Annual Results Report

2023

Canola Establishment in the Low Rainfall Zones of the Western Region

Project code:	LIV2112-001SAX
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REPORT SENSITIVITY

Does the report have any of the following sensitivities?

Intended for journal publication	YES ☐ NO ☒
Results are incomplete	YES ☐ NO ☒
Commercial/IP concerns	YES ☐ NO ☒
Embargo date	YES ☐ NO ☒ If Yes, Date: <Choose date>

KEY MESSAGES

1. The placement of the seed relative to soil moisture and soil temperature conditions at sowing during 2023 and 2023 seasons had the largest influence on canola establishment across the low rainfall zones of WA. Delaying sowing to avoid exposing the canola seed and seedlings to high temperatures and placing the seed shallow in the soil profile above soil moisture in North Mallee (2023), Merredin (2022), Morawa (2022 and 2022), and Yuna (2023) maximised canola establishment, with a follow up rainfall event.
2. Grading open pollinated seed to above 1.8 mm was shown to improve canola establishment on a sandy soil type in North Mallee (2023), however, did not influence canola establishment in Merredin (2022) or Holt Rock (2023) on heavier soil types where soil moisture was present at seeding.
3. Fertilizer placement was shown to influence canola establishment at Cunderdin with the increased separation UAN below the seed associated with improved establishment.
4. The use of 25 cm row spacing (compared to 75 cm spacing) maximised canola establishment rates at Southern Cross.
5. The addition of SACOA SE14 soil wetter did not significantly influence canola establishment in any of the nine trials in which it was tested. However, good soil moisture was present at sowing for majority of the trials and subsequently the influence of soil wetters on canola establishment requires further research in varying seasons.
6. Besides the two trials at Yuna in 2023, none of the trials experienced a dry season start for seeding. Further canola establishment research is required to better understand how to avoid large canola establishment failures in unfavourably dry sowing conditions.

SUMMARY

Across the 2022 and 2023 seasons, Living Farm conducted 14 canola establishment trials as part of the GRDC funded Canola Establishment in the Low Rainfall Zones (LRZ) of the Western Region Project (Project Code: LIV2112-001SAX). The trials aimed to target location specific treatments that would maximise canola establishment and evaluated the ease and limitations of implementation for local growers. A collaborative approach was developed for the project in which nine grower groups from across the LRZs of WA were asked to participate in surveys, workshops and in person field walks to achieve project outcomes. The survey results of the project highlighted sowing conditions (soil moisture and soil temperature), seeding depth and soil type as the major constraints of establishing a successful canola crop in the LRZs. From the small plot trials, several treatments were shown to maximise canola establishment. These included sowing shallow, delaying sowing to mid-late April in Northern regions to reduce seed exposure to high soil temperatures and using low rates of UAN placed at depth below the seed to reduce fertiliser toxicity. The addition of soil wetters was the most popular preferred treatment across all grower groups and therefore was included in nine or the fourteen trials. However, the addition of SACOA SE14 soil wetter was shown to have no significant impact on canola establishment when placed with the seed.

BACKGROUND

Successfully establishing a competitive canola crop remains a prevalent issue for canola producers in the low and medium rainfall zones (LRZs and MRZs) of WA, with grower reports of up to 50%

establishment failure when canola is sown dry or into a drying profile at the 2021 GRDC National Grower Network Forums. While yield penalties are the obvious outcome of poor establishment, other economic and agronomic factors such as loss of expensive hybrid seed, reduced canopy closure, and the need for resowing are also problematic. Previous research has explored a range of treatments which affect canola establishment including canola genetic traits (hypocotyl length and seed size), agronomic practices such as seeding depth and nutrient availability and environmental impact such as soil moisture at sowing (Nelson, 2022). Despite this research, the causes of poor canola establishment in the LRZs and MRZs in WA, appear to spatially and temporary vary from year to year.

The primary objective of this project was to provide growers with the locally specific agronomic knowledge to avoid large canola establishment failures in potentially challenging seasonal conditions. Specifically, this trial work provides growers the opportunity to engage in agronomic trial research, and potential management options that will assist in decision making related to establishing a canola crop. To achieve this project outcome, fourteen small plot trials were conducted across the 2022 and 2023 seasons. The trials aimed to target location specific treatments that were determined through engagement with nine Grower Growers through surveys, workshops and field walks.

Canola is a risky crop for growers in the LZRs of WA, with high input costs and high risk of crop failure in a poor season. However, as opposed to other break crop options, such as lupins, canola offers a range of benefits including improved cereal weed and disease control, in addition to higher prices. Subsequently, improving the confidence of growers located in the LRZs of WA to produce a successful canola crop is imperative.

OBJECTIVES

The project objective is to validate and extend previous agronomic and management research on how to successfully establish canola in the low rainfall zones of WA, as well as including feedback on what has/has not worked for growers through a series of field trial demonstrations and extension. By the conclusion of the project in March 2024, 60% of canola growers in the low rainfall zones of the Western Region will have access to the agronomic knowledge to improve the establishment and germination rates of canola.

Specifically, the project aims to:

1) Provide trial data and visual evidence of treatments that maximize canola establishment
2) Evaluate the ease of implementation of the treatments
3) Discuss and assess possible limitations to grower operation.

METHODS

Trial Design

A total of 14 trials were conducted as part of the project across nine locations in the low rainfall zones of WA with nine grower groups. The trials were arranged in a randomised complete block design and included three or four replicates. Each trial was limited to three factors with a maximum of 12

treatments to allow for clear results and robust statistical analysis. Due to the seeding and maintenance equipment limitations, seeding depth and soil wetter placement was not randomised within ranges, however, was randomised within replicates. All trial designs were submitted and approved by the Analytics for the Australian Grains Industry (SAGI/AAGI) prior to sowing. The trials were sown, maintained and harvested using small plot research equipment. An overview of the location, season, grower group, trial seeding conditions, target plant density and harvest date are provided in Table 1.

Table 1. Summary of Trial locations, Grower Group, sowing conditions and harvest date.

Trial	Year	Nearest Town	Grower Group	Target Plant Density *	Trial Variety	Sowing Date	Soil Moisture at Sowing (Depth) **	Harvest Date
1	2022	Morawa	MFIG	15 plants/m^2 30 plants/m^2	Nuseed Emu TF	TOS1: 6th Apr TOS2: 7th May	TOS1: Good (0.5 cm) TOS2: Fair (3.5 cm)	28th Oct
2		Merredin	MADFIG	40 plants/m^2	Nuseed HyTTec Trident Nuseed ATR Bonito	21st Apr	Fair (2.5 cm)	N/A
3		Cunderdin	ORG	40 plants/m^2	Nuseed Emu TF	19th Apr	Fair (1 cm)	23rd Oct
4	2023	Bruce Rock	BRLCDC	25 plants/m^2	Nuseed Raptor TF	TOS1: 13th Apr TOS2: 28th Apr	TOS1: Good (1 cm) TOS2: Excellent (0.5 cm)	20th Oct
5		Holt Rock	HRG	25 plants/m^2	Nuseed ATR Bonito	11th Apr	Excellent (0 cm)	26th Oct
6		Merredin	MADFIG	15 plants/m^2 25 plants/m^2	Nuseed Raptor TF	3rd Apr	Good (0.5 cm)	18th Oct
7		Merredin	MADFIG	25 plants/m^2	Nuseed Emu TF BASF InVigor 4022P	TOS1: 4th Apr TOS2: 25th Apr	TOS1: Good (0.5 cm) TOS2: Fair (3 cm)	18th Oct
8		Morawa	MFIG	15 plants/m^2 30 plants/m^2	Nuseed Emu TF	TOS1: 6th Apr TOS2: 28th Apr	TOS1: Fair (2.5 cm) TOS2: Poor (>5 cm)	28th Oct
9		North Mallee	NMFIG	30 plants/m^2	Nuseed ATR Bonito	TOS1: 12th Apr TOS2: 27th Apr	TOS1: Excellent (0 cm) TOS2: Excellent (0 cm)	24th Oct
10		North Mallee	NMFIG	30 plants/m^2	Nuseed ATR Bonito	TOS1: 12th Apr TOS2: 26th Apr	TOS1: Good (0.5 cm) TOS2: Excellent (0 cm)	24th Oct
11		Quairading	QSG	20 plants/m^2 40 plants/m^2	BASF InVigor R 4520	TOS1: 6th Apr TOS2: 4th May	TOS1: Excellent (0 cm) TOS2: Good (0.5 cm)	1st Nov
12		Southern Cross	FEAR	10 plants/m^2 20 plants/m^2 30 plants/m^2	Nuseed HyTTec Trident Nuseed ATR Bonito	5th Apr	Good (0.5 cm)	18th Oct
13		Yuna	YFIG	30 plants/m^2	Pioneer 44Y27	5th Apr	Fair (2 cm)	25th Oct
14		Yuna	YFIG	15 plants/m^2 30 plants/m^2	BASF InVigor 4022P	TOS1: 5th Apr TOS2: 27th Apr	TOS1: Good (1.5 cm) TOS2: Fair (4 cm)	25th Oct

* Target plant density was determined grower and local agronomist feedback. Where there were two target plant densities, both times of sowing had two sowing rates.

** Soil moisture at sowing classification refers to the depth soil moisture was present e.g. (excellent = surface-0.5 cm, good = 0.5-2 cm, fair = 2-5 cm, poor = >5 cm).

A collaborative approach was developed for the project to ensure locally relevant canola establishment issues were identified and addressed within the small plot trials. The participating nine Grower Groups were encouraged to drive treatment and site selection through interactive pre-seeding workshops and online and in-person surveys across the 2022 and 2023 seasons. These surveys were executed via two different platforms (Survey Monkey and Mentimeter) to optimise the response of growers within each grower group, and to increase overall grower engagement. Within surveys, growers were asked to articulate if they had experienced poor establishment of canola within the last

five years, and if so, to suggest the factors they believe may be contributing to this issue. In conjunction with the survey and workshop results, the knowledge of a canola advisory group composed of leading canola researchers and consultants was also utilised to develop relevant treatment lists for each location. The final treatment lists are presented in Table 2.

Table 2. 2022 and 2023 site treatment lists.

Site #	Year	Nearest town	Treatment	Variable 1	Variable 2	Variable 3
1	2022	Morawa	Seeding Depth (cm)	1-1.5	3-4	N/A
			Seeding Rate (plants/m^2)	15	30	N/A
			Time of Sowing	6th April	7th May	N/A
2		Merredin	Canola Type	Hybrid	OP	N/A
			Seed Size (mm)	Mixed	>1.8	N/A
			Soil Wetter	+ SE14	- SE14	N/A
3		Cunderdin	Pre-em Propyzamide Herbicide	+ PPZ	- PPZ	N/A
			UAN Placement (cm)	0	1.5	3-4
			Soil Wetter	+ SE14	- SE14	NA
4	2023	Bruce Rock	UAN Placement (cm)	0 cm	3-4 cm	N/A
			Soil Wetter	+ SE14	- SE14	N/A
			Time of Sowing	13th Apr	28th Apr	N/A
5		Holt Rock	UAN Placement (cm)	0	3-4	N/A
			Seed Size (mm)	Mixed	>1.8	N/A
			Soil Wetter	+ SE14	- SE14	N/A
6		Merredin SR	Seeding Depth (cm)	1-1.5	3-4	N/A
			Seeding Rate (plants/m^2)	15	30	N/A
			Soil Wetter	+ SE14	- SE14	N/A
7		Merredin TOS	Seeding Depth (cm)	1-1.5	3-4	N/A
			Time of Sowing	4th April	25th April	N/A
			Variety	Emu	4022P	N/A
8		Morawa	Seeding Depth (cm)	1-1.5	3-4	N/A
			Seeding Rate (plants/m^2)	15	30	N/A
			Time of Sowing	6th Apr	27th Apr	N/A
9		North Mallee (H)	Seed Size (mm)	Mixed	>1.8	N/A
			Time of Sowing	12th Apr	26th Apr	N/A
			UAN Placement (cm)	0	3-4	N/A
10		North Mallee (L)	Seed Size (mm)	Mixed	>1.8	N/A
			Soil Wetter	+ SE14	- SE14	N/A
			Time of Sowing	6th Apr	26th Apr	N/A
11		Quairading	Seeding Rate (plants/m^2)	20	40	N/A
			Soil Wetter	+ SE14	- SE14	N/A
			Time of Sowing	6th Apr	4th May	N/A
12		Southern Cross	Canola Type	Hybrid	OP	N/A
			Row Spacing (cm)	25	75	N/A
			Seeding Rate (plants/m^2)	10	20	30
13		Yuna (H)	Soil Wetter	+ SE14	- SE14	N/A
			UAN Placement (cm)	0	3-4	N/A
			UAN Rate (L/ha)	15	30	N/A
14		Yuna (L)	Seeding Rate (plants/m^2)	15	30	N/A
			Soil Wetter	+ SE14	- SE14	N/A
			Time of Sowing	5th Apr	27th Apr	N/A

Assessments

To understand the influence of the treatment factors on canola establishment and to develop clear and relevant data interpretable to growers, assessments including seedling density, hypocotyl length, canopy cover and yield were taken at each site.

Seedling counts were completed at 14 days (50% emergence) and 28 days (100% emergence) after sowing, with measurement of hypocotyl completed prior to the 2-leaf stage. Two replicates of five whole plants (including intact root system) were randomly sampled for each depth treatment and the coleoptile length was accurately measured for each plant to determine the average sowing depth achieved. Aerial imagery was utilised to monitor crop biomass and whole plot canopy cover which provided non-biased assessments of treatment outcomes appropriate for statistical analysis and also provided visual results for stakeholders who were unable to visit the trial in person. Each plot was harvested using a small plot research header with individual grain weights collected from each plot to calculate yield.

Data and Statistical Analysis

In season data was collated using Microsoft Excel with statistical analysis completed using the statistical analysis software R Studio. To present clear interpretable results showcasing statistically significant treatments for growers, the factors were treated as independent and one-way Analysis of Variance (ANOVA) analysis was performed.

Extension

Level of grower engagement was assessed with the use pre-seeding surveys, field walk attendance and field walk surveys. Living Farm utilised a variety of communication pathways to deliver project outcomes and effectively engage with growers, agronomists and industry stakeholders. Pre-seeding workshops and surveys were conducted with growers to determine locally relevant treatments for each location within the low rainfall zones. Regular updates on trial progress such as seeding, assessments, field walks and harvest were shared on the social media platform Twitter, allowing growers and agronomists to keep up to date with the project. In-season field walks were conducted at each of the trial sites in partnership with participating grower groups. These field-based extension activities enabled growers to:

1. Visualise evidence of treatments that maximise canola establishment.
2. Evaluate the ease of implementation of treatments on farm.
3. Discuss and assess possible limitations with the implementation.
4. Develop the confidence to implement strategies to maximise canola establishment in their operation.

The information provided at the field-based extension events was also communicated via formal delivery methods to the local grower groups, either through annual trial results reports, or presentation trial information sessions during the summer. The results were also extended at the GRDC Regional Crop Updates in Bencubbin (2022) and Mukinbudin (2023) by Living Farm Research Scientist Chloe Rout. The project results were also presented on the GRDC podcast and were included in the Jan/Feb issue of Ground Cover. An overview of extension activities conducted, and the number of attendees is presented in Table 3.

Table 3. Extensions activities completed for the canola establishment project.

Date	Group	Event	Attendees
17/06/2022	MFIG	Field Walk	15
23/06/2022	ORG	Field Walk	19
27/06/2022	MADFIG	Field Walk	18
02/03/2023	MADFIG	Bencubbin Crop Updates	70
13/03/2023	HRG	Season Review	30
06/06/2023	QSG	Field Walk	23
12/06/2023	MFIG	Field Walk	30
14/06/2023	HRG	Field Walk	21
16/06/2023	NMFIG	Field Walk	14
21/06/2023	MADFIG	Field Walk	32
27/06/2023	YFIG	Field Walk	30
30/06/2023	FEAR	Field Walk	7
26/07/2023	BRLCDC	Field Walk	21
09/08/2023	NA	GRDC Podcast	NA
17/08/2023	MADFIG/HRG	Elders Field Walk	65
23/08/2023	MFIG	Spring Field Day	32
5/10/2023	FEAR	Spring Field Day	18
1/02/2024	NA	Ground Cover Feature	NA
19/03/2024	MADFIG	Mukinbudin Crop Updates	100

LOCATION

Site #	Latitude (decimal degrees)	Longitude (decimal degrees)	Nearest town
Trial Site #1	-29.4074883	116.0764843	Morawa
Trial Site #2	-31.6463671	118.4841156	Merredin
Trial Site #3	-31.4338629	117.3086214	Cunderdin
Trial Site #4	-31.801467	118.348995	Bruce Rock
Trial Site #5	-32.358463	118.683128	Holt Rock
Trial Site #6	-31.3860541	118.2896112	Merredin
Trial Site #7	-31.3860541	118.2896112	Merredin
Trial Site #8	-29.405094	116.076649	Morawa
Trial Site #9	-32.216610	117.37560	Quairading
Trial Site #10	-33.092687	121.674027	Salmon Gums
Trial Site #11	-33.075128	121.752487	Salmon Gums
Trial Site #12	-31.210818	119.309628	Southern Cross
Trial Site #13	-28.159565	114.940305	Yuna
Trial Site #14	-28.447200	114.945780	Yuna

If the research results are applicable to a specific GRDC region/s (e.g. North/South/West) or GRDC agro-ecological zone/s, indicate which in the table below:

Research	Benefiting GRDC region (select up to three)	Benefitting GRDC agro-ecological zone	
Canola establishment in the low rainfall zones of the Western Region	Western Region Choose an item. Choose an item.	☐ Qld Central ☐ NSW NE/Qld SE ☐ NSW Vic Slopes ☐ Tas Grain ☐ SA Midnorth-Lower Yorke Eyre ☒ WA Northern ☒ WA Eastern ☒ WA Mallee	☐ NSW Central ☐ NSW NW/Qld SW ☐ Vic High Rainfall ☐ SA Vic Mallee ☐ SA Vic Bordertown-Wimmera ☒ WA Central ☒ WA Sandplain

RESULTS AND DISCUSSION

Extension

A total of 109 growers from the nine grower groups participated in the pre-seeding protocol surveys, 144 growers participated in the in-field surveys and 545 growers, agronomists and researchers attended the in-season field walks, and project events. Of the 109 growers that participated in the pre-seeding protocol surveys, 98% reported to have experienced poor canola establishment, with 42% reporting poor canola establishment consistently across seasons. Across both 2022 and 2023 (Figure 1), growers highlighted seeding depth, soil type and wet vs wet dry sowing conditions as primary factors influencing canola establishment. Other major influences raised by growers included unforeseen weather events, placement of seed (on-row, off-row or near-row) and soil moisture at seeding.

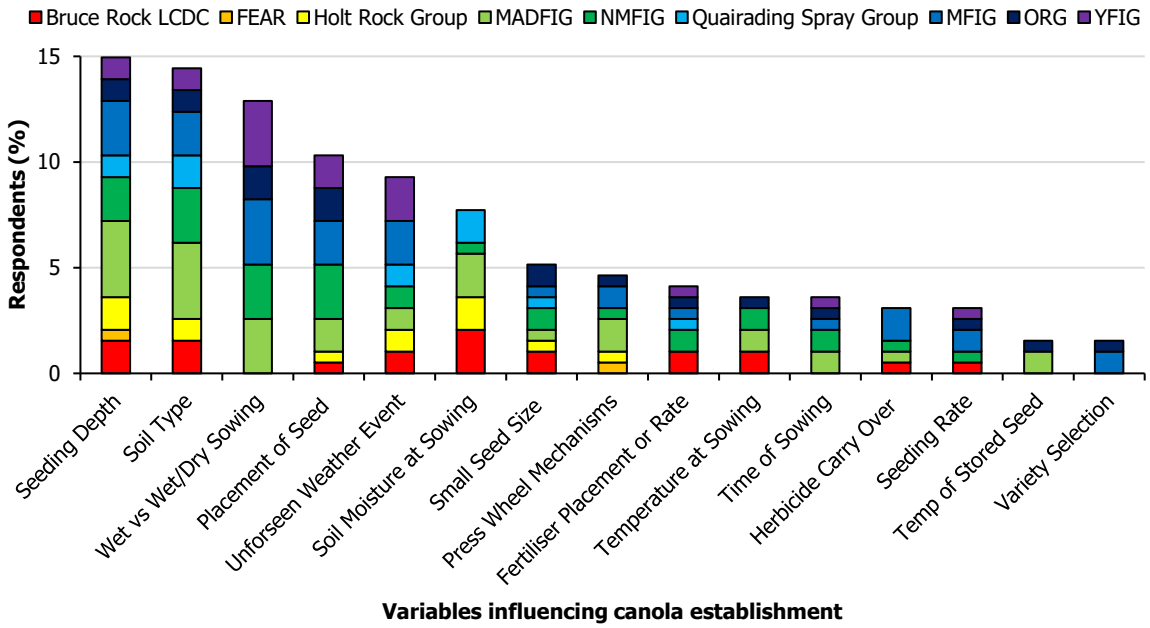

Figure 1. Summary of the 2022 and 2023 survey results of factors growers believe are contributing to poor canola establishment in their region.

The addition of soil wetter and comparing wet vs dry sowing conditions were highlighted as important treatment factors by the grower groups to investigate within the small plot trials (Figure 2). In addition to these treatment factors, fertiliser placement, seed placement (on-row, off-row or near-row), seed size, seeding rate and time of sowing were also popular. From these results, the protocols for the 2022 and 2023 trials were developed. Due to low engagement with the preliminary survey, the treatments for FEAR were developed in consultation with the FEAR Chairperson and local growers. From these discussions, row spacing, canola type and seeding rate were identified as key treatments for the Southern Cross trial.

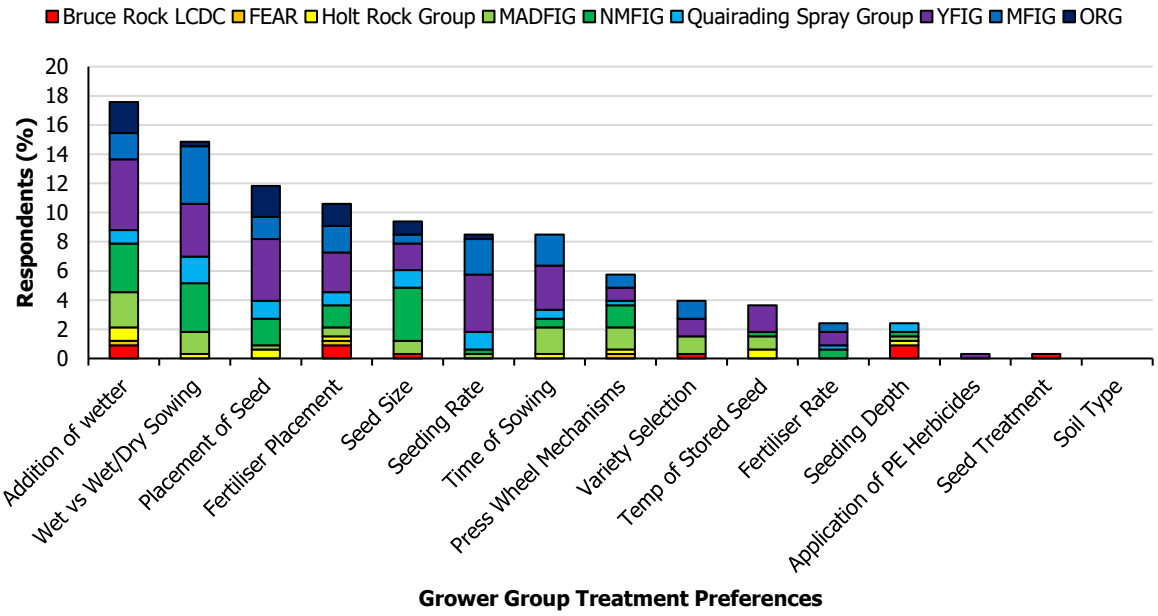

Figure 2. Summary of the 2022 and 2023 survey results for each grower groups treatment preferences.

Seasonal Conditions

Rainfall

As presented in Figure 3, the low rainfall zones (LRZ) of WA generally experienced average (decile 4-7) to very much above average (decile 8-9) rainfall during the 2022 growing season. The trial sites in Merredin, Morawa and Cunderdin during 2022 received between 60mm and 100mm additional annual rainfall compared to long term averages. At all 2022 sites, the month of August recorded the highest rainfall, ranging from 88mm (Merredin) to 100mm (Morawa). High summer/ pre-season rainfall (February to March) was also observed (Table 4). In comparison, 2023 observed opposite rainfall trends, with average growing season rainfall in the LRZs ranging from below average (decile 2-3) to lowest on record (decile 0) in the North. This trend was observed across all 2023 trial sites with monthly rainfall generally sharply declining following June. Despite the lower-than-average growing season conditions, adequate moisture was recorded prior to seeding (Table 4). During 2023, the Yuna light site (Yuna L), located approximately 20 km Northwest of Yuna recorded the lowest growing season rainfall (80.6 mm) which likely contributed to the very poor canola establishment observed. Similarly, the Yuna heavy site (Yuna H), received very low pre-seeding rainfall (38.8 mm) which may have also contributed to the low canola plant densities (Appendix A and Appendix B).

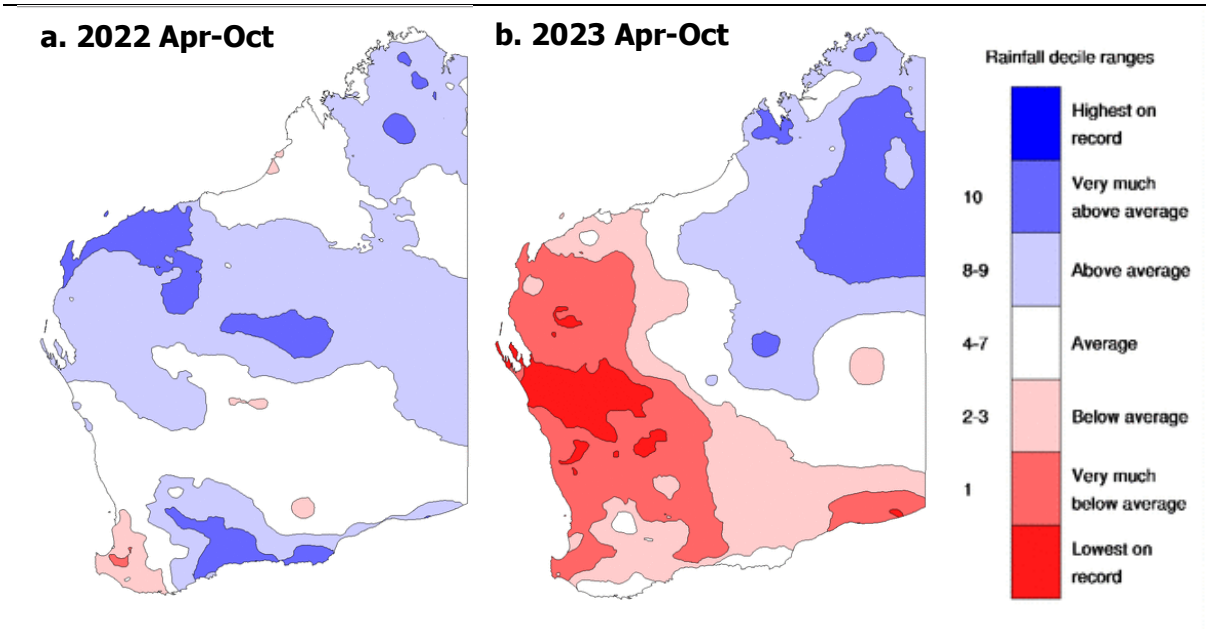

Figure 3. Comparison of the 2022 (a) and 2023 (b) growing season rainfall deciles (Apr-Oct) for Western Australia produced using BOM (2024). Base data from 1900 to October 2023.

Table 4. Summary of total monthly rainfall (mm) at each location for 2022 and 2023. Rainfall data for the 2023 Merredin, Morawa, North Mallee (Heavy site) and Holt Rock sites was provided by host growers. The other sites rainfall data was produced using SILO (Queensland Government, 2024).

Year	Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Total
2022	Cunderdin	0	4	55	23.3	30.7	50.7	54.2	99	36.3	13.8	**367**
	Merredin	0	50.7	39.4	37.1	33.4	48.5	40.9	88.7	52.7	31.3	**422.7**
	Morawa	0.3	40.7	79.8	22.8	14.1	25.9	44.6	100.3	41.5	1.2	**371.2**
2023	Merredin	3.5	0	54.5	29.5	8.5	56	16	17	17	0	**202**
	Morawa	26.5	4	22	1.25	12	37.5	21.8	19	15	1	**160**
	Yuna (L)	6.6	0	22.3	0.2	8.2	26.9	17.5	16.6	9.5	1.7	**109.5**
	Yuna (H)	8.5	0.1	30.2	4.2	15.5	63.7	27.3	24.2	15.3	1.5	**190.5**
	North Mallee (L)	9.6	12.6	9	43.5	6	60.2	16.7	28.2	10.7	6.8	**203.3**
	North Mallee (H)	7.6	13.3	8.2	45.4	4.8	49.7	16.9	27	11.4	7	**191.3**
	Holt Rock	2	2	56	30	7	42.8	21.5	28.8	22.3	2.5	**214.8**
	Quairading	0.2	0.3	71.2	71.4	14.2	80.1	28.3	31.1	28.9	1.6	**327.3**
	Southern Cross	9.8	11.7	30.1	48.3	6.3	25.4	12.5	25.6	17.9	1.6	**189.2**
	Bruce Rock	0	0	18.5	42.3	28.6	34.3	18.1	21.5	15.2	0	**178.5**

Temperature

Annual maximum temperature in the low rainfall zones of WA generally increased from 2022 to 2023, raising from decile 4-7 (average) and decile 8-9 (above average) to decile 10 (very much above average) (Figure 4).

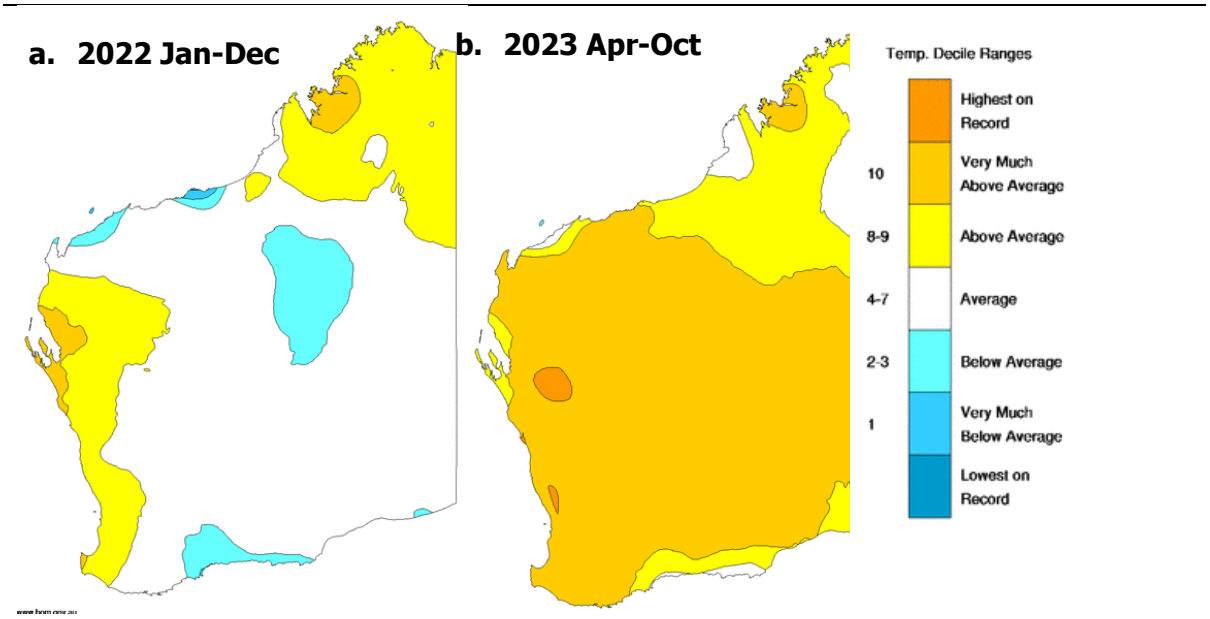

Figure 4. Comparison of the 2022 (a) and 2023 (b) annual maximum temperature decile for WA produced using BOM (2024).

Table 5. Summary of average maximum temperature (°C) at each location for 2022 and 2023. All data was derived from SILO (Queensland Government, 2024).

Year	Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Av.
2022	Cunderdin	36.2	36.2	30.2	23.9	21.4	17.9	17.4	16.4	19.8	23.3	24.3
	Merredin	35.9	35.7	29.8	23.6	20.8	17.3	17	16.3	19.6	22.7	23.9
	Morawa	38.7	38.3	33.2	26.3	23	20.5	19.6	18.7	21.3	25.3	26.5
2023	Merredin	34.6	35.2	30.9	22.8	21.6	14.8	17	20.6	24.8	28.8	25.1
	Morawa	37.6	37.5	33.9	25.9	24.7	17.5	19	23.6	26.1	31.4	27.7
	Yuna (L)	35.1	34.7	32.7	26.1	25.6	18.9	19.6	23.7	25.4	30.4	27.2
	Yuna (H)	34.7	34.2	32.2	26	25.4	18.6	19.3	23.2	24.9	30.1	26.9
	North Mallee (L)	29.5	30.3	28	23.1	20.7	15.2	17	19.7	24.9	25.3	23.4
	North Mallee (H)	29.7	30.4	28.1	23.1	20.7	15.1	17	19.7	24.9	25.4	23.4
	Holt Rock	33.4	33.7	30	22	20.9	14.5	16.4	19.6	24.1	27.9	24.3
	Quairading	34.4	34.2	30.6	22.3	21.3	15.4	16.7	19.2	23.4	28.1	24.6
	Southern Cross	34.6	35.7	31.5	23.5	21.9	15.2	17.7	21.5	25.9	29.1	25.7
	Bruce Rock	34.3	34.8	30.7	22.7	21.6	15	17	20.3	24.6	28.6	25.0

Canola Establishment, Canopy Cover and Yield

Seed Size

Grading seed greater than 1.8 mm significantly improved canola establishment in North Mallee on a sandy soil type in comparison to using a mixed seed size straight from the bag (Table 6). The North Mallee soil was composed of 84% coarse sand, and therefore using larger seed may have increased soil-seed contact improving canola establishment rates. Grading seed was not found to be beneficial at the other trial sites (Merredin, Holt Rock, North Mallee) and this may be attributed to the influence of soil type and the presence of optimal soil moisture at seeding. Previous research by Harries (2017) also showed a positive relationship between seed size and establishment within Western Australia with the larger seed size, correlating to larger cotyledon size suggested to improve embryo growth (Nelson, 2022).

Larger seed size also generally resulted in increased canopy cover for all sites, however, this result was only significant at the sandy North Mallee trial site. Similarly, average yield was greater for the graded seed treatment across locations, but no statistically significant difference was observed (Table 6).

Table 6. Summary of the influence of seed size (mixed or graded to >1.8 mm) on canola establishment 14 and 28 days after sowing (DAS), canopy coverage percentage and yield. The values within the table represent averages.

Year	Location	Soil Type	GSR	PSR	14 DAS (plants/m^2)		28 DAS (plants/m^2)		Canopy Cover (%)		Yield (t/ha)	
					>1.8 mm	mix	>1.8 mm	mix	>1.8 mm	mix	>1.8 mm	mix
2022	Merredin	Sand	295	63	9.3	10.6	17.8	18.6	52	47	N/A	N/A
2023	Holt Rock	Sandy Loam	158	65	27.6	27.2	26.0	24.7	94	93	1.9	1.8
2023	North Mallee	Clay Loam	162	29	24.1	19.3	26.4	24.4	95	93	1.7	1.6
2023	North Mallee	Sand	162	29	23.9	18.7	26.7	21.6	98	95	1.7	1.6

Note: Statistical significance denoted by colours, green value statistically greater than yellow value. No colour indicates no statistical significance between values.

Seeding Depth

Shallow sowing canola at 1-1.5 cm significantly improved canola establishment at 100% emergence (28 DAS) compared to deep sowing at 3 to 4 cm depth at all sites (Table 7). This result has also been shown in previous research by Harries (2017) with deep sowing placing the canola seed at a depth exceeding the hypocotyl length (3cm), thereby reducing establishment (Nelson, 2022). Shallow sowing canola also significantly improved crop canopy coverage for all sites except one of the Merredin trials in which the canopy coverage was similar for both treatments.

Yield generally followed the opposite trend in which the deeper sown canola achieved higher yields compared to the shallow sown canola at Merredin and Morawa during 2023. This result may indicate lower interplant competition for moisture and nutrition in a moisture limited season due to reduced plant numbers for the deeper sown treatments. The opposite trend was observed in 2022 for Morawa with the shallow sown canola treatments achieving an average greater yield compared to the deeper sown treatments (Table 7). This may be due to the lack of sufficient moisture at 3.5cm the Morawa site at the time of sowing and low rainfall amounts throughout the season. In Morawa in the 2022 season there was considerably greater growing season rainfall of 273 mm than in 2023 resulting in increased plant density of the shallow sown treatments contributed to improved yields.

Table 7. Summary of the influence of seeding depth (1-1.5 cm or 3-4 cm) on canola plant density at 14 and 28 days after sowing (DAS), canopy coverage percentage and yield. The values within the table represent averages.

Year	Location	Soil Type	GSR	PSR	14 DAS (plants/m^2)		28 DAS (plants/m^2)		Canopy Cover (%)		Yield (t/ha)	
					1 cm	3 cm	1 cm	3 cm	1 cm	3 cm	1 cm	3 cm
2022	Morawa	Loamy Clay	273	121	13.7	10.3	15.0	12.0	56	50	2.5	2.3
2023	Merredin SR	Loamy Sand	144	58	16.5	14.2	19.7	16.3	54	56	1.4	1.5
2023	Merredin TOS	Loamy Sand	144	58	13.6	16.6	20.0	15.8	67	61	1.5	1.5
2023	Morawa	Loamy Sand	160	68	15.3	11.1	25.9	15.4	78	73	0.8	0.9

Hypocotyl Length

The hypocotyl length followed a similar trend, with the average hypocotyl length greater for deeper sown treatments for all sites, however this trend was only significant at Merredin (Table 8).

Table 8. Average hypocotyl length for 1 cm and 3 cm seeding depth.

Year	Location	Soil Type	GSR	PSR	Hypocotyl Length (mm)	
					1 cm	3 cm
2022	Morawa	Loamy Clay	273	121	20	21
2023	Merredin SR	Loamy Sand	144	58	31	41
2023	Merredin TOS	Loamy Sand	144	58	38	48
2023	Morawa	Loamy Sand	160	68	16	19

Note: Statistical significance denoted by colours, green value statistically greater than yellow value. No colour indicates no statistical significance between values.

Seeding Rate

Across all locations and both seasons, seeding rate was positively correlated with establishment, with high seeding rates significantly increasing crop plant density (Table 9). Crop canopy coverage followed the same positive trend and with the use of higher seeding rates significantly increasing crop canopy coverage at all sites besides Morawa during the 2023 season. Despite increasing crop canopy cover and crop density, the 2022 Morawa trial was the only site to observe an increase in yield due to seeding rate (Table 9). The 2023 season was generally drier in comparison to the 2022 season across all locations. The trials demonstrated without the moisture to support the higher plant densities, the yield benefits of using an increased seeding rate were not observed.

Table 9. Summary of the influence of seeding rate (high or low) on canola plant density at 14 and 28 days after sowing (DAS), canopy coverage percentage and yield. The values within the table represent averages. Specific plant density targets for each seeding rate is presented in Table 2.

Year	Location	Soil Type	GSR	PSR	14 DAS (plants/m²)		28 DAS (plants/m²)		Canopy Cover (%)		Yield (t/ha)	
					High	Low	High	Low	High	Low	High	Low
2022	Morawa	Loamy Clay	273	121	14.8	9.0	17.0	10.0	58	48	2.6	2.2
2023	Merredin SR	Loamy Sand	144	58	18.7	12.0	20.6	15.0	60	50	1.5	1.5
2023	Morawa	Loamy Sand	160	68	15.1	12.0	25.9	15.0	77	74	0.9	0.9
2023	Quairading	Loamy Sand	256	72	35.3	24.0	30.1	23.0	60	59	2.2	2.1
2023	Southern Cross	Sandy Loam	140	73	N/A	N/A	10.1	6.0	38	27	0.9	0.9
2023	Yuna (L)	Sand	74	58	1.0	1.0	1.4	1.0	30	23	0.5	0.4

Note: Statistical significance denoted by colours, green value statistically greater than yellow value. No colour indicates no statistical significance between values.

Soil Wetter

The addition of soil wetter was the most popular treatment requested by growers for inclusion in trials (Figure 2) and therefore the effect of soil wetter on canola establishment was investigated at nine of the fourteen trial sites. Regardless of location, the addition of SACOA SE14 soil wetter did not significantly improve canola establishment, canopy cover or yield at any site over the two years of trials (Table 10). Soil moisture was generally present within the top 3 cm of soil at seeding for all sites. Therefore, the effects of SACOA SE14 soil wetter on canola establishment may have been reduced as soil moisture was not a limitation to germination. Further research is required to understand the situations in which the addition of soil wetter would be beneficial for canola establishment.

Table 10. Summary of the influence of soil wetter (SACOA SE14) on canola plant density at 14 and 28 days after sowing (DAS), canopy coverage percentage and yield. The values within the table represent averages.

Year	Location	Soil Type	GSR mm	PSR mm	14 DAS (plants/m²)		28 DAS (plants/m²)		Canopy Cover (%)		Yield (t/ha)	
					-SE14	+SE14	-SE14	+SE14	-SE14	+SE14	-SE14	+SE14
2022	Cunderdin	Sand (nw)	308	59	5.1	4.9	10.0	11.1	29	30	2.4	2.4
2022	Merredin	Sand	295	63	10.5	9.3	17.3	19.1	48	50	N/A	N/A
2023	Bruce Rock	Sandy Loam	167	24	13.2	11.6	17.8	17.6	79	79	1.2	1.2
2023	Holt Rock	Sandy Loam	158	65	25.4	29.4	24.6	26.1	93	94	1.8	1.9
2023	Merredin SR	Loamy Sand	144	58	15.3	15.5	18.9	17.1	55	54	1.5	1.5
2023	North Mallee	Sand	162	29	21.0	21.6	24.8	23.5	96	97	1.7	1.6
2023	Quairading	Loamy Sand	256	72	25.9	35.4	24.5	30.3	58	62	2.1	2.1
2022	Yuna (H)	Sandy Loam	73	39	1.2	1.1	3.0	2.8	76	73	1.0	1.0
2023	Yuna (L)	Sand	74	58	0.8	0.7	1.2	1.4	28	27	0.5	0.5

Note: Statistical significance denoted by colours, green value statistically greater than yellow value. No colour indicates no statistical significance between values.

Time of sowing

Delaying sowing until the end of April or early May showed a general trend of improved canola establishment at all sites except Merredin in 2023 (Table 11). Delaying sowing decreases the risk of poor canola establishment through reducing the exposure of the seed to excessive temperatures (particularly in the northern LRZs) and reduces the likelihood of the seed germinating into rapidly drying soil conditions. Time of sowing did not significantly influence plant density at Bruce Rock; however, the early time of sowing did produce a larger canopy (Table 11). In moisture limited seasonal conditions, the earlier time of sowing, with a lower plant density, generally out yielded the later time of sowing treatments. However, when soil moisture was available, such as Quairading in 2023 and Morawa in 2022, the earlier time of sowing significantly out yielded the later time of sowing.

Table 11. Summary of the influence of time of sowing on canola plant density at 14 and 28 days after sowing (DAS), canopy coverage percentage and yield. The values within the table represent averages.

Year	Location	Soil Type	GSR mm	PSR mm	14 DAS (plants/m²)		28 DAS (plants/m²)		Canopy Cover (%)		Yield (t/ha)	
					Early	Late	Early	Late	Early	Late	Early	Late
2022	Morawa	Loamy Clay	273	121	9.7	18.4	10.4	21.1	47	73	2.4	2.7
2023	Bruce Rock	Sandy Loam	167	24	12.0	12.8	19.6	15.8	86	72	1.2	1.2
2023	Merredin TOS	Loamy Sand	144	58	18.6	10.9	17.8	13.8	69	59	1.6	1.5
2023	Morawa	Loamy Sand	160	67.5	10.4	19.2	22.2	23.0	76	77	0.9	0.9
2023	North Mallee	Clay Loam	162	29	18.2	25.2	24.0	26.0	99	89	1.9	1.4
2023	North Mallee	Sand	162	29	18.5	24.1	22.5	25.8	98	95	1.8	1.4
2023	Quairading	Loamy Sand	256	72	28.2	32.3	22.9	31.8	44	83	2.0	2.4
2023	Yuna (L)	Sand	73.8	57.7	0.7	0.9	0.9	1.6	27	28	0.6	0.4

Note: Statistical significance denoted by colours, green value statistically greater than yellow value. No colour indicates no statistical significance between values.

UAN Placement

Deep placement of UAN below the seed significantly improved canola establishment on a non-wetting, sandy soil type in Cunderdin during the 2022 season (Table 12). UAN placement was not found to significantly affect canola establishment at Bruce Rock, Holt Rock, North Mallee or Yuna during 2023, however, the deeper placement of UAN did generally improve canola establishment at these sites (Table

12). The rate of UAN applied was reduced from 50 L/ha (2022) to 30 L/ha (2023) under grower advisal. Therefore, the reduction in UAN rate may have contributed to the lack of significant results in the 2023 trials. The heavier soil types at Bruce Rock, Holt Rock and North Mallee and presence of soil moisture at seeding also contributed to reduced fertiliser toxicity when the UAN was placed with the seed. Drier soil conditions can increase the potential for fertiliser toxicity (GRDC, 2011). As the Yuna trial was sown in very dry conditions, plant density may have been severely reduced due to fertiliser toxicity (Table 12).

Table 12. Summary of the influence of UAN placement relative to the seed on canola plant density at 14 and 28 days after sowing (DAS), canopy coverage percentage and yield. The values within the table represent averages.

Year	Location	Soil Type	GSR mm	PSR mm	14 DAS (plants/m²)		28 DAS (plants/m²)		Canopy Cover (%)		Yield (t/ha)	
					0 cm	3-4 cm	0 cm	3-4 cm	0 cm	3-4 cm	0 cm	3-4 cm
2022	Cunderdin*	Sand	308	59	3.5	7.0	7.9	14.7	24	33	2.3	2.4
2023	Bruce Rock	Sandy Loam	167	24	10.9	13.9	16.5	18.8	76	82	1.2	1.2
2023	Holt Rock	Sandy Loam	158	65	25.1	29.7	24.6	26.2	93	93	1.8	1.8
2023	North Mallee	Clay Loam	162	29	20.5	23.0	24.6	26.2	94	94	1.7	1.7
2022	Yuna (H)	Sandy Loam	73	39	0.9	1.3	2.8	3.0	74	77	0.9	1.1

Note: Statistical significance denoted by colours, green value statistically greater than yellow value. No colour indicates no statistical significance between values.

*Cunderdin also had a 1.5 cm UAN depth placement treatment. The results for this treatment are presented in Appendix A, B, C and D.

UAN Rate

The application of 30 L/ha of UAN reduced canola plant density in comparison to 15 L/ha when placed with the seed or 3-4 cm below the seed in Yuna. Despite the reduction in plant density due to fertiliser toxicity, canopy coverage and yield were not influenced by UAN application rate (Table 13). This result likely reflects the poor seasonal conditions limiting growth across all treatments.

Table 13. Summary of the influence of UAN rate on canola plant density at 14 and 28 days after sowing (DAS), canopy coverage percentage and yield. The values within the table represent averages.

Year	Location	Soil Type	GSR mm	PSR mm	14 DAS (plants/m²)		28 DAS (plants/m²)		Canopy Cover (%)		Yield (t/ha)	
					15 L/ha	30 L/ha	15 L/ha	30 L/ha	15 L/ha	30 L/ha	15 L/ha	30 L/ha
2022	Yuna (H)	Sandy Loam	73	39	1.2	1.0	3.2	2.6	76	75	1.0	1.0

Note: Statistical significance denoted by colours, green value statistically greater than yellow value. No colour indicates no statistical significance between values.

Pre-emergent Propyzamide

Anecdotal farmer evidence suggests propyzamide applied as a pre-emergent, affects canola establishment on particular soil types. This was trialled in Cunderdin in 2022. There was no significant effect of propyzamide on canola establishment in this trial. There were significant differences in canopy cover and yield in response to propyzamide treatments at this site. This result may be due to site effects (the propyzamide was applied in blocks instead of to single plots) (Table 14). Weed counts were not taken at this site and may explain the weed competition factor in the nil propyzamide treatments. Therefore, further research is required to determine the effect of the pre-emergent application of propyzamide on canola establishment.

Table 14. Summary of the influence of pre-emergent herbicide Propyzamide on canola plant density at 14 and 28 days after sowing (DAS), canopy coverage percentage and yield. The values within the table represent averages.

Year	Location	Soil Type	GSR mm	PSR mm	14 DAS (plants/m^2)		28 DAS (plants/m^2)		Canopy Cover (%)		Yield (t/ha)	
					-PPZ	+PPZ	-PPZ	+PPZ	-PPZ	+PPZ	-PPZ	+PPZ
2022	Cunderdin	Sand	308	59	4.2	5.8	9.7	11.5	26	33	2.2	2.6

Note: Statistical significance denoted by colours, green value statistically greater than yellow value. No colour indicates no statistical significance between values.

Canola Type (Open Pollinated or Hybrid)

Canola plant density was not significantly influenced by canola type (Table 15). This result was unexpected as previous research has suggested hybrid canola generally has improved establishment rates due to a larger seed size (Brill et al., 2016). Good soil moisture was present at seeding for both sites, and therefore the influence of seed size or canola type on canola establishment was reduced, with even germination and establishment. Canopy cover percentage was significantly greater for the hybrid canola treatment at Southern Cross and was generally greater at Merredin (Table 15). Despite improved canopy cover, no significant difference was observed for yield.

Table 15. Summary of the influence of canola type; Hybrid (H) or Open Pollinated (OP) on canola plant density at 14 and 28 days after sowing (DAS), canopy coverage percentage and yield. The values within the table represent averages.

Year	Location	Soil Type	GSR mm	PSR mm	14 DAS (plants/m^2)		28 DAS (plants/m^2)		Canopy Cover (%)		Yield (t/ha)	
					H	OP	H	OP	H	OP	H	OP
2022	Merredin	Sand	295	63	10.7	9.1	16.1	20.2	55	43	N/A	N/A
2023	Southern Cross	Sandy Loam	140	73	N/A	N/A	8.4	7.7	38	29	0.9	0.9

Note: Statistical significance denoted by colours, green value statistically greater than yellow value. No colour indicates no statistical significance between values.

Variety (Season Length)

Across all assessments, Nuseed Emu TF performed significantly better in comparison to BASF InVigor R 4022P for establishment, canopy cover and yield.

Table 16. Summary of the influence of variety season length (Early-Mid season InVigor R 4022P and Early season Nuseed Emu) on canola plant density at 14 and 28 days after sowing (DAS), canopy coverage percentage and yield. The values within the table represent averages.

Year	Location	Soil Type	GSR mm	PSR mm	14 DAS (plants/m^2)		28 DAS (plants/m^2)		Canopy Cover (%)		Yield (t/ha)	
					4022P	Emu	4022P	Emu	4022P	Emu	4022P	Emu
2023	Merredin TOS	Loamy Sand	144	58	11.4	22.2	14.3	21.4	58	70	1.4	1.7

Note: Statistical significance denoted by colours, green value statistically greater than yellow value. No colour indicates no statistical significance between values.

Row Spacing

The influence of row spacing (25 cm or 75 cm) was explored at Southern Cross. Canola plant density, canopy cover and yield were all significantly greater for the narrow (25cm) row spacing compared to the wide row spacing.

Table 17. Summary of the influence of row spacing (25 cm or 75 cm) on canola plant density at 14 and 28 days after sowing (DAS), canopy coverage percentage and yield. The values within the table represent averages.

Year	Location	Soil Type	GSR mm	PSR mm	14 DAS (plants/m^2)		28 DAS (plants/m^2)		Canopy Cover (%)		Yield (t/ha)	
					25 cm	75 cm	25 cm	75 cm	25 cm	75 cm	25 cm	75 cm
2023	Southern Cross	Sandy Loam	140	73	N/A	N/A	10.2	5.9	38	28	1.0	0.9

Note: Statistical significance denoted by colours, green value statistically greater than yellow value. No colour indicates no statistical significance between values.

Conclusions

- The results from the 2 years of the project indicate caution is required when planning to seed in rapidly drying soil conditions and when daytime temperatures exceed 35°C. These effects are enhanced where seeding depth is increased, in a drying soil profile, and there is no follow up rainfall within seven days of sowing.
- Deep sowing (3cm) showed uneven establishment, which may have been caused by the varied soil moisture at the depth of sowing in addition to placement below average hypocotyl length.
- Grading open pollinated seed was only shown to increase canola establishment on a sand textured soil in North Mallee. Further research is required to determine if seed size can effect open pollinated canola establishment.
- The use of a high seeding rate significantly improved establishment at all sites tested.
- The addition of soil wetter did not significantly effect canola establishment in the two years tested. Further research is required to investigate the benefits of soil wetters on canola establishment in challenging dry seasons.
- Deep banding UAN below the seed (increasing fertiliser and seed separation) significantly improved canola establishment on a non-wetting sand in Cunderdin during the 2022 season.
- The use of 30 L/ha of UAN significantly reduced canola establishment compared to 15 L/ha when placed with the seed or deep banded below the seed at Yuna in 2023.
- The pre-emergent application of propyzamide was not found to significantly effect canola establishment on a non-wetting soil in Cunderdin. Site effects may have influenced these results and subsequently further research is required to determine the effect of the pre-emergent application of propyzamide on canola establishment.
- Canola type was not observed to effect canola establishment when comparing hybrid canola (Nuseed HyTTec Trident) and open pollinated canola (Nuseed ATR Bonito) at Merredin (2022) and Southern Cross (2023).
- The shorter season Nuseed Emu TF was observed to have greater canola establishment rates compared to the early-mid season maturity BASF InVigor 4022P, during the short 2023 season at Merredin.
- The use of narrow row spacing (25 cm) significantly increased canola establishment compared to wide row spacing (75 cm) at Southern Cross in 2023.

Appendix

Appendix A. Average canola plant density (plants/m^2) for each treatment across all sites assessed 14 days after sowing (DAS). See below table for treatment descriptions. The soil type and total growing season rainfall (GSR) is also provided.

				Canola Type		PPZ		Row Spacing (cm)		Seed Size (mm)		Seeding Depth (cm)		Seeding Rate			Soil Wetter		TOS		UAN Placement (cm)			UAN Rate (L/ha)		Variety	
Yr	Location	Soil Type	GSR	H	OP	-	+	25	75	>1.8	M	1	3	H	M	L	-	+	Early	Late	0	1.5	3-4	15	30	4022P	Emu
2022	Cunderdin	Sand	308			4	6										5	5			4	5	7				
	Merredin	Sand	333	11	9					9	11						10	9									
	Morawa	Loamy Clay	250									14	10	15		9			10	18							
2023	Bruce Rock	Sandy Loam	160														13	12	12	13	11		14				
	Holt Rock	Sandy Loam	155							28	27						25	29			25		30				
	Merredin SR	Loamy Sand	144									17	14	19		12	15	15									
	Merredin TOS	Loamy Sand	144									14	17						19	11						11	22
	Morawa	Loamy Sand	108									15	11	15		12			10	19							
	North Mallee	Clay Loam	172							24	19								18	25	21		23				
	North Mallee	Sand	162							24	19						21	22	18	24							
	Quairading	Loamy Sand	256											35		24	26	35	28	32							
	Southern Cross	Sandy Loam	138																								
	Yuna (H)	Sandy Loam	152														1	1			1		1	1	1		
	Yuna (L)	Sand	81											1		1	1	1	1	1							

Treatment Descriptions

- Canola Type: Hybrid (H) or open Pollinated (OP)
- Application of Pre-emergent Herbicide Propyzamide (PPZ): Addition (+) or untreated (-)
- Row Spacing: 25 cm or 75 cm row spacing
- Seed Size: Graded to greater than 1.8 mm or mixed (M) from the bag
- Seeding Depth: 1-1.5 cm or 3-4 cm seeding depth
- Seeding Rate: High, medium or low (see Table 2 for seeding rates used in each trial)
- Soil Wetter: The addition (+) or absence (-) of SACOA SE14 Soil Wetter, applied at 3 L/ha
- Time of Sowing (TOS): Early or late time of sowing (see Table 1 for all time of sowing)
- UAN Placement: The placement of UAN at 0 cm depth (with the seed) or 1.5 cm or 3-4 cm depth below the seed.
- UAN Rate: The rate of UAN applied at seeding. The UAN was placed either with the seed or 3-4 cm below the seed.
- Variety: BASF InVigor R 4022P or Nuseed Emu TF

Appendix B. Average canola plant density (plants/m^2) for each treatment across all sites assessed 28 days after sowing (DAS). See below table for treatment descriptions. The soil type and total growing season rainfall (GSR) is also provided.

				Canola Type		PPZ		Row Spacing (cm)		Seed Size (mm)		Seeding Depth (cm)		Seeding Rate			Soil Wetter		TOS		UAN Placement (cm)			UAN Rate (L/ha)		Variety	
Yr	Location	Soil Type	GSR	H	OP	-	+	25	75	>1.8	M	1	3	H	M	L	-	+	Early	Late	0	1.5	3-4	15	30	4022P	Emu
2022	Cunderdin	Sand	308			10	11										10	11			8	9	15				
	Merredin	Sand	333	16	20					18	19						17	19									
	Morawa	Loamy Clay	250									15	12	17		10			10	21							
2023	Bruce Rock	Sandy Loam	160														18	18	20	16	17		19				
	Holt Rock	Sandy Loam	155							26	25						25	26			25		26				
	Merredin SR	Loamy Sand	144									20	16	21		15	19	17									
	Merredin TOS	Loamy Sand	144									20	16						18	14						14	21
	Morawa	Loamy Sand	108									26	15	26		15			22	23							
	North Mallee	Clay Loam	172							26	24								24	26	25		26				
	North Mallee	Sand	162							27	22						25	24	23	26							
	Quairading	Loamy Sand	256											30		23	25	30	23	32							
	Southern Cross	Sandy Loam	138	8	8			10	6					10	9	6											
	Yuna (H)	Sandy Loam	152														3	3			3		3	3	3		
	Yuna (L)	Sand	81											1		1	1	1	1	2							

Treatment Descriptions

- Canola Type: Hybrid (H) or open Pollinated (OP)
- Application of Pre-emergent Herbicide Propyzamide (PPZ): Addition (+) or untreated (-)
- Row Spacing: 25 cm or 75 cm row spacing
- Seed Size: Graded to greater than 1.8 mm or mixed (M) from the bag
- Seeding Depth: 1-1.5 cm or 3-4 cm seeding depth
- Seeding Rate: High, medium or low (see Table 2 for seeding rates used in each trial)
- Soil Wetter: The addition (+) or absence (-) of SACOA SE14 Soil Wetter, applied at 3 L/ha
- Time of Sowing (TOS): Early or late time of sowing (see Table 1 for all time of sowing)
- UAN Placement: The placement of UAN at 0 cm depth (with the seed) or 1.5 cm or 3-4 cm depth below the seed.
- UAN Rate: The rate of UAN applied at seeding. The UAN was placed either with the seed or 3-4 cm below the seed.
- Variety: BASF InVigor R 4022P or Nuseed Emu TF

Appendix C. Average canola canopy coverage (%) for each treatment across all sites assessed at BBCH18 (rosette). See below table for treatment descriptions. The soil type and total growing season rainfall (GSR) is also provided.

				Canola Type		PPZ		Row Spacing (cm)		Seed Size (mm)		Seeding Depth (cm)		Seeding Rate			Soil Wetter		TOS		UAN Placement (cm)			UAN Rate (L/ha)		Variety	
Yr	Location	Soil Type	GSR	H	OP	-	+	25	75	>1.8	M	1	3	H	M	L	-	+	Early	Late	0	1.5	3-4	15	30	4022P	Emu
2022	Cunderdin	Sand	308			26	33										29	30			24	31	33				
	Merredin	Sand	333	55	43					52	47						48	50									
	Morawa	Loamy Clay	250									56	50	58		48			47	73							
2023	Bruce Rock	Sandy Loam	160														79	79	86	72	76		82				
	Holt Rock	Sandy Loam	155							94	93						93	94			93		93				
	Merredin SR	Loamy Sand	144									54	56	60		50	55	54									
	Merredin TOS	Loamy Sand	144									67	61						69	59						58	70
	Morawa	Loamy Sand	108									78	73	77		74			76	77							
	North Mallee	Clay Loam	172							95	93								99	89	94		94				
	North Mallee	Sand	162							98	95						96	97	98	95							
	Quairading	Loamy Sand	256											60	59		58	62	44	83							
	Southern Cross	Sandy Loam	138	38	29			38	28					38	35	27											
	Yuna (H)	Sandy Loam	152														76	73			74		77	76	75		
	Yuna (L)	Sand	81											30		23	28	27	27	28							

Treatment Descriptions

- Canola Type: Hybrid (H) or open Pollinated (OP)
- Application of Pre-emergent Herbicide Propyzamide (PPZ): Addition (+) or untreated (-)
- Row Spacing: 25 cm or 75 cm row spacing
- Seed Size: Graded to greater than 1.8 mm or mixed (M) from the bag
- Seeding Depth: 1-1.5 cm or 3-4 cm seeding depth
- Seeding Rate: High, medium or low (see Table 2 for seeding rates used in each trial)
- Soil Wetter: The addition (+) or absence (-) of SACOA SE14 Soil Wetter, applied at 3 L/ha
- Time of Sowing (TOS): Early or late time of sowing (see Table 1 for all time of sowing)
- UAN Placement: The placement of UAN at 0 cm depth (with the seed) or 1.5 cm or 3-4 cm depth below the seed.
- UAN Rate: The rate of UAN applied at seeding. The UAN was placed either with the seed or 3-4 cm below the seed.
- Variety: BASF InVigor R 4022P or Nuseed Emu TF

Appendix D. Average yield (t/ha) for each treatment across all sites. See below table for treatment descriptions. The soil type and total growing season rainfall (GSR) is also provided.

				Canola Type		PPZ		Row Spacing (cm)		Seed Size (mm)		Seeding Depth (cm)		Seeding Rate			Soil Wetter		TOS		UAN Placement (cm)			UAN Rate (L/ha)		Variety	
Yr	Location	Soil Type	GSR	H	OP	-	+	25	75	>1.8	M	1	3	H	M	L	-	+	Early	Late	0	1.5	3-4	15	30	4022P	Emu
2022	Cunderdin	Sand	308			2.2	2.6										2.4	2.4			2.3	2.4	2.4				
	Merredin	Sand	333																								
	Morawa	Loamy Clay	250									2.5	2.3	2.6		2.2			2.4	2.7							
2023	Bruce Rock	Sandy Loam	160														1.2	1.2	1.2	1.2	1.2		1.2				
	Holt Rock	Sandy Loam	155							1.9	1.8						1.8	1.9			1.8		1.8				
	Merredin SR	Loamy Sand	144									1.4	1.5	1.5		1.5	1.5	1.5									
	Merredin TOS	Loamy Sand	144									1.5	1.5						1.6	1.5						1.4	1.7
	Morawa	Loamy Sand	108									0.8	0.9	0.9		0.9			0.9	0.9							
	North Mallee	Clay Loam	172							1.7	1.6								1.9	1.4	1.7		1.7				
	North Mallee	Sand	162							1.7	1.6						1.7	1.6	1.8	1.4							
	Quairading	Loamy Sand	256											2.2		2.1	2.1	2.1	2.0	2.4							
	Southern Cross	Sandy Loam	138	0.9	0.9			1.0	0.9					0.9	1.0	0.9											
	Yuna (H)	Sandy Loam	152														1.0	1.0			0.9		1.1	1.0	1.0		
	Yuna (L)	Sand	81											0.5	0.4		0.5	0.5	0.6	0.4							

Treatment Descriptions

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- Seeding Depth: 1-1.5 cm or 3-4 cm seeding depth
- Seeding Rate: High, medium or low (see Table 2 for seeding rates used in each trial)
- Soil Wetter: The addition (+) or absence (-) of SACOA SE14 Soil Wetter, applied at 3 L/ha
- Time of Sowing (TOS): Early or late time of sowing (see Table 1 for all time of sowing)
- UAN Placement: The placement of UAN at 0 cm depth (with the seed) or 1.5 cm or 3-4 cm depth below the seed.
- UAN Rate: The rate of UAN applied at seeding. The UAN was placed either with the seed or 3-4 cm below the seed.
- Variety: BASF InVigor R 4022P or Nuseed Emu TF
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