-term average for the nearest Bureau of Meteorology station (bom.gov.au)

| Month        | Douglas 2023     | Douglas 2024     | Douglas 2025     | Kalkee 2024      | Minyip 2025      |
|--------------|------------------|------------------|------------------|------------------|------------------|
| January      | 3.4 (2)          | 58.2 (10)        | 7.6 (3)          | 48.3 (9)         | 14.8 (5)         |
| February     | 19.4 (6)         | 0.0 (1)          | 5.4 (3)          | 0.0 (1)          | 11.4 (5)         |
| March        | 18.2 (6)         | 0.0 (1)          | 21.6 (7)         | 0.5 (1)          | 19.3 (6)         |
| April        | 77.4 (10)        | 20.8 (6)         | 17.6 (4)         | 32.0 (7)         | 23.0 (6)         |
| May          | 28.2 (3)         | 13.4 (3)         | 12.8 (1)         | 8.8 (1)          | 3.0 (1)          |
| June         | 102.2 (10)       | 35.2 (4)         | 44.2 (5)         | 26.2 (3)         | 41.6 (6)         |
| July         | 36.4 (3)         | 57.8 (6)         | 59.4 (6)         | 39.2 (5)         | 44.8 (6)         |
| August       | 30 (2)           | 57.8 (6)         | 50.6 (5)         | 35.8 (4)         | 42.6 (5)         |
| September    | 16.6 (1)         | 30.59 (3)        | 19 (1)           | 12.6 (2)         | 12.4 (2)         |
| October      | 18.4 (2)         | 16.6 (2)         | 56 (6)           | 7.6 (2)          | 39.8 (6)         |
| November     | 50.2 (8)         | 16.1 (2)         | 50.6 (8)         | 48.0 (8)         | 16.4 (4)         |
| December     | 81.2 (10)        | 34.3 (7)         | 16.4 (4)         | 28.0 (7)         | 49.6 (9)         |
| <b>Total</b> | <b>481.6 (5)</b> | <b>340.8 (1)</b> | <b>361.2 (2)</b> | <b>287.0 (2)</b> | <b>318.7 (3)</b> |

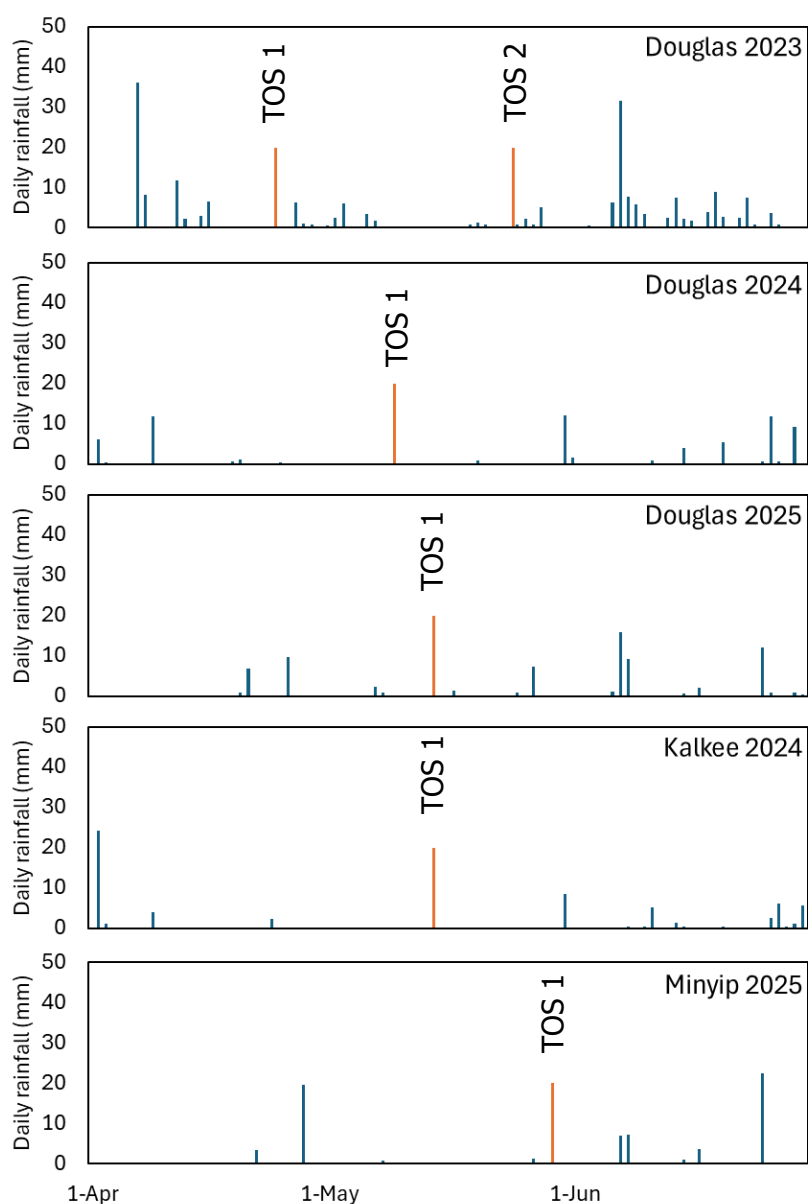


**Figure 2:** Daily rainfall from 1-April to 30-June at each field trial site from 2023 to 2025. Orange bars indicate sowing dates for field trials.

## RESULTS

### Surveying current canola establishment practices in the Wimmera

Benchmarking across the Wimmera showed that most surveyed paddocks achieved commercially acceptable canola establishment, but poorer outcomes were usually patchy and localised rather than whole-paddock failures. The survey also identified regional differences in rotation and residue management that help explain where stubble-related establishment risks are most likely to occur. Key findings from the survey work were:

- Most surveyed paddocks achieved plant densities within commercially acceptable ranges.
- Poor establishment was typically patchy and localised, rather than a whole-paddock failure.
- Canola was more likely than other crops to be sown into cereal stubbles that had been actively managed before sowing.
- Rotation and residue risks differed across the Wimmera, with greater reliance on cereal-canola rotations in the south and more legume phases before canola in the north.
- Establishment issues occurred in both managed and unmanaged stubble systems, indicating that stubble load alone was not the primary driver.

To inform project development and ensure that the treatments tested throughout the experimental program were relevant to Wimmera growers, a two-part survey was undertaken to benchmark current practices and outcomes relating to canola establishment in the region. The first component involved a desktop analysis of the Wimmera Catchment Management Authority's annual land management survey.

In 2022 canola represented 11% of the surveyed area under crop with 35% having been sown into cereal stubbles from 2021 (Figure 3). Of these stubbles, 50% were subjected to some form of 'management' (either burning, cultivation, windrow burning or some other form of disturbance other than sowing into a standing stubble) prior to sowing. In comparison, for crops other than canola being sown into cereal stubble, growers only implemented stubble management across 15% of the sown area indicating that growers were three times more likely to manage cereal stubbles prior to canola in comparison to other species. Analysing the survey data by district indicated that in the southern Wimmera an increased proportion of canola was sown into cereal stubbles (54%) and an even higher proportion of these stubbles required 'management' prior to sowing (64%).

In 2023 canola represented 18% of the surveyed area under crop and of this area, 25% was sown into cereal stubbles with 76% of these stubbles having required some form of 'management' prior to April in preparation for sowing (Figure 3). For crops other than canola, this figure reduced to 29%. As was the case in 2022, these observations varied across the region with growers more likely to grow canola on cereal stubbles in the southern

Wimmera (53% of the canola area) and more likely to apply some form of 'management' to these cereal stubbles; 90% of canola grown on cereal stubbles, approximately twice as likely compared with paddocks sown to other species. These observations collectively confirm a general perception that the southern Wimmera is more reliant on cereal-canola rotations and that the higher production potential in this region places greater pressure in relation to management of crop residues. It also suggests that in the northern Wimmera, growers are more likely to grow canola on legume stubbles to avoid issues relating to cereal residues when establishing canola.

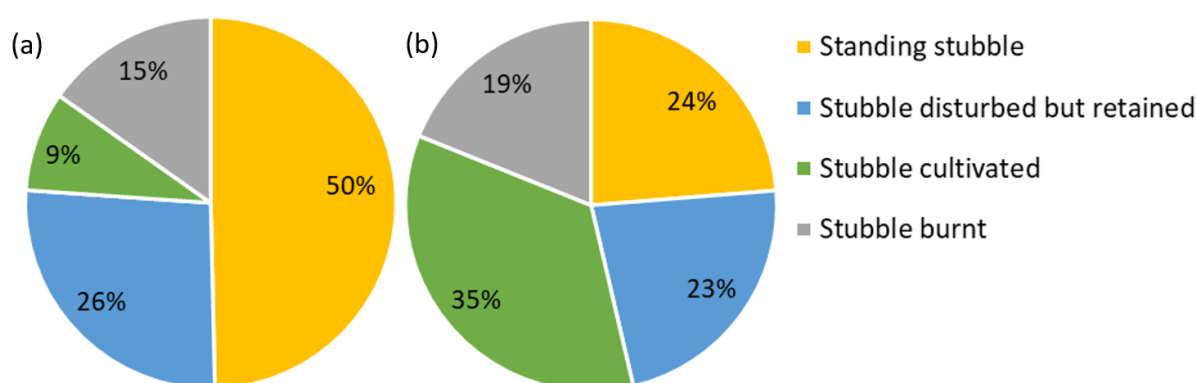


**Figure 3:** Management practices for cereal stubble prior to sowing canola in the Wimmera based on the Wimmera Catchment Management Authority land management survey 2022 (a) and 2023 (b)

The second component of the benchmarking involved a survey of 30 canola paddocks across the Wimmera during 2022 and 2023 to measure plant density across a range of farming systems and environments. Results indicated that the surveyed paddocks achieved plant density values within typical targets for high yielding canola, with a median of 34 plants/m<sup>2</sup> and 50% of values falling between 27 and 43 plants/m<sup>2</sup> (Figure 4 and 5). Intra-paddock variation was generally low, with a median interquartile range of 10 plants/m<sup>2</sup>. In some cases, variability was far higher, up to 25 plants/m<sup>2</sup>.

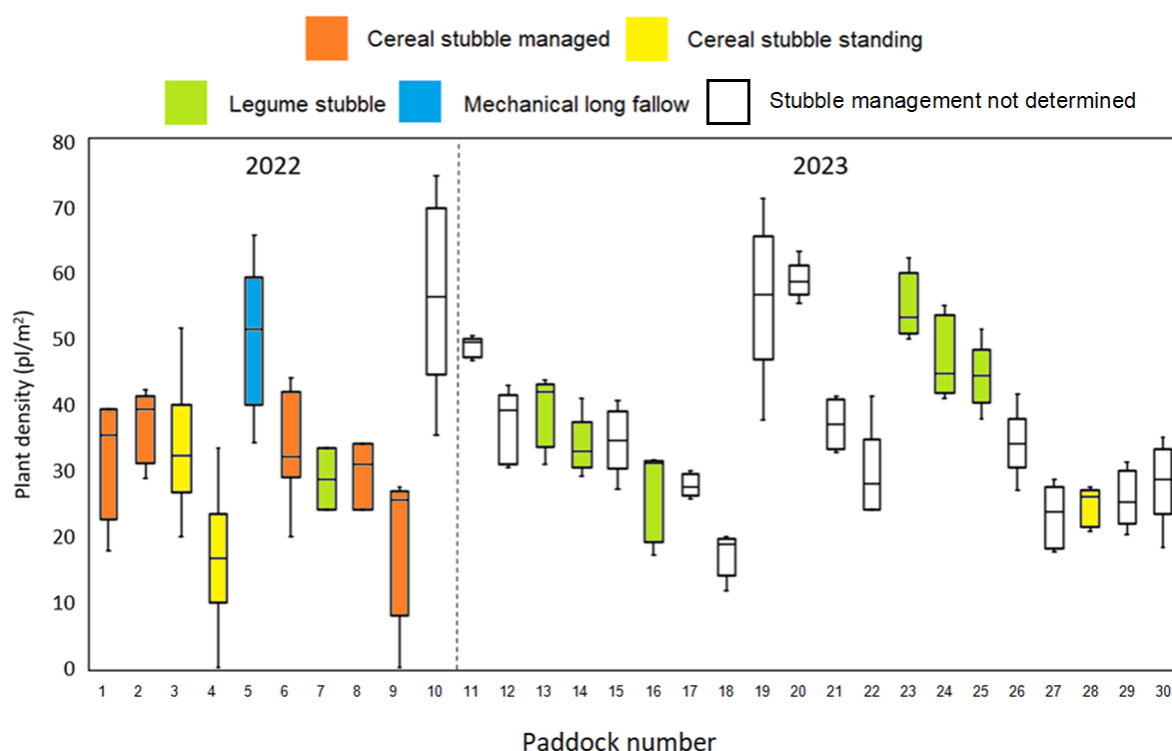


**Figure 4:** Distribution of measured plant density for paddocks surveyed across the Wimmera between 2022 and 2023 with varying rotations and stubble management. Values represent the median, 25<sup>th</sup> and 75<sup>th</sup> percentiles for a minimum of 5 survey points per paddock and where available, colour coding indicates rotation and stubble management prior to sowing canola

In paddocks where canola establishment was poorest, plant numbers varied markedly within the paddock. Bare areas and delayed emergence occurred alongside areas where establishment was strong (Figure 5). In some cases, this was associated with heavy, lodged cereal stubble that had not been managed before sowing. In other cases, establishment issues occurred despite prior stubble management, such as mulching, and appeared to be associated with machinery challenges or pest pressure. Very high plant densities were also observed in parts of some paddocks, often with many small plants that did not develop strong branching or yield potential. These examples show that poor establishment was not explained by stubble load alone and should be interpreted alongside machinery performance, pest pressure and target plant density.



**Figure 5:** Example of a surveyed paddock where canola had been sown into a heavy barley stubble leading to uneven establishment and large patches of low plant density (Horsham, 2023)

### **What is the critical plant density for modern, hybrid canola in the Wimmera?**

Plant density experiments across the Wimmera showed that modern hybrid canola maintained high yield potential across a broad range of plant densities. Final plant densities were often below target, mainly because field establishment was poor where the autumn break was delayed and seed remained in dry soil before germination. Canola compensated strongly through branching and higher yield per plant, but this compensation declined where seasonal conditions limited branching and canopy development. Key findings from the plant density experiments were:

- Modern hybrid canola compensated strongly for lower plant densities through increased yield per plant.
- Field establishment was often below target, especially where the autumn break was delayed and seed remained in dry soil for two to three weeks before germination.
- Very low densities, below about 10 to 12 plants/m<sup>2</sup>, increased yield risk, particularly where seasonal conditions limited canopy development.
- Plant densities of about 20 to 30 plants/m<sup>2</sup> supported high yield potential in most situations tested.
- The upper end of this range is the safer target where establishment risk is high or seasonal conditions are likely to limit crop compensation.

The experiments tested target plant densities of 10 to 80 plants/m<sup>2</sup> across four site-year combinations. Annual rainfall ranged from 287 to 482 mm, and yield potential ranged from less than 1 t/ha to 3.8 t/ha. In 2024 and 2025, delayed autumn breaks meant seed often remained in dry soil for up to three weeks before germination. This contributed to low field establishment across most experiments, averaging 46% and ranging from 30% to 54%. The exception was Minyip in 2025, where establishment averaged 75%. Field establishment reflects both seedling emergence and survival through to established plants.

By tracking the rate of emergence, data relating to seedling mortality was also captured and found to be highly variable. While treatment effects were limited, it was found that across all trials seedling mortality (the proportion of emerged seedlings which failed to reach full establishment) was higher at Douglas in 2023 (TOS 1) and Douglas in 2025 (28 and 31% respectively) compared to Douglas and Kalkee in 2024 and Minyip in 2025 (11%, 1% and <1% respectively). While pests were actively managed across all sites with upfront insecticides and baiting for slugs, these results are indicative of potentially higher pest pressure in these situations or other factors which contributed towards seedling stress.

**Table 3:** Plant density and field establishment values for canola sown at varying seed rates to achieve target densities from 10-80 plants/m<sup>2</sup>. Values presented in parentheses represent the standard error of the mean (n=4)

| Target density<br>(plants/m <sup>2</sup> ) | 2024                                      |               |                                           |               |
|--------------------------------------------|-------------------------------------------|---------------|-------------------------------------------|---------------|
|                                            | Douglas                                   |               | Kalkee                                    |               |
|                                            | Final density<br>(plants/m <sup>2</sup> ) | Establishment | Final density<br>(plants/m <sup>2</sup> ) | Establishment |
| 10                                         | 6.7 (0.4)                                 | 50% (3%)      | 5.8 (0.9)                                 | 44% (7%)      |
| 20                                         | 10.3 (2.8)                                | 39% (10%)     | 12.0 (2.0)                                | 46% (8%)      |
| 30                                         | 21.2 (1.8)                                | 54% (5%)      | 18.5 (0.8)                                | 47% (2%)      |
| 40                                         | 26.7 (1.4)                                | 51% (3%)      | 20.6 (3.6)                                | 39% (7%)      |
| 50                                         | 27.5 (3.6)                                | 42% (6%)      | 26.9 (0.7)                                | 41% (1%)      |
| 80                                         | 31.4 (9.7)                                | 30% (9%)      | 41.8 (4.2)                                | 40% (4%)      |

| Target density<br>(plants/m <sup>2</sup> ) | 2025                                      |               |                                           |               |
|--------------------------------------------|-------------------------------------------|---------------|-------------------------------------------|---------------|
|                                            | Douglas                                   |               | Minyip                                    |               |
|                                            | Final density<br>(plants/m <sup>2</sup> ) | Establishment | Final density<br>(plants/m <sup>2</sup> ) | Establishment |
| 10                                         | 8.6 (2.0)                                 | 53% (13%)     | 12.8 (0.7)                                | 79% (4%)      |
| 20                                         | 15.8 (2.7)                                | 49% (8%)      | 24.6 (2.4)                                | 76% (8%)      |
| 30                                         | 25.5 (1.7)                                | 52% (4%)      | 39.5 (1.2)                                | 81% (2%)      |
| 40                                         | 31.0 (3.0)                                | 48% (5%)      | 39.3 (7.1)                                | 61% (11%)     |
| 50                                         | 44.1 (1.9)                                | 54% (2%)      | 64.6 (6.5)                                | 80% (8%)      |
| 70                                         | 53.6 (1.8)                                | 47% (2%)      | 80.4 (3.0)                                | 71% (3%)      |

Final plant densities were usually below target, except at Minyip in 2025. Where the target density was 10 plants/m<sup>2</sup>, final densities were typically only 6 to 9 plants/m<sup>2</sup>. Even where target densities were 70 to 80 plants/m<sup>2</sup>, final densities were usually only 30 to 50 plants/m<sup>2</sup>. Despite this, yield results indicated that canola can compensate for low plant density through greater branching and higher yield per plant under favourable conditions. At Douglas in 2024, yield of up to 3.62 t/ha was achieved from an average plant density of just 21.2 plants/m<sup>2</sup>.

**Table 4:** Canola yield for varying target plant densities sown at Douglas and Kalkee in 2024, and Douglas and Minyip in 2025. Values followed by different letters indicate significant differences ( $P < 0.05$ ) between treatments

| Target density<br>(plants/m <sup>2</sup> ) | 2024           |               | 2025           |               |
|--------------------------------------------|----------------|---------------|----------------|---------------|
|                                            | Douglas (t/ha) | Kalkee (t/ha) | Douglas (t/ha) | Minyip (t/ha) |
| 10                                         | 2.73b          | 0.56c         | 1.70           | 1.07b         |
| 20                                         | 3.00b          | 0.84ab        | 2.21           | 1.81a         |
| 30                                         | 3.62a          | 0.75bc        | 1.97           | 1.98a         |
| 40                                         | 3.56a          | 0.83ab        | 2.19           | 1.84a         |
| 50                                         | 3.82a          | 0.75bc        | 2.27           | 1.99a         |
| 70                                         | -              | -             | 2.15           | 1.92a         |
| 80                                         | 3.56a          | 0.98a         | -              | -             |
| P-value                                    | <0.001         | 0.018         | 0.17           | <0.001        |
| CV                                         | 5%             | 14%           | 6.5%           | 19.6%         |
| LSD ( $P < 0.05$ )                         | 0.46           | 0.21          | n.s.           | 0.21          |

Yield response to plant density was statistically significant at Douglas and Kalkee in 2024 and at Minyip in 2025. At these sites, yield generally increased as plant density increased, although the response varied with seasonal conditions and yield potential. At Kalkee in 2024, where yield potential was lowest, plant densities of about 6 plants/m<sup>2</sup> reduced yield compared with densities of 12 plants/m<sup>2</sup> or more. There was also a trend towards higher yield above 20 plants/m<sup>2</sup>. This likely reflected dry conditions that limited branching and canopy development, reducing the crop's ability to compensate for low establishment.

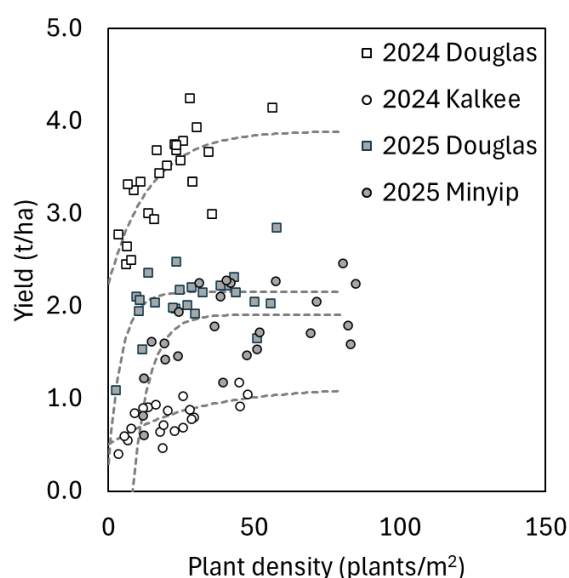


**Figure 6:** Relationship between plant density and yield for canola grown at Douglas and Kalkee in 2024 and Douglas and Minyip in 2025. Dotted lines indicate line of best fit for an exponential regression between plant density and yield for each site and year combination

Across the four experiments, the critical plant density was generally lower than traditional rules of thumb, but it still varied with yield potential and seasonal conditions. In high-yielding situations above 3 t/ha, plant densities of at least 20 plants/m<sup>2</sup>, and preferably 25 to 30 plants/m<sup>2</sup>, were needed to protect yield potential in these trials. In lower-yielding situations around 2 t/ha, densities of at least 15 plants/m<sup>2</sup>, and preferably 20 to 25 plants/m<sup>2</sup>, were generally sufficient. A practical target from these results is 20 to 30 plants/m<sup>2</sup>, using the upper end of this range where establishment risk is high or conditions are likely to limit crop compensation. In situations where seed costs are a limitation, targeting lower densities (15-25 plants/m<sup>2</sup>) may maintain moderate to high yield potential, but presents a greater risk if field establishment or crop vigour are poor.

### Measuring the impact of fertiliser placement on canola establishment for disc and tyne-based seeding systems

Fertiliser placement had a clear effect on canola establishment under the dry sowing conditions tested. MAP placed close to the seed reduced plant density, with the level of risk shaped by soil moisture, seedbed utilisation and the ability of the seeder to separate seed and fertiliser. The results show a practical trade-off: seed safety matters, but phosphorus must also remain available early in the season where soils are responsive to P.

Key findings from the fertiliser placement experiments were:

- MAP placed with the seed significantly reduced canola establishment under dry sowing conditions.
- Separating fertiliser from the seed improved plant density where machinery allowed reliable separation.

- Disc seeders were more exposed to fertiliser toxicity risk because seed and fertiliser separation was limited.
- Rainfall soon after sowing reduced establishment risk from fertiliser placement.
- In P-responsive soils, moving fertiliser away from the seed improved establishment but could reduce yield if early phosphorus supply was inadequate.

Fertiliser toxicity can occur when seed is placed too close to fertiliser. The risk is caused by salt effects, which can draw water away from seed, and ammonia toxicity, which can reduce germination. MAP is a higher-risk fertiliser for canola because it can act as both a salt and a source of ammonia. The risk is influenced by fertiliser rate, placement, soil moisture and seedbed utilisation.

Phosphorus fertiliser at sowing remains important for crop productivity in the Wimmera because phosphorus has low mobility in soil and needs to be close enough to the seed to support early growth. The 2024 Douglas experiment tested whether MAP could be separated from canola seed using a disc seeder with an additional seed boot. Early testing with rice as an inert grain suggested some separation was possible, but canola establishment was similar to the treatment where MAP was placed with the seed. This indicated that the below-seed treatment did not provide enough separation to avoid fertiliser toxicity at the rates tested.

Surface application of MAP after sowing increased plant density from 21.9 to 23.3 plants/m<sup>2</sup> to 31.6 plants/m<sup>2</sup> ( $P < 0.05$ , Table 5). Yield differences were not statistically significant, although there was a trend towards higher yield where plant density increased.

**Table 5:** Plant density and yield of canola sown at Douglas in 2024 and 2025 and Minyip in 2025 with varying fertiliser placement at sowing. Fertiliser was applied as MAP and values represent an average of 60 kg/ha and 100 kg/ha rates in 2024 and 80 kg/ha and 120 kg/ha rates in 2025. Plots were sown using a disc seeder in 2024 and a tyne seeder in 2025. Values followed by different letters indicate significant differences ( $P < 0.05$ ) between treatments for a given site and year combination

| Fertiliser placement       | Douglas 2024                           |              | Douglas 2025                           |              | Minyip 2025                            |                    |
|----------------------------|----------------------------------------|--------------|----------------------------------------|--------------|----------------------------------------|--------------------|
|                            | Plant density (plants/m <sup>2</sup> ) | Yield (t/ha) | Plant density (plants/m <sup>2</sup> ) | Yield (t/ha) | Plant density (plants/m <sup>2</sup> ) | Yield (t/ha)       |
| With the                   | 23.3 <sup>b</sup>                      | 3.06         | 13.0 <sup>b</sup>                      | 2.02         | 45.2                                   | 1.86 <sup>a</sup>  |
| Below seed                 | 21.9 <sup>b</sup>                      | 3.20         | 28.7 <sup>a</sup>                      | 2.34         | 53.1                                   | 1.95 <sup>a</sup>  |
| Split (50% with seed, 50%) | -                                      | -            | 17.3 <sup>b</sup>                      | 2.16         | 51.2                                   | 1.77 <sup>ab</sup> |
| Surface                    | 31.6 <sup>a</sup>                      | 3.76         | 27.9 <sup>a</sup>                      | 2.06         | 52.8                                   | 1.54 <sup>b</sup>  |
| <i>P-value</i>             | <i>0.006</i>                           | <i>0.39</i>  | <i>0.009</i>                           | <i>0.51</i>  | <i>0.39</i>                            | <i>0.017</i>       |
| <i>CV</i>                  | <i>8%</i>                              | <i>11%</i>   | <i>2.8%</i>                            | <i>5.6%</i>  | <i>8.9%</i>                            | <i>3.0%</i>        |
| <i>LSD</i>                 | <i>7.4</i>                             | <i>n.s.</i>  | <i>9.9</i>                             | <i>n.s.</i>  | <i>n.s.</i>                            | <i>0.25</i>        |

In 2025, similar experiments were conducted at Douglas and Minyip using a tyne seeder with twin-shoot seed and fertiliser boots that could separate seed and fertiliser more reliably. An additional split treatment placed 50% of the fertiliser with the seed and applied the remaining 50% to the soil surface after sowing.

At Douglas, placing 80 or 120 kg MAP/ha with the seed reduced plant density by an average of 55% compared with below-seed or surface application ( $P < 0.05$ , Table 5). The split treatment also reduced plant density, although less severely. The prolonged dry period between sowing and germination likely increased the risk of fertiliser toxicity. At Minyip, where rainfall occurred within eight days of sowing, fertiliser rate and placement did not significantly affect plant density.

At Douglas, the lower plant density caused by MAP placed with the seed did not significantly reduce canola yield in line with the observation that yield was not strongly responsive to plant density at this site (Table 4). At Minyip, the opposite pattern occurred. Fertiliser placement had little effect on establishment, but yield differed significantly ( $P < 0.05$ ). The Minyip soil had lower Colwell P (22 mg/kg) and high phosphorus buffering capacity (PBI 150), increasing the likelihood of a phosphorus response.

In this situation, applying phosphorus only to the soil surface, or reducing the rate placed near the seed and surface applying the remainder, reduced yield. These results reinforce the importance of placing P fertiliser close to the seed and show that these decisions need to balance seed safety with early phosphorus availability. The best placement option will depend on machinery configuration, sowing moisture and soil P-responsiveness.

### **Can excessive press-wheel pressure affect seeding depth or emergence of canola?**

Variation in press-wheel pressure had limited impact on canola establishment across sites and seasons. Higher press-wheel pressure increased downforce at the furrow surface, but did not produce deeper seed placement or improve plant density or yield under the conditions tested. Attempts to sow deeper were largely limited by dry soil conditions, with most seed remaining shallow regardless of press-wheel setting. Key findings from the press-wheel experiments were:

- Press-wheel pressure had no significant effect on final plant density or canola yield across experiments.
- Increasing press-wheel pressure increased measured downforce at the furrow surface, but did not result in deeper seed placement.
- Targeting deeper sowing depths produced only small increases in actual seed depth, with most seed placed about 10 to 15 mm from the soil surface.
- Dry soil conditions limited the ability to achieve deeper sowing, regardless of press-wheel setting or seeding configuration.

- Small differences in seeding depth had little effect on emergence, establishment or yield, although deeper targets slightly delayed emergence at Douglas in 2024.

Press-wheels are an important part of modern no-till farming systems because they improve seed-soil contact and consolidate the seedbed. However, excessive pressure can form deep furrows, alter seeding depth and increase soil strength above the seed. This can be a risk for canola because it is an epigeal germinating species with a short hypocotyl. Field experiments were conducted at Douglas and Kalkee in 2024 and Douglas and Minyip in 2025 to test the interaction between press-wheel pressure, seeding depth and canola establishment.

All experiments were sown under dry soil conditions using a tyne seeder followed by spring-controlled press-wheels. Across the experiments, increasing target depth beyond 10 to 15 mm did not reliably place seed deeper, regardless of tyne depth or press-wheel pressure (Table 6, Figure 7). Targeting deeper placement increased measured depth at Douglas in 2024 and 2025 ( $P < 0.05$ ), but the increase was less than 5 mm and remained well below the target depth.

This was likely because dry soil limited tyne penetration and caused the seeding furrow to collapse ahead of the seed boot. As a result, canola seed was often caught closer to the soil surface rather than being placed at the base of the furrow.

**Table 6:** Measured sowing depth for canola sown at various target depths with varying press-wheel pressure applied. Plots targeting 'shallow' placement aimed to place seed at a depth of 15 mm, while in 2024 'deep' placement aimed for 30 mm and in 2025 this was increased to 40 mm following poor results in 2024. Values followed by different letters indicate significant differences ( $P < 0.05$ ) between mean values for a given target depth treatment. Differences between press-wheel settings were not significant ( $P > 0.05$ )

| Press-wheel setting     | Douglas 2024 |           | Kalkee 2024  |           | Douglas 2025 |           | Minyip 2025  |           |
|-------------------------|--------------|-----------|--------------|-----------|--------------|-----------|--------------|-----------|
|                         | Shallow (mm) | Deep (mm) | Shallow (mm) | Deep (mm) | Shallow (mm) | Deep (mm) | Shallow (mm) | Deep (mm) |
| Lifted (no pressure)    | 9.3          | 12.5      | 13.1         | 14.5      | 10.1         | 12.0      | 10.6         | 10.7      |
| Single spring (control) | 9.8          | 12.3      | 12.4         | 12.6      | 6.3          | 9.8       | 10.9         | 9.9       |
| Twin spring (high)      | 9.1          | 10.6      | 10.9         | 12.1      | 8.1          | 10.9      | 9.5          | 9.1       |
| Average                 | 9.4b         | 11.8a     | 12.1         | 13.1      | 8.2b         | 10.9a     | 10.3         | 9.9       |
| P-value                 | 0.007        |           | 0.435        |           | 0.033        |           | 0.133        |           |
| CV                      | 7.8%         |           | 3.2%         |           | 10.0%        |           | 2.2%         |           |
| LSD ( $P < 0.05$ )      | 1.6          |           | n.s.         |           | 2.5          |           | n.s.         |           |

Press-wheel pressure had no significant effect on seed depth, despite measurable differences in downforce at the furrow surface. A single spring applied downforce equivalent to 17 kg across a 75 mm press-wheel, while adding a second spring increased this to 25 kg, a 47% increase. Under the dry soil conditions tested, this additional pressure did not meaningfully change seed placement.

Across all four experiments, differences in plant density due to seeding depth or press-wheel pressure were small and not statistically significant ( $P > 0.05$ , data not shown). Yield differences were also minimal. The only exception was a trend towards delayed emergence from deeper sowing at Douglas in 2024 ( $P = 0.096$ ), where targeting 30 mm resulted in an average of 58 days to complete emergence compared with 54 days for the 15 mm target depth.



**Figure 7:** Image showing differences in sowing depth for canola targeting 'deep' sowing (top) and 'shallow' sowing (bottom) at Douglas in 2025. Dot spacing equal to 1 cm has been added to provide perspective

### Is there an optimal stubble load for establishment of canola in the Wimmera?

Field experiments over three years showed no consistent relationship between stubble load and canola establishment under the conditions tested. Stubble influenced establishment risk through effects on seedbed moisture, residue distribution and machinery performance, but the size and direction of these effects varied with season and seeder type. The practical implication from these trials is that stubble management should be based on establishment risk and machinery capability, rather than a fixed stubble load threshold.

- There was no consistent relationship between total stubble load and canola establishment across seasons.
- Burning or removing stubble did not consistently improve establishment or yield.

- Retained stubble improved seedbed moisture in some situations but could create seeding constraints where residue distribution or stubble height interfered with machinery operation.
- Stubble effects depended on seeder type, soil moisture, residue distribution and seasonal conditions.
- Stubble management should be based on machinery capability and establishment risk, not a fixed stubble load threshold.

Cereal stubble can affect canola establishment by blocking the soil surface, increasing hair-pinning, disrupting seed placement and creating habitat for pests. It can also interact with pre-emergent herbicides. These risks help explain why burning, cultivation and other stubble interventions are commonly used before canola in parts of the Wimmera. However, many growers can establish canola successfully under retained stubble. The key question is how to manage establishment risk without defaulting to residue removal.

From 2023 to 2025, field experiments at Douglas tested a range of stubble management practices. Stubble loads were closely linked to the yield potential of the preceding wheat crop. Total residue after harvest averaged 4.8 t/ha in 2023, 5.4 t/ha in 2024 and 4.3 t/ha in 2025 (Figure 8). Residue distribution varied between standing stubble and chaff, depending on harvest height and post-harvest treatment. Burning also varied between seasons. In 2023, cool burning conditions left significant unburnt chaff on the soil surface, while in 2024 burning removed nearly all residue.

The highest residue load was recorded in 2023 where additional stubble was spread across plots. This increased total residue to 7 t/ha, with 88% present as surface chaff. Stubble height also affected residue flow through seeding equipment. Harvesting wheat at the highest setting produced standing stubble heights averaging 37 cm, compared with 24 cm under standard harvest height.

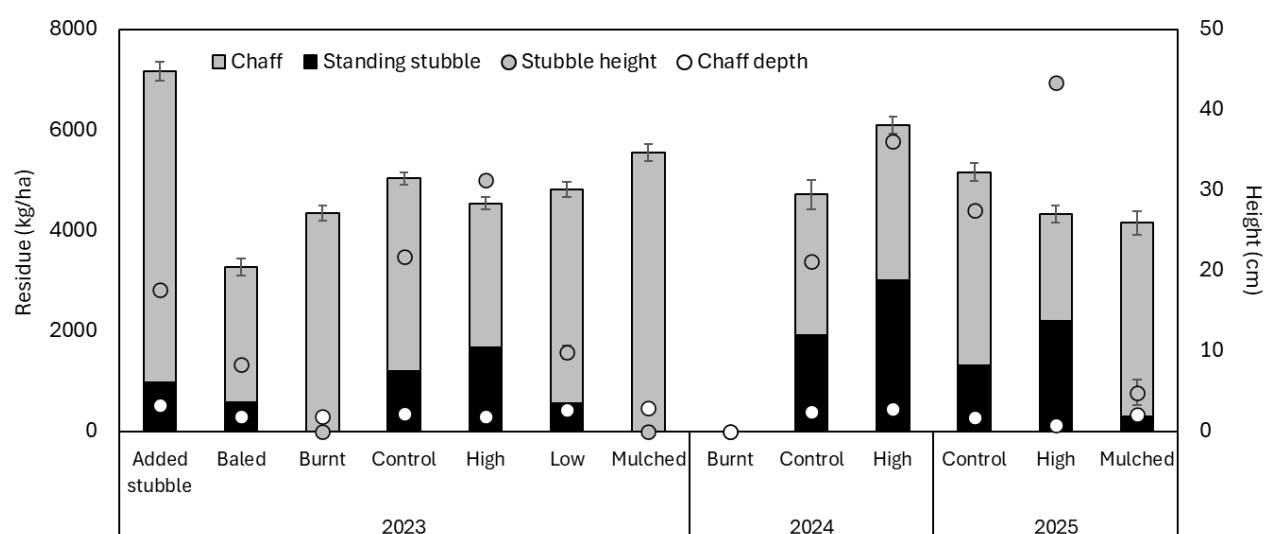


**Figure 8:** Stubble load for plots under varying stubble management strategies prior to sowing at Douglas in 2023, 2024 and 2025. Error bars indicate the standard error of the mean for each treatment and stubble load is divided into standing stubble and chaff. Height of standing stubble and depth of chaff values are also presented

In 2023, seedbed moisture was measured across multiple stubble treatments. Two days after sowing, soil moisture was significantly higher where additional stubble had been spread or where stubble had been mulched, compared with baled or burnt treatments ( $P < 0.05$ , Table 7). This shows that retained surface residue can improve moisture retention and potentially support more timely establishment when soil water is limiting.

**Table 7:** Seedbed soil moisture content (sampled to a depth of 0-0.03 m) following time of sowing one at Douglas in 2023. Letters indicate significant differences between treatments ( $P < 0.05$ )

| Stubble treatment  | Seedbed soil moisture (mm) |
|--------------------|----------------------------|
| Added stubble      | 6.8 <sup>a</sup>           |
| High cut           | 5.9 <sup>b</sup>           |
| Regular cut        | 5.9 <sup>b</sup>           |
| Low cut            | 5.9 <sup>b</sup>           |
| Stubble baled      | 4.7 <sup>c</sup>           |
| Stubble burnt      | 4.9 <sup>c</sup>           |
| Stubble mulched    | 6.4 <sup>ab</sup>          |
| LSD ( $P < 0.05$ ) | 0.7                        |

Soil temperature was also monitored during crop establishment in 2023. Burnt plots were generally 1 to 2 °C warmer during the middle of the day than retained stubble treatments, likely due to reduced shading and greater heat absorption from blackened residue and exposed soil. This may support faster emergence, but any benefit was likely offset by lower soil moisture in the burnt treatments.

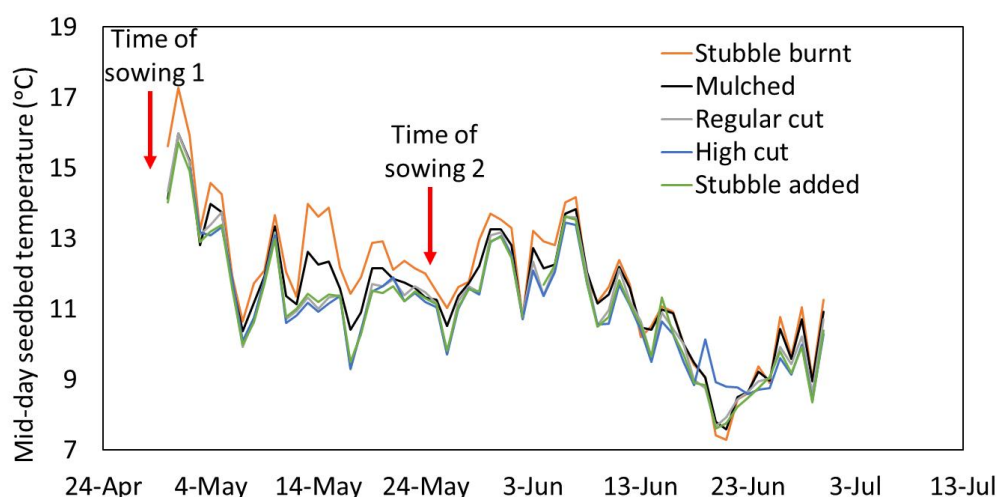


**Figure 9:** Seedbed soil temperature (0-0.03 m) measured daily at 12 pm prior to and following the sowing period for three replicates of selected stubble treatments at Douglas in 2023

Across the three years of stubble management trials at Douglas, the relationship between stubble load and canola establishment was weak, whether measured as total above-ground residue or chaff on the soil surface (Figure 10). Burning did not guarantee strong establishment, and retained stubble did not consistently reduce establishment. Outcomes were influenced by soil moisture, residue distribution, seeder type and spatial variability within plots.

The best establishment in these trials was generally achieved where the seeder could manage the residue present, maintain consistent seed placement and avoid excessive chaff or standing stubble interference. In these experiments, this was most often achieved with a tyne seeder where chaff was limited and stubble height was below 30 cm, allowing effective inter-row sowing. The amount of residue that can be managed will differ between machines, operators, soil conditions and seasons.

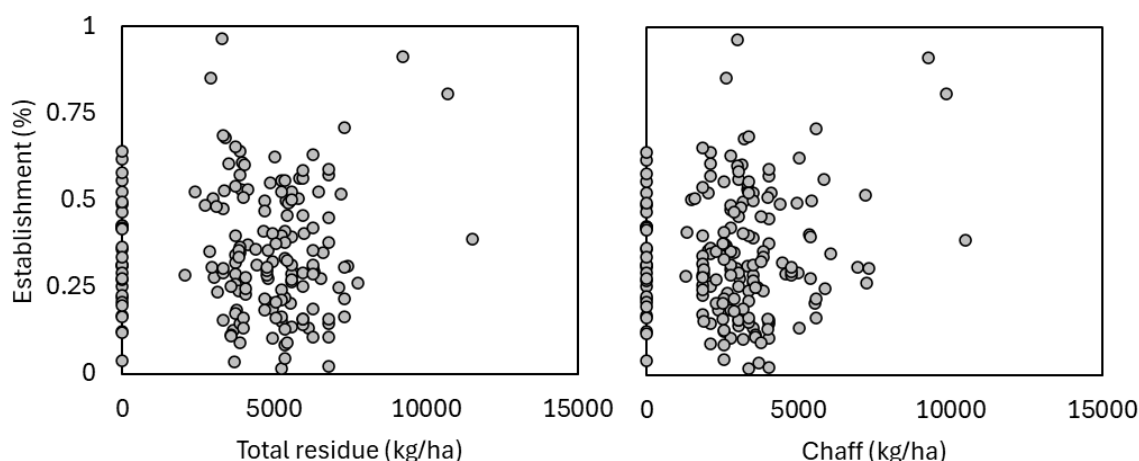


**Figure 10:** Relationship between canola establishment and total residue (standing stubble and chaff, left) and chaff residue (right) for plots sown at Douglas between 2023 and 2025

Although stubble load had limited direct impact on establishment, other factors influenced the rate of canola emergence. In 2023, comparisons were planned between tyne and disc-based seeders across two sowing times. The prototype disc seeder was impacted by poor seed metering in the first year, so those treatments were removed from analysis. For the tyne seeder, earlier sowing led to faster establishment (Figure 11). Soil temperatures were similar at sowing, but conditions cooled after the second sowing time, likely slowing emergence. The slightly warmer soil in burnt plots did not translate into a meaningful emergence response.

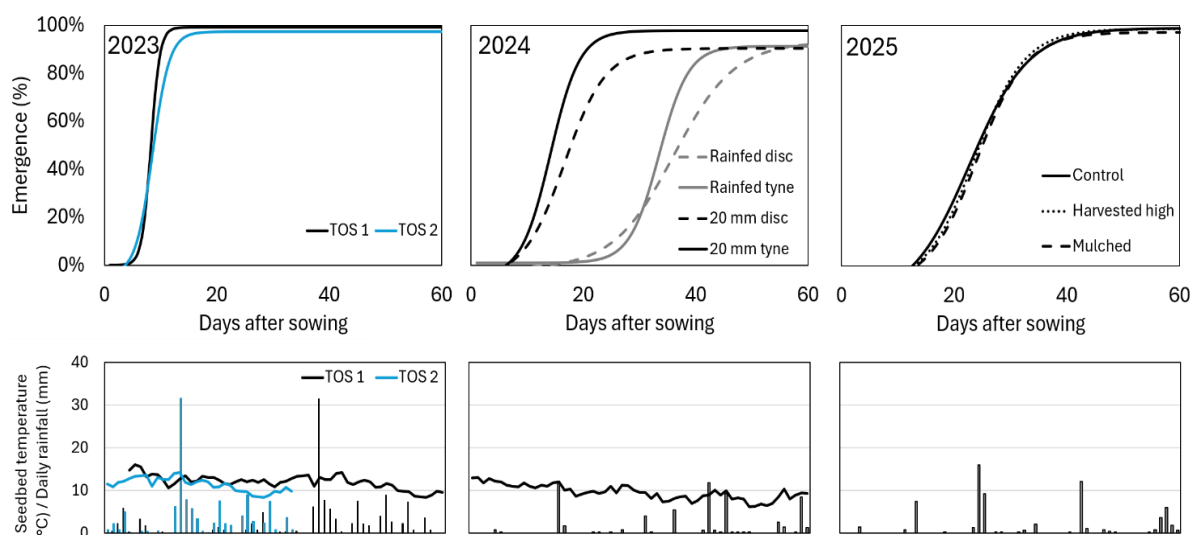


**Figure 11:** Results of logistic regression between days after sowing and establishment as a proportion of final plant density for treatments where significant differences were observed at Douglas in 2023, 2024 and 2025 (top) and corresponding daily rainfall and soil temperature over the same period (bottom)

In 2024, stubble treatment again had limited effect on the rate of canola emergence, while irrigation timing and seeder type influenced emergence rate (Figure 11). Plots that received 20 mm of irrigation after sowing completed emergence in about 20 days, compared with 35 to 45 days for rainfed plots. Emergence was also faster under the tyne seeder than the disc seeder. This may have reflected small differences in seed placement or the ability of the tyne furrow to direct water into the seedbed more effectively. In 2025 neither stubble treatment or seeder type impacted the rate of canola emergence.

At Douglas in 2023, final plant density was not significantly affected by stubble treatment or time of sowing ( $P=0.08$  and  $P=0.742$ , respectively). There was a trend towards lower plant density where additional stubble had been applied or where wheat had been harvested at low height (10 cm; Figure 8, Table 8). Stubble treatment and time of sowing also did not significantly affect yield, although there was a trend towards higher yield from the first sowing time ( $P=0.156$ ) and lower yield where stubble had been burnt ( $P=0.075$ ).

**Table 8:** Effect of stubble treatment on plant density and yield of canola sown using a knife-point tyne-based seeder at Douglas in 2023

| Stubble treatment              | Plant density (plants/m <sup>2</sup> ) |       |         | Yield (t/ha) |       |         |
|--------------------------------|----------------------------------------|-------|---------|--------------|-------|---------|
|                                | TOS 1                                  | TOS 2 | Average | TOS 1        | TOS 2 | Average |
| Added stubble                  | 24.7                                   | 31.8  | 28.2    | 4.11         | 3.70  | 3.90    |
| Baled                          | 52.5                                   | 41.9  | 47.2    | 3.75         | 3.90  | 3.82    |
| Burnt                          | 44.2                                   | 31.9  | 38.1    | 3.36         | 2.84  | 3.10    |
| Control                        | 29.7                                   | 40.6  | 35.1    | 4.24         | 3.91  | 4.10    |
| High                           | 35.0                                   | 34.7  | 34.9    | 3.74         | 3.40  | 3.57    |
| Low                            | 21.1                                   | 31.4  | 26.3    | 4.12         | 4.37  | 4.25    |
| Mulched                        | 33.7                                   | 38.1  | 35.9    | 4.30         | 3.72  | 4.01    |
| Average                        | 34.4                                   | 35.8  | -       | 3.94         | 3.69  | -       |
|                                |                                        |       |         |              |       |         |
| <i>P-value (TOS)</i>           | <i>0.742</i>                           |       |         | <i>0.156</i> |       |         |
| <i>LSD (P&lt;0.05, TOS)</i>    | <i>n.s.</i>                            |       |         | <i>n.s.</i>  |       |         |
| <i>P-value (Stubble)</i>       | <i>0.08</i>                            |       |         | <i>0.075</i> |       |         |
| <i>LSD P&lt;0.05, Stubble)</i> | <i>n.s.</i>                            |       |         | <i>n.s.</i>  |       |         |

In 2024, final plant density in rainfed canola was affected more by seeding system than by stubble treatment. The disc seeder produced significantly lower plant density than the tyne seeder, averaging 14 plants/m<sup>2</sup> compared with 32 plants/m<sup>2</sup> ( $P<0.05$ , Table 9). This was likely linked to fertiliser toxicity risk in the disc seeder treatments under dry sowing conditions, as discussed in the fertiliser placement section. Yield was also lower in the disc-sown treatments, consistent with the critical plant density thresholds established at this site.

Stubble treatment also affected yield in 2024, despite limited differences in plant density. Plots with high standing stubble had yield reductions of up to 22% compared with burnt plots ( $P < 0.05$ , Table 9). This response differed from 2023, when stubble treatment did not significantly affect plant density or yield.

**Table 9:** Effect of stubble treatment and seeder type on plant density and yield of rainfed canola grown at Douglas in 2024. Values followed by different letters indicate significant differences ( $P < 0.05$ ) when comparing seeding system and/ or stubble management treatments

| Stubble treatment                | Plant density (plants/m <sup>2</sup> ) |                   |             | Yield (t/ha)      |                   |                   |
|----------------------------------|----------------------------------------|-------------------|-------------|-------------------|-------------------|-------------------|
|                                  | Disc                                   | Tyne              | Average     | Disc              | Tyne              | Average           |
| Burnt                            | 13.4                                   | 36.9              | 25.1        | 3.49              | 3.78              | 3.63 <sup>a</sup> |
| Control                          | 18.1                                   | 22.6              | 20.3        | 3.24              | 3.63              | 3.44 <sup>a</sup> |
| High                             | 11.8                                   | 36.5              | 24.1        | 2.47              | 3.20              | 2.83 <sup>b</sup> |
| Average                          | 14.4 <sup>b</sup>                      | 32.0 <sup>a</sup> | -           | 3.07 <sup>b</sup> | 3.54 <sup>a</sup> | -                 |
|                                  |                                        |                   |             |                   |                   |                   |
| <i>P-value (averages)</i>        | <i>&lt;0.001</i>                       |                   | <i>0.41</i> | <i>0.019</i>      |                   | <i>0.036</i>      |
| <i>LSD (P&lt;0.05, averages)</i> | <i>3.9</i>                             |                   | <i>n.s.</i> | <i>0.37</i>       |                   | <i>0.58</i>       |

In 2024, irrigation timing had limited effect on plant density, and there was no clear interaction between irrigation timing and seeder (Table 10). Although disc seeders are often considered less suited to wet soil conditions, applying 20 mm of irrigation before sowing did not reduce establishment compared with irrigation after sowing under the otherwise dry conditions tested at Douglas. Seeder type still had a significant effect on plant density, with some improvement where residue managers were added to the disc seeder. These plant density differences were large enough to reduce yield, again aligning with the critical plant density results from the same site.

**Table 10:** Effect of sowing irrigation timing and seeder type on plant density and yield of canola grown at Douglas in 2024. Values followed by different letters indicate significant differences ( $P < 0.05$ ) when comparing seeder type

| Sowing irrigation               | Plant density (plants/m <sup>2</sup> ) |                   |                         | Yield (t/ha)      |                   |                         |
|---------------------------------|----------------------------------------|-------------------|-------------------------|-------------------|-------------------|-------------------------|
|                                 | Disc                                   | Tyne              | Disc w/ residue manager | Disc              | Tyne              | Disc w/ residue manager |
| 20 mm pre-sowing                | 18.6                                   | 34.0              | 19.6                    | 3.39              | 3.92              | 3.82                    |
| 20 mm post-sowing               | 13.2                                   | 27.8              | 19.2                    | 3.21              | 3.68              | 3.61                    |
| Average                         | 15.9 <sup>b</sup>                      | 30.9 <sup>a</sup> | 19.4 <sup>b</sup>       | 3.30 <sup>b</sup> | 3.80 <sup>a</sup> | 3.71 <sup>a</sup>       |
|                                 |                                        |                   |                         |                   |                   |                         |
| <i>P-value (average)</i>        | <i>&lt;0.001</i>                       |                   |                         | <i>0.001</i>      |                   |                         |
| <i>LSD (P&lt;0.05, average)</i> | <i>4.7</i>                             |                   |                         | <i>0.27</i>       |                   |                         |

Results at Douglas in 2025 differed from previous seasons, with a significant interaction between seeder type and stubble management on plant density ( $P < 0.05$ , Table 11). The tyne seeder generally produced higher plant densities than the disc seeder. However, this advantage was reduced where stubble was harvested high or mulched, with plant density falling from 33.1 plants/m<sup>2</sup> under the control treatment to 21.1 to 22.9 plants/m<sup>2</sup>. This suggests that tall standing stubble increased machinery interference, while mulched stubble may have increased chaff load in the furrow. These plant density differences did not significantly affect yield, consistent with the limited yield response to plant density at this site in 2025.

**Table 11:** Effect of stubble management and seeder type on plant density and yield of canola sown at Douglas in 2025. Values followed by different letters indicate significant differences ( $P < 0.05$ ) when comparing the interaction of stubble management and seeder type

| Stubble treatment                 | Plant density (plants/m <sup>2</sup> ) |                    |                               | Yield (t/ha) |      |                               |
|-----------------------------------|----------------------------------------|--------------------|-------------------------------|--------------|------|-------------------------------|
|                                   | Disc                                   | Tyne               | Disc w/<br>residue<br>manager | Disc         | Tyne | Disc w/<br>residue<br>manager |
| Control                           | 14.5 <sup>cd</sup>                     | 33.1 <sup>a</sup>  | 9.7 <sup>d</sup>              | 2.26         | 2.27 | 2.24                          |
| High                              | 12.1 <sup>d</sup>                      | 21.1 <sup>bc</sup> | 16.7 <sup>bcd</sup>           | 2.14         | 2.33 | 2.29                          |
| Mulched                           | 14.9 <sup>cd</sup>                     | 22.9 <sup>b</sup>  | 12.4 <sup>d</sup>             | 2.05         | 2.52 | 2.03                          |
|                                   |                                        |                    |                               |              |      |                               |
| <i>P-value (Stubble × Seeder)</i> | 0.026                                  |                    |                               | 0.7          |      |                               |
| <i>LSD (P&lt;0.05)</i>            | 7.9                                    |                    |                               | n.s.         |      |                               |

## CONCLUSIONS

The surveyed Wimmera paddocks generally achieved commercially acceptable canola establishment, including under retained stubble. Where establishment was poor, the problem was usually patchiness, bare areas and uneven emergence, not whole-paddock failure. Stubble load alone did not explain establishment, and burning or removing stubble did not consistently improve outcomes in the trials. Stubble can affect establishment, but the effect is driven by residue distribution, stubble height, soil moisture, pest pressure, machinery setup and seasonal conditions. The clear conclusion is that growers should manage establishment risk, not chase a fixed stubble load threshold.

Target plant density is a practical starting point for managing establishment risk. Across the project, 20 to 30 plants/m<sup>2</sup> supported strong yield potential, with the upper end of this range preferred where establishment risk is high. Field establishment was often less than 50% of viable seed sown, particularly where the autumn break was delayed and seed remained in dry soil for two to three weeks before germination. These dry sowing conditions increased the risk of poor establishment and fertiliser toxicity.

Fertiliser placement was an establishment risk. Placing typical rates of MAP with canola seed reduced establishment, especially under dry sowing. However, moving phosphorus too far from the seed reduced yield in P-responsive soils. This creates a clear trade-off between seed safety and early phosphorus supply. The right placement strategy depends on machinery configuration, sowing moisture and soil P status.

Machinery setup mattered, but no single machine setting solved establishment risk. Changing press-wheel pressure and targeting deeper sowing under dry soil conditions did not reliably place seed deeper or improve emergence, plant density or yield. In the plot-scale experiments, a tyne-based seeder generally produced higher plant densities than the prototype single-disc seeder, likely because seed and fertiliser separation was better under dry conditions. The project does not support blanket advice that one machine type will always manage heavy stubble better than another.

For on-farm decisions, stubble load can be estimated from the previous crop yield using a harvest index calculation, where grain yield represents about 40% of total biomass. This should be combined with a paddock assessment of lodging, residue distribution, stubble height and chaff load. Growers and advisers can then consider whether the seeder is likely to maintain residue flow, consistent seed placement and adequate seed and fertiliser separation. Where this is unlikely, targeted interventions such as grazing, mechanical residue management or strategic burning may be warranted.

## Recommendations for growers and advisers based on these trials

- Target 20 to 30 plants/m<sup>2</sup>, using the upper end where establishment risk is high.
- Treat burning as a targeted intervention, not a default response to high stubble loads.

- Assess stubble load, lodging, residue distribution, stubble height and chaff load before sowing canola.
- Match stubble management to machinery capability, especially residue flow, seed placement and seed and fertiliser separation.
- Avoid placing MAP with the canola seed under dry sowing conditions where practical, while maintaining adequate early phosphorus supply in P-responsive soils.
- Check establishment after emergence and use measured plant density to refine future seed rates, stubble management and machinery setup.

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