

# Agronomic and value equation outcomes associated with a matrix of different canola seed sizes by plant populations by seeding depth.

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## Key Words

Canola hybrids, seeding depth, seed size, plant populations, maximising grower returns, exploring value equations

## Key messages

1. The larger seed size combined with normal sowing depth and the higher plant population target provided higher effective plant establishment, harvested grain yields and the best value equations.
2. Mid-sized hybrid seed sown at the higher population target whether sown at the normal or deep levels, provided competitive establishment and grain yields.
3. The smallest seed size only provided moderately competitive yields at normal sowing depth and the higher plant population target.
4. The relative flowering maturity showed the trend of slowing down (later maturing) with the lower plant population target, especially for the smaller seed size at both normal and deep sowing levels.

## Aims

This research examines the environmental differences in canola plant establishment, flowering maturity, grain yield, oil % and economic returns when using one canola hybrid comparing a matrix of different canola seed sizes by plant populations by seeding depths.

## Introduction

Australian canola growers and agricultural advisors have been seeking increased scientific information and recommendations on seed size by plant population by seeding depth relationships in hybrid canola and its impact on plant establishment, grain yield, and resulting gross income.

The cost of purchasing F1 hybrid seed each year has some Australian growers and advisers strategically lowering seeding rates and effective plant populations to minimise input costs whilst aiming to maximise returns.

French et al. (2016) reported that field establishment in spring canola under Western Australian conditions ranges from 0.3 -1.0 of the target population, with a median value of 0.855 for the target population of 40 plants/m<sup>2</sup>. This new research was conducted across all the key Australian canola-growing regions. Replicated field trials were planted in various environmental conditions, representing a wide range of sowing dates, seasonal temperatures, rainfall, and soil types.

Brill et al. (2013) showed that planting canola deeper than 2.5 cm reduced overall establishment in 2012; however, grain yield was generally affected to a smaller degree. Where planting into moisture below the optimum seeding depth (>2.5 cm), use large seed (minimum 5 g per 1000 seeds), avoid high rates of fertiliser in direct contact with the seed and avoid high stubble loads.

Brill et al. (2014) also demonstrated that growers should aim to sow large (>5 g/1000 seeds) canola seed to achieve adequate establishment rates from early sowing. Hybrid vigour (heterosis) has an indirect effect (larger seed size) and a direct effect (enhanced vigour) on canola establishment.

Fletcher et al. (2024) determined that deep sowing decreased plant emergence by an average of 41%, confirming previous studies suggesting a decline in emergence at depths below 25mm with current canola genetics.

## Method

17 Pacific Seeds Hyola® Innovation Systems Trials were established with this specific research across Australia, representing a diverse range of environments within the canola-growing regions in 2024. 14 sites were retained for harvest and data analysis, as 3 sites were not harvested due to the trials having unacceptable agronomic integrity.

The 14 trial environments had a wide range of differences relating to sowing timing, seasonal rainfall, cropping histories, soil types and soil pH, with a combination of Best Management Practice (BMP) and District Standard Practice (DSP) treatments applied per each location aimed at maximising potential yields for the treatments present, thus enabling a diverse set of data collection for accurate comparisons.

The trials were mostly sown at later dates than normally expected for canola production, due to the later than usual seasonal opening rainfall breaks across Australia and these later emergence timings may have had an influence on effective plant establishment and GDD driven plant biomass growth and subsequent grain yields.

### *Treatments and Trial agronomic details*

The seeding depth by population by seed size matrix of treatments were embedded within the unique Hyola Innovations Systems technology trial design.

These trials are based upon RCB spatial designs (2 reps, 12 ranges), with one hybrid variety Hyola Defender CT having a treatment matrix of 3 size variables (165,000, 195,000, 222,000 seeds per kg), 2 populations variables of 20 and 40 plants per m<sup>2</sup> targets and 2 seeding depths of 10-20mm and 30-40mm.

Hyola Defender CT had the full registered label rate of appropriate herbicides applied at the optimum timing as per the inherent herbicide tolerances. (no CL applied as was in the TT Block)

Trial Locations	Sowing Date	Paddock History	Soil Type (0-10cm)	Soil pH CaCl <sub>2</sub> (0-10 cm)	GSR mm (Apr-Oct)	Harvest Date	Trial Mean Yield (t/ha)
Allora QLD, (CLF)	20.05.24	F-B-F	DB Clay	7.9	223	01.11.24	3.35
Arthurlton SA, (ART)	24.05.24	B-L-W	DB Loam	6.7	188	19.11.24	1.91
Birchip, Vic (BIR)	14.05.24	F-W-F	DB Clay	7.3	141	15.11.24	1.37
Cowra, NSW (COW)	10.05.24	W-B-W	BR Clay Loam	6.3	305	20.11.24	1.95
Cummins SA (CMN)	27.05.24	C-W-B	DB Loamy Sand	5.6	259	12.11.24	3.77
Gibson, WA (GIB)	27.05.24	W-C-W	GR Loamy Sand	5.6	279	18.11.24	1.96
Geraldton, WA (GTN)	24.05.24	W-C-W	LTBR Loamy Sand	5.0	542	29.10.24	1.99
Hyden WA (HYD)	09.05.24	W-L-B	GRYW Sandy Loam	6.2	205	18.11.24	2.72
Latham, WA (LTM)	21.04.24	W-C-W	BRYW Sandy Loam	6.4	285	11.11.24	1.96
Lockhart, NSW (LKH)	08.05.24	W-B-V	RB Silty Loam	5.8	152	20.11.24	1.62
Mullewa, WA (MLW)	31.05.24	F-W-F	BRGR Sandy Loam	6.3	328	06.11.24	1.98
Streatham, Vic (STR)	14.05.24	FB-B-C-W	BR Duplex	5.4	215	09.12.24	3.24
Yarrawonga, Vic (YAR)	13.05.24	C-W-W	BR Silty Loam	5.4	221	22.11.24	2.61
York, WA (YRK)	28.05.24	C-W-B	BR Sandy Loam	6.3	292	15.11.24	2.40

Table 1: 2024 trial locations, sowing dates, environmental conditions, and site mean yields.



The two plant densities targeted at sowing for specific treatments were 20 and 40 plants per square meter and adjusted by sowing a set number of seeds per plot, using 90% germination and a 75% establishment factorial. The F1 hybrid Hyola Defender CT seed used for all size and depth treatments were hybrid seedlots produced in 2023. Seeding depth was monitored for all sites with measurements taken for all normal vs deep sowing operations.



Image 1a: Gibson WA 10-15mm sowing depth treatment



Image 1b: Gibson WA 30-40mm sowing depth treatment



Images 1c-1f: Cummins SA, York WA, Arthurton SA, and Yarrowonga Vic sowing depth treatments per trial.

Plant establishment counts at each location were conducted at the 3-5 leaf stage (BBCH 13-16) by counting 3\*1m or 4\*1m rows per plot or whole plots to establish plants per meter square.

Grain yields were measured on each treatment by small plot harvesters. Grain oil percentage content was measured using standard calibrated NIR.

A “simplified” Gross Margin (SGM) was calculated as,  $SGM = \text{Grain yield} * \text{grain price} - \text{estimated seed cost}$ .

These values were used in this research as each environment will have differing input costs relative to the expected grain yield, but within each environment, the input costs for fertiliser, herbicides, etc. are assumed to be equal, irrespective of the treatment applied. Assumptions for the value of seed and harvested grain pricing are shown in Tables 2 a-b.

F1 hybrid variety	Purchase price \$/kg (2024)
Hyola Defender CT	\$40.00

Table 2a: Assumptions used for SGM calculations for Hyola Defender CT seed costs.

Grain commodity price (2024 mean values)	
CAN1	\$720/t

Table 2b: Assumptions used for SGM calculations for non-GM commodity with prices averaged between Geelong and Kwinana Ports for 12 months Jan – Dec 2024 Australia

Establishment, maturity, yield and oil analysis for single sites were performed fitting variety, row and column as fixed linear factors and spatial adjustments were performed using the auto-regressive model hence giving a blup output with standard error for each site. Statistical reference: Using ASReml (Butler *et al.*, 2023).

In addition, Establishment, maturity, yield and oil were further investigated using single step factor analytic Multiple Environment Trial (MET) analysis with ASReml in a model with generation as a linear fixed factor with composite variety as a random factor hence giving a blup for each site. Spatial adjustments were determined using the auto-regressive model. Statistical reference: Using ASReml (Butler *et al.*, 2023).

## Results and discussion

### Plant establishment

With respect to plant establishment, French et al. (2016) showed that canola field establishment varied from 0.3 to 1 and was higher at low target density with a median of 0.585 at a target density of 40 plant/m<sup>2</sup>. This research achieved a mean establishment of 0.62 for the target population density of 40 plants/m<sup>2</sup> across all treatments. These trials experienced a range of highly variable establishment conditions which showed a range between 46-91% of the target populations.

Variety by treatment	Analysed plant establishment (plants/m <sup>2</sup> )	% Established vs Target population
HYOLADEFENDERCT165K-40N	31.32	78.30%
HYOLADEFENDERCT195K-40N	30.52	76.30%
HYOLADEFENDERCT165K-40D	24.38	60.96%
HYOLADEFENDERCT222K-40N	23.22	58.06%
HYOLADEFENDERCT195K-40D	21.74	54.34%
HYOLADEFENDERCT222K-40D	18.58	46.45%
HYOLADEFENDERCT165K-20N	18.34	91.68%
HYOLADEFENDERCT195K-20N	17.32	86.61%
HYOLADEFENDERCT222K-20N	14.41	72.07%
HYOLADEFENDERCT165K-20D	14.40	71.99%
HYOLADEFENDERCT195K-20D	13.62	68.12%
HYOLADEFENDERCT222K-20D	10.86	54.29%
<b>MEAN VALUE %</b>	<b>19.89</b>	<b>68.26%</b>

Table 3: Analysed plant density achieved across seed size and depth treatments.

The Deeper sowing treatments (30-40mm) decreased establishment by 30% on average across the different seed size treatments compared to the Normal sowing depth of 10 – 20 mm treatments.

The mean of the 40 plants per m<sup>2</sup> treatments across the 3 seed sizes was 168% of the mean of 20 plants per m<sup>2</sup> treatments.



WESTERN AUSTRALIA 2024 SINGLE SITE ANALYSIS	LATHAM WA		MULLEWA WA		GERALDTON WA	
Variety * Seed Size * Population* Depth	Est (plants/m2)	se_blup	Est (plants/m2)	se_blup	Est (plants/m2)	se_blup
HYOLADEFENDERCT165K-20D	19.045	2.443	16.102	6.285	17.741	4.677
HYOLADEFENDERCT165K-20N	28.376	2.420	16.956	5.213	19.851	4.677
HYOLADEFENDERCT165K-40D	31.483	2.414	21.968	5.107	28.464	4.677
HYOLADEFENDERCT165K-40N	44.556	2.379	29.378	5.130	33.023	4.677
HYOLADEFENDERCT195K-20D	16.043	3.406	16.263	4.236	17.614	3.091
HYOLADEFENDERCT195K-20N	23.757	3.351	21.193	4.192	19.851	3.091
HYOLADEFENDERCT195K-40D	23.590	3.429	29.061	4.287	28.379	3.091
HYOLADEFENDERCT195K-40N	33.340	3.447	30.523	4.178	20.316	3.091
HYOLADEFENDERCT222K-20D	10.304	3.405	9.362	4.262	16.052	3.091
HYOLADEFENDERCT222K-20N	19.986	3.412	13.399	4.246	21.667	3.091
HYOLADEFENDERCT222K-40D	24.529	3.346	18.210	4.205	23.271	3.091
HYOLADEFENDERCT222K-40N	26.785	3.425	22.700	4.334	19.514	3.091
TRIAL MEAN POPULATION (plants/m2)	33.08		25.07		29.04	
CV%	11.29		21.29		21.36	

Table 4: WA analysed Single Site plant establishment density achieved across seed size and depth treatments.

WESTERN AUSTRALIA 2024 SINGLE SITE ANALYSIS	YORK WA		HYDEN WA		GIBSON WA	
Variety * Seed Count/Size * Population* Depth	Est (plants/m2)	se_blup	Est (plants/m2)	se_blup	Est (plants/m2)	se_blup
HYOLADEFENDERCT165K-20D	18.312	2.484	12.968	1.571	14.125	2.270
HYOLADEFENDERCT165K-20N	21.705	2.484	12.620	1.577	19.730	2.265
HYOLADEFENDERCT165K-40D	30.755	2.484	26.212	1.570	22.900	2.265
HYOLADEFENDERCT165K-40N	35.633	2.484	16.981	1.568	34.623	2.267
HYOLADEFENDERCT195K-20D	18.170	2.700	13.439	1.573	11.893	3.425
HYOLADEFENDERCT195K-20N	21.918	2.700	11.144	1.563	19.301	4.181
HYOLADEFENDERCT195K-40D	28.825	3.609	21.548	1.568	19.618	3.422
HYOLADEFENDERCT195K-40N	38.108	2.700	21.011	1.570	33.879	3.430
HYOLADEFENDERCT222K-20D	25.877	2.700	8.873	1.578	11.322	3.425
HYOLADEFENDERCT222K-20N	18.595	2.700	9.163	1.568	10.032	3.427
HYOLADEFENDERCT222K-40D	25.806	2.700	14.081	1.560	12.962	3.427
HYOLADEFENDERCT222K-40N	26.230	2.700	13.754	1.571	26.469	3.426
TRIAL MEAN POPULATION (plants/m2)	21.85		22.75		19.91	
CV%	18.52		23.80		16.43	

Table 5: WA analysed Single Site plant establishment density achieved across seed size and depth treatments. (cont.)

NEW SOUTH WALES & QLD 2024 SINGLE SITE ANALYSIS	COWRA NSW		LOCKHART NSW		ALLORA QLD	
Variety * Seed Count/Size * Population* Depth	Est (plants/m2)	se_blup	Est (plants/m2)	se_blup	Est (plants/m2)	se_blup
HYOLADEFENDERCT165K-20D	11.425	1.804	11.439	2.147	64.380	2.166
HYOLADEFENDERCT165K-20N	14.422	1.808	11.866	2.149	44.926	2.164
HYOLADEFENDERCT165K-40D	20.407	1.804	19.423	2.148	71.524	2.164
HYOLADEFENDERCT165K-40N	23.599	1.804	21.927	2.145	78.877	2.166
HYOLADEFENDERCT195K-20D	11.929	1.810	8.734	2.754	75.978	4.328
HYOLADEFENDERCT195K-20N	14.485	1.823	13.698	2.758	45.010	4.331
HYOLADEFENDERCT195K-40D	16.211	1.819	15.715	2.756	77.111	4.333
HYOLADEFENDERCT195K-40N	25.327	1.818	23.431	2.763	77.008	4.333
HYOLADEFENDERCT222K-20D	10.054	1.812	10.629	2.756	77.596	4.332
HYOLADEFENDERCT222K-20N	10.701	1.807	9.212	2.758	47.108	4.333
HYOLADEFENDERCT222K-40D	14.307	1.809	12.224	2.762	82.896	4.329
HYOLADEFENDERCT222K-40N	18.608	1.800	14.786	2.761	75.411	4.330
TRIAL MEAN POPULATION (plants/m2)	15.72		15.12		58.98	
CV%	13.81		18.87		12.70	

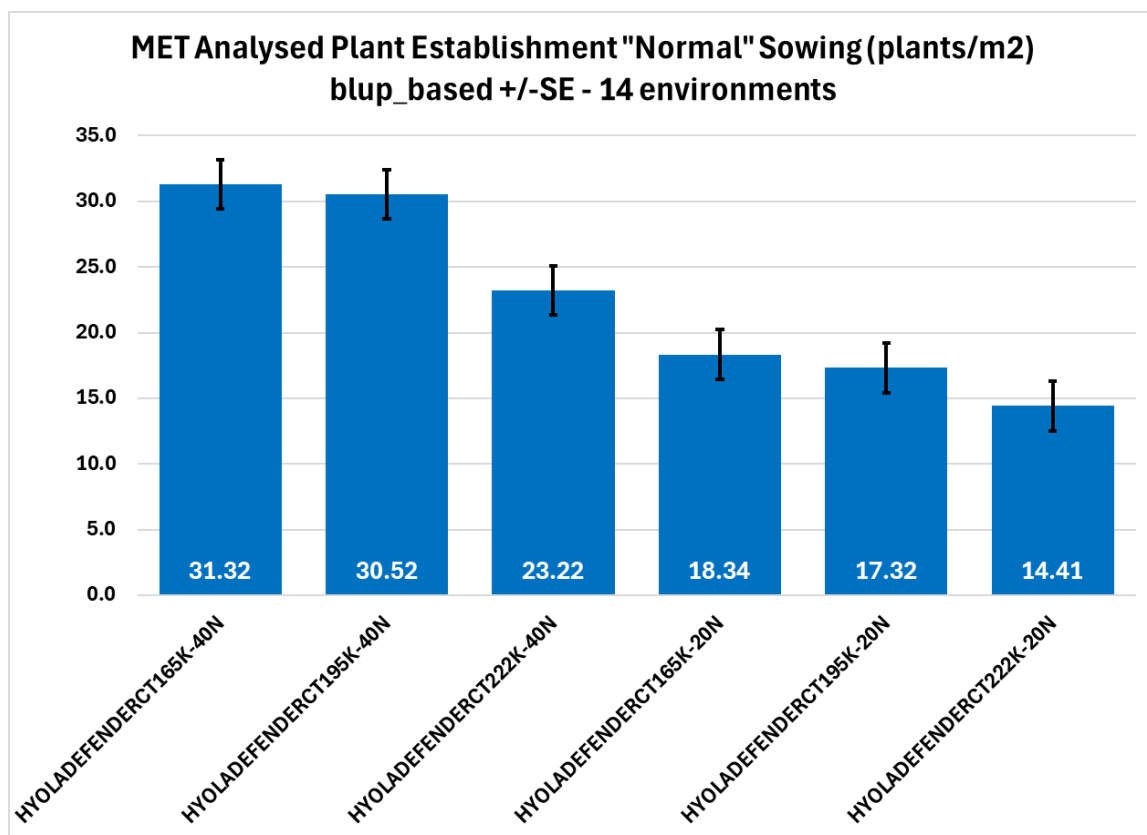
Table 6: NSW/QLD analysed Single Site plant establishment density achieved across seed size and depth treatments.

VICTORIA 2024 SINGLE SITE ANALYSIS	YARRAWONGA VIC		BIRCHIP VIC		STREATHAM VIC	
Variety * Seed Count/Size * Population* Depth	Est (plants/m2)	se_blup	Est (plants/m2)	se_blup	Est (plants/m2)	se_blup
HYOLADEFENDERCT165K-20D	15.531	3.156	12.435	2.003	12.373	0.676
HYOLADEFENDERCT165K-20N	17.639	3.156	12.266	2.001	17.439	0.660
HYOLADEFENDERCT165K-40D	29.154	3.156	15.195	2.003	21.433	0.660
HYOLADEFENDERCT165K-40N	31.426	3.156	19.162	2.003	29.944	0.659
HYOLADEFENDERCT195K-20D	16.509	2.459	11.757	0.666	10.978	0.658
HYOLADEFENDERCT195K-20N	18.868	2.459	12.870	0.667	16.550	0.803
HYOLADEFENDERCT195K-40D	26.846	2.459	15.618	0.664	18.005	0.803
HYOLADEFENDERCT195K-40N	33.396	2.459	20.505	0.663	25.336	0.821
HYOLADEFENDERCT222K-20D	11.785	2.459	9.483	0.663	8.810	0.820
HYOLADEFENDERCT222K-20N	14.311	2.458	10.630	0.663	12.431	0.823
HYOLADEFENDERCT222K-40D	20.570	2.459	15.490	0.666	18.984	0.803
HYOLADEFENDERCT222K-40N	26.740	2.459	16.813	0.665	22.845	0.804
TRIAL MEAN POPULATION (plants/m2)	23.62		12.22		15.95	
CV%	11.16		14.24		6.10	

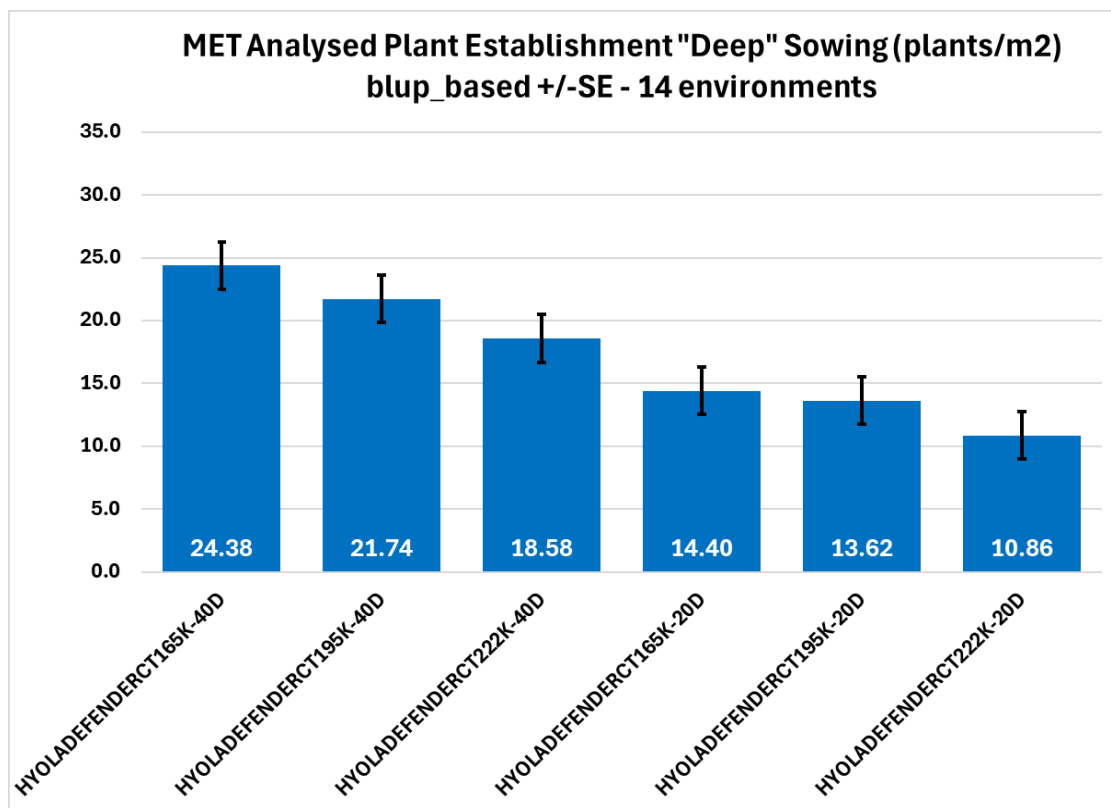
Table 7: VIC analysed Single Site plant establishment density achieved across seed size and depth treatments.

SOUTH AUSTRALIA 2024 SINGLE SITE ANALYSIS	ARTHURTON SA		CUMMINS SA	
Variety * Seed Count/Size * Population* Depth	Est (plants/m2)	se_blup	Est (plants/m2)	se_blup
HYOLADEFENDERCT165K-20D	15.500	2.350	34.371	7.180
HYOLADEFENDERCT165K-20N	19.139	2.355	33.476	7.180
HYOLADEFENDERCT165K-40D	29.437	2.362	56.206	7.199
HYOLADEFENDERCT165K-40N	33.347	2.346	52.677	7.191
HYOLADEFENDERCT195K-20D	16.134	3.595	28.214	5.644
HYOLADEFENDERCT195K-20N	19.230	3.596	26.598	5.644
HYOLADEFENDERCT195K-40D	27.283	3.593	41.463	5.633
HYOLADEFENDERCT195K-40N	34.070	3.573	51.118	5.634
HYOLADEFENDERCT222K-20D	12.771	3.599	21.465	5.628
HYOLADEFENDERCT222K-20N	15.853	3.661	24.652	5.633
HYOLADEFENDERCT222K-40D	22.297	3.577	33.170	5.628
HYOLADEFENDERCT222K-40N	24.968	3.578	38.561	5.628
TRIAL MEAN POPULATION (plants/m2)	23.65		33.86	
CV%	8.34		12.78	

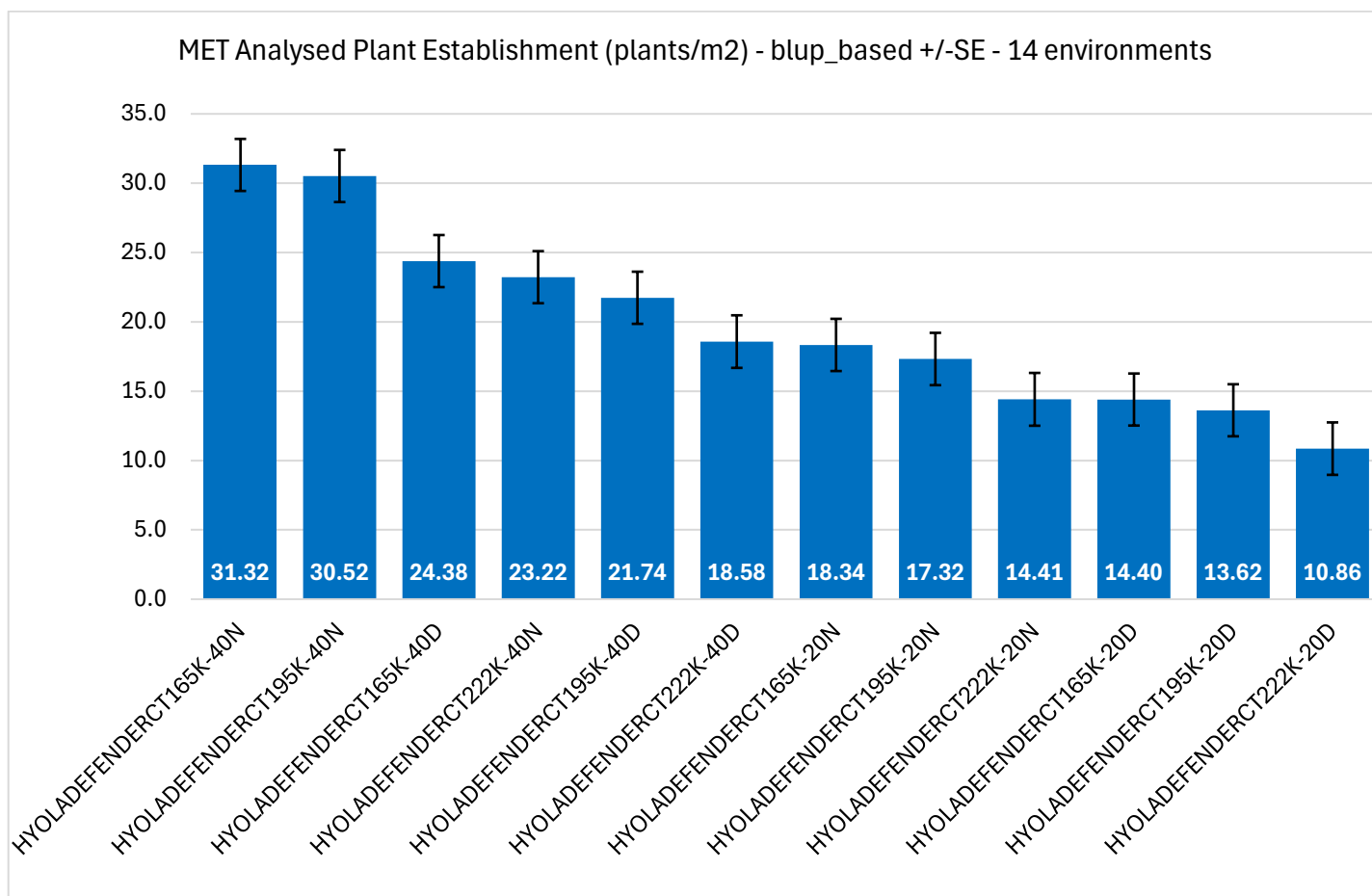
Table 8: SA analysed Single Site plant establishment density achieved across seed size and depth treatments.



Graph 1: MET analysed established plant density by seed size, Normal seed depth and population targets (Mean + SE,  $p < 0.05$ ).



Graph 2: MET analysed established plant density by seed size, Deep sowing depth and population targets (Mean + SE,  $p < 0.05$ ).



Graph 3: MET analysed established plant density by seed size, seed depth and population targets (Mean + SE,  $p < 0.05$ ).

Established plant density for the larger seed size of 165,000 seeds per kg ( $>2\text{mm}$ ) (do we have these seed sizes) sown at normal depth showed some significantly greater ( $p < 0.05$ ) responses compared to mid-size 195,000 seeds per kg ( $=2\text{mm}$ ) and the small size 222,000 seeds per kg ( $<2\text{mm}$ ) treatments.

The 165,000 seeds per kg larger seed with a population target of 20 plants per m<sup>2</sup> sown at normal depth treatment showed plant counts not significantly different to 222,000 seeds per kg smaller seed sown at depth targeting 40m plants per m<sup>2</sup> treatment. This result demonstrates the additional hybrid vigour associated with larger seed vs smaller seed and the associated influence of seeding depth.

There was no significant difference between 165,000 seeds per kg and 195,000 seeds per kg seed treatments sown at 40 plants per m<sup>2</sup> at the normal depth of 10-20mm across all the environments.

Furthermore, there was also no significant difference in plant establishment between the large and mid-size seed sown deeper 30-40 mm at 40 plants per m<sup>2</sup> target, compared to the smaller seed sown at normal depth at 40 plants per m<sup>2</sup> target.

Graph 3 shows the decline in effective plant establishment with greater sowing depth and smaller seed size, which implies that a higher seeding rate would be required when sowing smaller seed especially at depth to establish the equivalent plant density as that of the larger seed.

This leads to increasing costs associated with the smaller seed at greater sowing depth treatments to achieve the agronomic benefits of more plants being additional weed competition and associated harvest management.

The lower established plant densities with some treatments achieved could be attributed to several factors combined such as seed size, population target and seeding depth. Some single sites exhibited better establishment from sowing deeper where subsoil moisture was better than on the surface, irrespective of seed size.

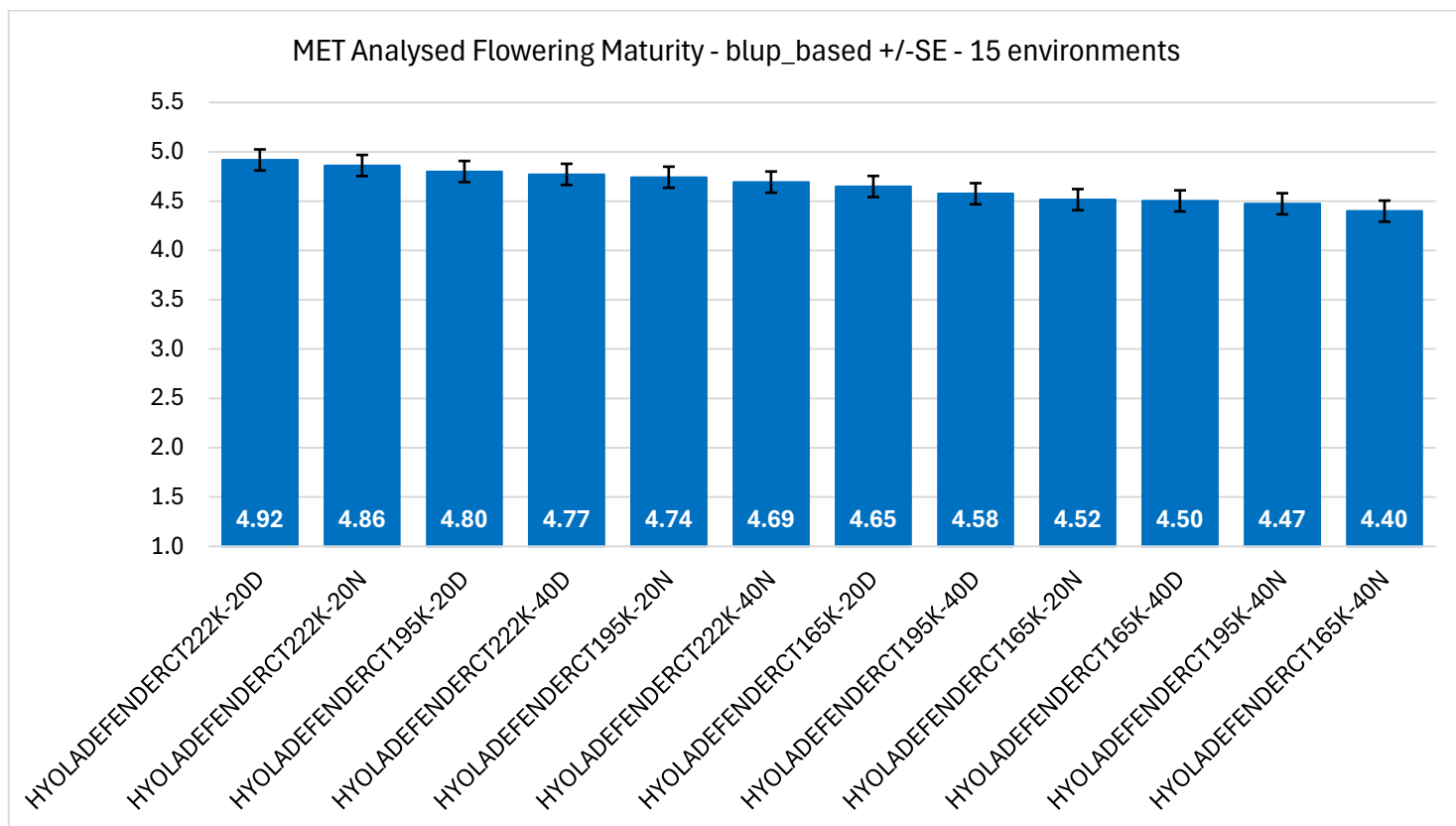
The different rainfall volumes that subsequently fell at individual sites after sowing, then had variable influences on continued germination and establishment of both normal and deep sown treatments.



AUSTRALIAN HYOLA INNOVATION TRIALS - 14 LOCATIONS MET		
Canola Treatment	Establishment (p/m <sup>2</sup> )	SE Significance
HYOLADEFENDERCT165K-40N	31.32	<i>a</i>
HYOLADEFENDERCT195K-40N	30.52	<i>a</i>
HYOLADEFENDERCT165K-40D	24.38	<i>b</i>
HYOLADEFENDERCT222K-40N	23.22	<i>b</i>
HYOLADEFENDERCT195K-40D	21.74	<i>bc</i>
HYOLADEFENDERCT222K-40D	18.58	<i>cd</i>
HYOLADEFENDERCT165K-20N	18.34	<i>cd</i>
HYOLADEFENDERCT195K-20N	17.32	<i>de</i>
HYOLADEFENDERCT222K-20N	14.41	<i>ef</i>
HYOLADEFENDERCT165K-20D	14.40	<i>ef</i>
HYOLADEFENDERCT195K-20D	13.62	<i>ef</i>
HYOLADEFENDERCT222K-20D	10.86	<i>f</i>

Table 9: MET analysed plant establishment density achieved across seed size and depth treatments.

#### Flowering maturity



Graph 4: MET analysed flowering maturity by seed size, seed depth and population targets (Mean + SE,  $p < 0.05$ ).

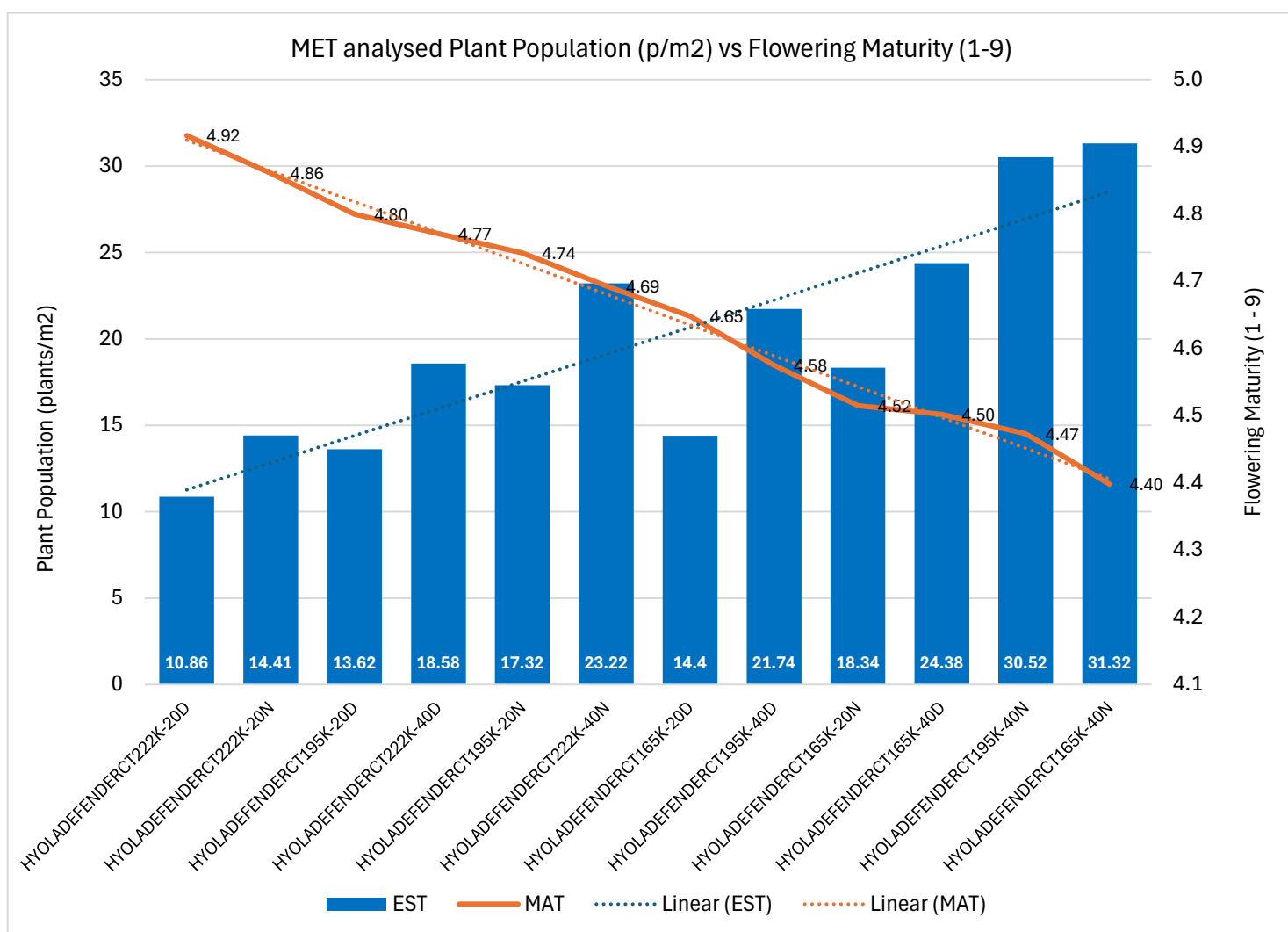
The relative flowering maturity showed the trend of slowing down (later maturing) with the lower plant population target, especially for the smaller seed size at both normal and deep sowing levels.

The faster flowering growth habit was encouraged by larger and mid-size seed sown at the 40 plants per m<sup>2</sup> targets, whether sown at normal or deeper depths.

There was no significant difference between 165,000 seeds per kg and 195,000 seeds per kg seed treatments sown at the normal depth of 10-20mm across all the environments.

Canola Treatment	Flowering Maturity (1-9)	SE_Significance
HYOLADEFENDERCT222K-20D	4.917	<i>a</i>
HYOLADEFENDERCT222K-20N	4.861	<i>ab</i>
HYOLADEFENDERCT195K-20D	4.800	<i>ab</i>
HYOLADEFENDERCT222K-40D	4.771	<i>abc</i>
HYOLADEFENDERCT195K-20N	4.742	<i>abc</i>
HYOLADEFENDERCT222K-40N	4.693	<i>bcd</i>
HYOLADEFENDERCT165K-20D	4.648	<i>b-e</i>
HYOLADEFENDERCT195K-40D	4.575	<i>c-f</i>
HYOLADEFENDERCT165K-20N	4.515	<i>def</i>
HYOLADEFENDERCT165K-40D	4.502	<i>def</i>
HYOLADEFENDERCT195K-40N	4.473	<i>ef</i>
HYOLADEFENDERCT165K-40N	4.398	<i>f</i>

Table 10: MET analysed flowering maturity achieved across seed size and depth treatments.



Graph 5: MET analysed established plants per m2 vs flowering maturity by seed size, seed depth and population targets.

The relationship between flowering maturity to plants established showed a general trend of maturity decreasing as plant population targets increased, however the 165,000 seeds per kg larger seed at 20 plants per m2 target also quickened up in maturity across all the environments.

This may be contributed to the larger seeds ability to germinate and sustain higher growth levels when compared to slower plant growth from the smaller seed treatments.

The 165,000 seeds per kg larger seed treatment also had similar flowering maturity with less established plants per m2 compared to the treatments 195,000 seeds per kg mid-size seed sown at 40 plants per m2 deep and the 222,000 seeds per kg smaller size seed sown at normal depth.

### Grain yield

WESTERN AUSTRALIA 2024 SINGLE SITE ANALYSIS	LATHAM WA		MULLEWA WA		GERALDTON WA	
Variety * Seed Size * Population* Depth	Yield (t/ha)	se_blup	Yield (t/ha)	se_blup	Yield (t/ha)	se_blup
HYOLADEFENDERCT165K-20D	1.861	0.106	1.252	0.132	1.364	0.180
HYOLADEFENDERCT165K-20N	2.032	0.105	1.762	0.126	1.646	0.182
HYOLADEFENDERCT165K-40D	2.043	0.105	1.732	0.128	1.563	0.182
HYOLADEFENDERCT165K-40N	2.147	0.105	2.078	0.125	2.014	0.179
HYOLADEFENDERCT195K-20D	1.558	0.107	1.594	0.127	1.472	0.178
HYOLADEFENDERCT195K-20N	1.816	0.107	1.531	0.134	1.748	0.180
HYOLADEFENDERCT195K-40D	1.953	0.105	1.752	0.126	1.483	0.178
HYOLADEFENDERCT195K-40N	2.006	0.105	1.967	0.125	1.655	0.181
HYOLADEFENDERCT222K-20D	1.472	0.108	1.299	0.128	0.876	0.177
HYOLADEFENDERCT222K-20N	1.535	0.105	1.645	0.127	1.581	0.177
HYOLADEFENDERCT222K-40D	1.620	0.109	1.371	0.126	1.399	0.186
HYOLADEFENDERCT222K-40N	1.585	0.107	1.551	0.127	1.714	0.178
<b>TRIAL MEAN YIELD (t/ha)</b>	<b>1.962</b>		<b>1.980</b>		<b>1.986</b>	
<b>CV%</b>	<b>5.781</b>		<b>8.688</b>		<b>11.400</b>	

Table 11: WA analysed Single Grain yield (t/ha) achieved across seed size and depth treatments.

EASTERN AUSTRALIA 2024 SINGLE SITE ANALYSIS	YORK WA		GIBSON WA		HYDEN WA	
Variety * Seed Count/Size * Population* Depth	Yield (t/ha)	se_blup	Yield (t/ha)	se_blup	Yield (t/ha)	se_blup
HYOLADEFENDERCT165K-20D	2.121	0.195	1.615	0.144	2.522	0.106
HYOLADEFENDERCT165K-20N	2.244	0.199	1.788	0.144	2.165	0.107
HYOLADEFENDERCT165K-40D	2.473	0.196	1.919	0.144	2.650	0.108
HYOLADEFENDERCT165K-40N	2.600	0.195	1.871	0.144	2.531	0.106
HYOLADEFENDERCT195K-20D	1.793	0.196	1.792	0.144	2.220	0.106
HYOLADEFENDERCT195K-20N	2.231	0.202	1.689	0.144	1.964	0.107
HYOLADEFENDERCT195K-40D	2.091	0.197	1.646	0.144	2.351	0.107
HYOLADEFENDERCT195K-40N	2.145	0.197	1.783	0.144	2.271	0.108
HYOLADEFENDERCT222K-20D	1.551	0.198	1.804	0.144	1.870	0.106
HYOLADEFENDERCT222K-20N	1.870	0.196	1.771	0.144	1.843	0.108
HYOLADEFENDERCT222K-40D	1.956	0.197	1.817	0.144	2.082	0.106
HYOLADEFENDERCT222K-40N	1.893	0.197	1.909	0.144	2.048	0.107
<b>TRIAL MEAN YIELD (t/ha)</b>	<b>2.403</b>		<b>1.962</b>		<b>2.717</b>	
<b>CV%</b>	<b>8.996</b>		<b>14.298</b>		<b>4.637</b>	

Table 12: WA analysed Single Grain yield (t/ha) achieved across seed size and depth treatments. (Cont.)

NEW SOUTH WALES & QLD 2024 SINGLE SITE ANALYSIS	COWRA NSW		LOCKHART NSW		ALLORA QLD	
Variety * Seed Count/Size * Population* Depth	Yield (t/ha)	se_blup	Yield (t/ha)	se_blup	Yield (t/ha)	se_blup
HYOLADEFENDERCT165K-20D	1.728	0.104	1.705	0.144	3.146	0.198
HYOLADEFENDERCT165K-20N	1.755	0.103	1.397	0.142	3.329	0.198
HYOLADEFENDERCT165K-40D	1.888	0.105	1.797	0.142	3.305	0.198
HYOLADEFENDERCT165K-40N	1.889	0.105	1.522	0.145	2.915	0.198
HYOLADEFENDERCT195K-20D	1.537	0.103	1.497	0.143	3.164	0.200
HYOLADEFENDERCT195K-20N	1.650	0.103	1.243	0.146	3.142	0.198
HYOLADEFENDERCT195K-40D	1.545	0.103	1.597	0.140	3.353	0.197
HYOLADEFENDERCT195K-40N	1.757	0.104	1.458	0.141	3.113	0.198
HYOLADEFENDERCT222K-20D	1.332	0.106	1.266	0.140	2.930	0.199
HYOLADEFENDERCT222K-20N	1.605	0.108	1.167	0.140	3.046	0.198
HYOLADEFENDERCT222K-40D	1.547	0.103	1.651	0.146	3.170	0.199
HYOLADEFENDERCT222K-40N	1.500	0.103	1.494	0.141	3.380	0.199
<b>TRIAL MEAN YIELD (t/ha)</b>	<b>1.954</b>		<b>1.619</b>		<b>3.348</b>	
<b>CV%</b>	<b>6.386</b>		<b>10.641</b>		<b>7.474</b>	

Table 13: NSW & QLD analysed Single Grain yield (t/ha) achieved across seed size and depth treatments.

VICTORIA 2024 SINGLE SITE ANALYSIS	YARRAWONGA VIC		BIRCHIP VIC		STREATHAM VIC	
Variety * Seed Count/Size * Population* Depth	Yield (t/ha)	se_blup	Yield (t/ha)	se_blup	Yield (t/ha)	se_blup
HYOLADEFENDERCT165K-20D	2.272	0.104	1.203	0.137	3.028	0.186
HYOLADEFENDERCT165K-20N	2.460	0.105	1.179	0.137	3.127	0.186
HYOLADEFENDERCT165K-40D	2.712	0.103	1.305	0.137	3.217	0.186
HYOLADEFENDERCT165K-40N	2.608	0.103	1.411	0.137	3.290	0.184
HYOLADEFENDERCT195K-20D	2.071	0.109	1.225	0.138	2.905	0.185
HYOLADEFENDERCT195K-20N	2.073	0.103	1.387	0.138	3.185	0.185
HYOLADEFENDERCT195K-40D	2.300	0.103	1.327	0.137	3.228	0.184
HYOLADEFENDERCT195K-40N	2.384	0.105	1.273	0.139	3.046	0.187
HYOLADEFENDERCT222K-20D	1.702	0.104	1.174	0.137	2.701	0.188
HYOLADEFENDERCT222K-20N	1.925	0.103	1.197	0.137	3.224	0.185
HYOLADEFENDERCT222K-40D	2.060	0.103	1.396	0.137	2.759	0.186
HYOLADEFENDERCT222K-40N	2.324	0.104	1.389	0.140	3.258	0.186
<b>TRIAL MEAN YIELD (t/ha)</b>	<b>2.607</b>		<b>1.374</b>		<b>3.235</b>	
<b>CV%</b>	<b>5.361</b>		<b>11.276</b>		<b>9.413</b>	

Table 14: VIC analysed Single Grain yield (t/ha) achieved across seed size and depth treatments.

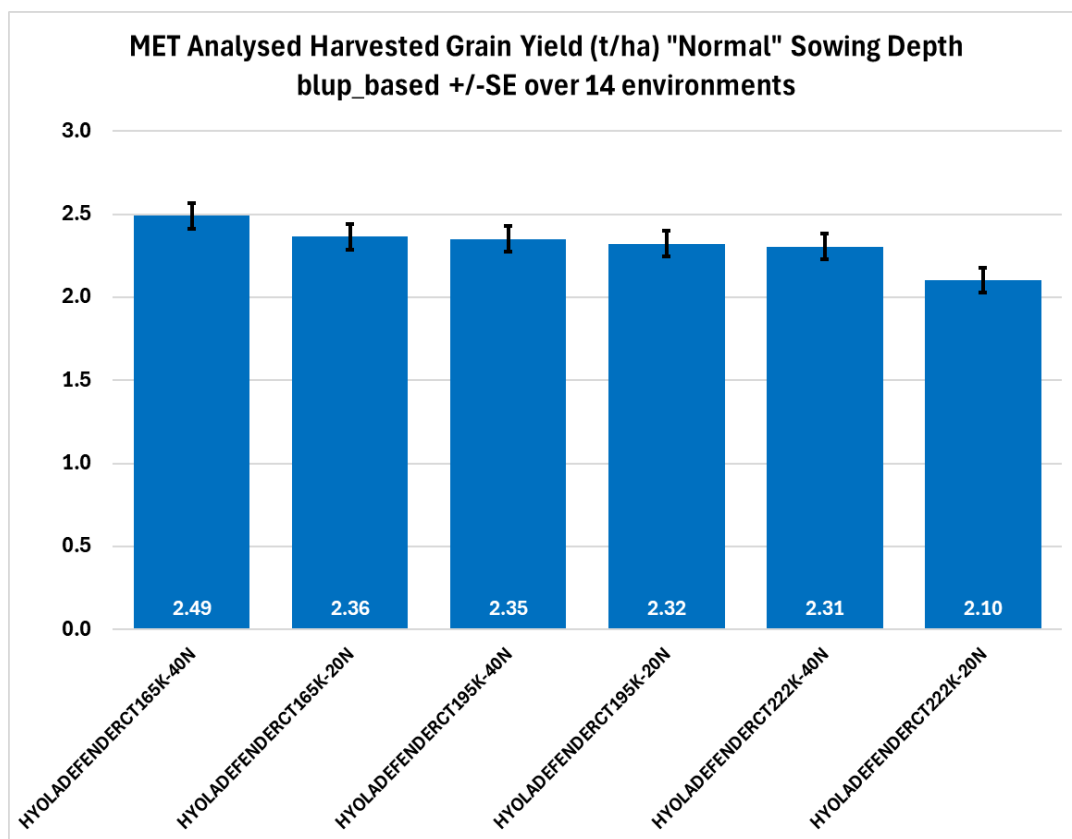
SOUTH AUSTRALIA 2024 SINGLE SITE ANALYSIS	ARTHURTON SA		CUMMINS SA	
Variety * Seed Count/Size * Population* Depth	Yield (t/ha)	se_blup	Yield (t/ha)	se_blup
HYOLADEFENDERCT165K-20D	1.924	0.104	4.762	0.172
HYOLADEFENDERCT165K-20N	1.912	0.103	4.759	0.171
HYOLADEFENDERCT165K-40D	1.986	0.103	4.792	0.176
HYOLADEFENDERCT165K-40N	1.797	0.103	4.658	0.171
HYOLADEFENDERCT195K-20D	1.987	0.103	4.517	0.172
HYOLADEFENDERCT195K-20N	2.032	0.104	4.621	0.171
HYOLADEFENDERCT195K-40D	1.840	0.105	4.774	0.171
HYOLADEFENDERCT195K-40N	1.958	0.104	4.509	0.174
HYOLADEFENDERCT222K-20D	1.544	0.106	3.971	0.171
HYOLADEFENDERCT222K-20N	1.736	0.103	4.452	0.171
HYOLADEFENDERCT222K-40D	1.968	0.103	4.481	0.176
HYOLADEFENDERCT222K-40N	1.819	0.107	4.611	0.174
<b>TRIAL MEAN YIELD (t/ha)</b>	<b>1.913</b>		<b>4.889</b>	
<b>CV%</b>	<b>6.337</b>		<b>3.766</b>	

Table 15: SA analysed Single Grain yield (t/ha) achieved across seed size and depth treatments.

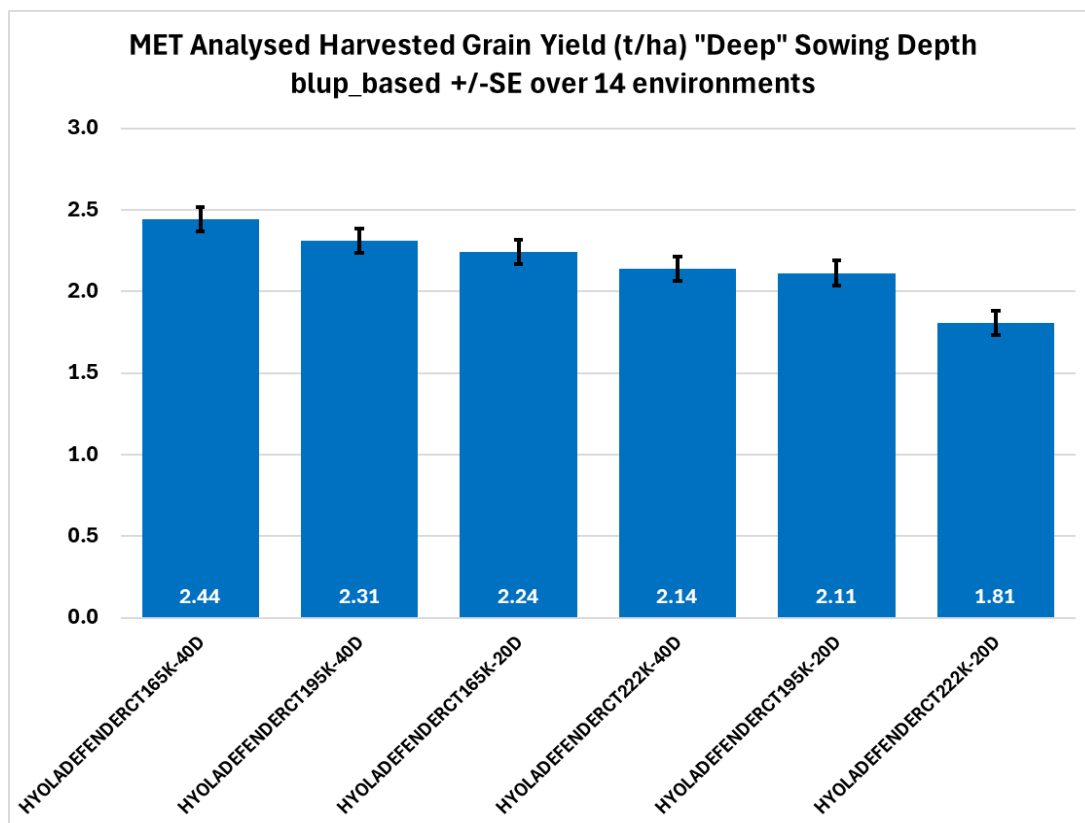
Some single site environments exhibited better establishment and yields from sowing deeper where subsoil moisture was better than on the surface, irrespective of seed size.

Establishment patterns and final yields were similar to what growers can experience with commercial canola crops. The different starting soil moisture profiles and variable rainfall events that subsequently fell at individual trial sites after sowing, had variable influences on continued germination, establishment and growth of both normal and deep sown treatments ultimately may have also affected final yields across some of the environments.

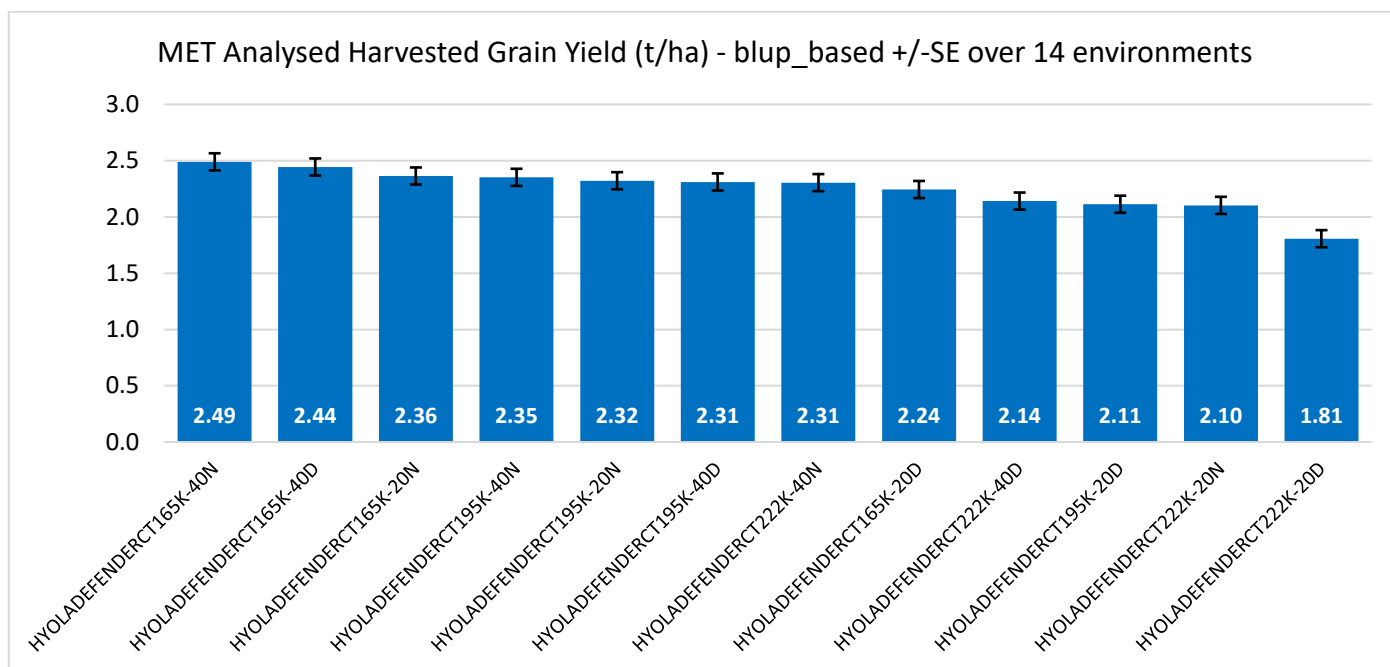




Graph 6: MET analysed harvested grain yield by seed size, normal sowing depth and population targets (Mean + SE,  $p < 0.05$ ).



Graph 7: MET analysed harvested grain yield by seed size, Deep sowing depth and population targets (Mean + SE,  $p < 0.05$ ).



Graph 8: MET analysed harvested grain yield by seed size, seed depth and population targets (Mean + SE,  $p < 0.05$ ).

AUSTRALIAN HYOLA INNOVATION TRIALS - 14 LOCATIONS MET			
Canola Treatment	Yield (t/ha)	se_blup	Significance
HYOLADEFENDERCT165K-40N	2.49	0.076	a
HYOLADEFENDERCT165K-40D	2.44	0.076	ab
HYOLADEFENDERCT165K-20N	2.36	0.076	abc
HYOLADEFENDERCT195K-40N	2.35	0.076	abc
HYOLADEFENDERCT195K-20N	2.32	0.076	bc
HYOLADEFENDERCT195K-40D	2.31	0.076	bc
HYOLADEFENDERCT222K-40N	2.31	0.076	bc
HYOLADEFENDERCT165K-20D	2.24	0.076	cd
HYOLADEFENDERCT222K-40D	2.14	0.076	d
HYOLADEFENDERCT195K-20D	2.11	0.076	d
HYOLADEFENDERCT222K-20N	2.10	0.076	d
HYOLADEFENDERCT222K-20D	1.81	0.076	e

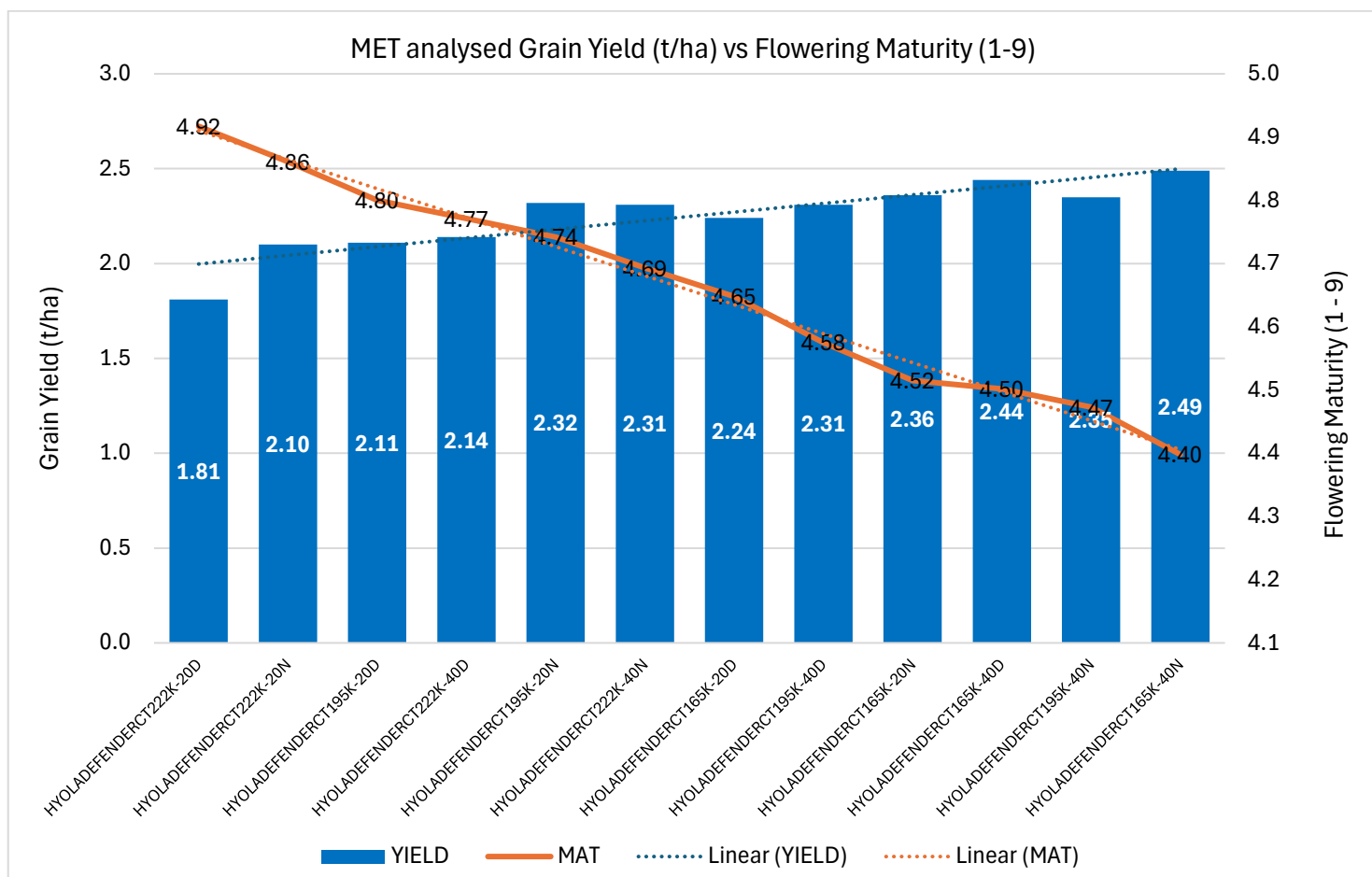
Table 16: MET analysed harvested grain yield (t/ha) achieved across seed size and depth treatments.

The larger seed size of 165,000 seeds per kg (>2mm) sown at normal depth for 20 or 40 plants per m<sup>2</sup> targets showed some significantly greater ( $p < 0.05$ ) yield responses, compared to mid-size 195,000 seeds per kg (=2mm) sown at depth for 20 plants per m<sup>2</sup> target and the small size 222,000 seeds per kg (<2mm) sown either normal or at depth whether 20 or 40 plants per m<sup>2</sup> targets.

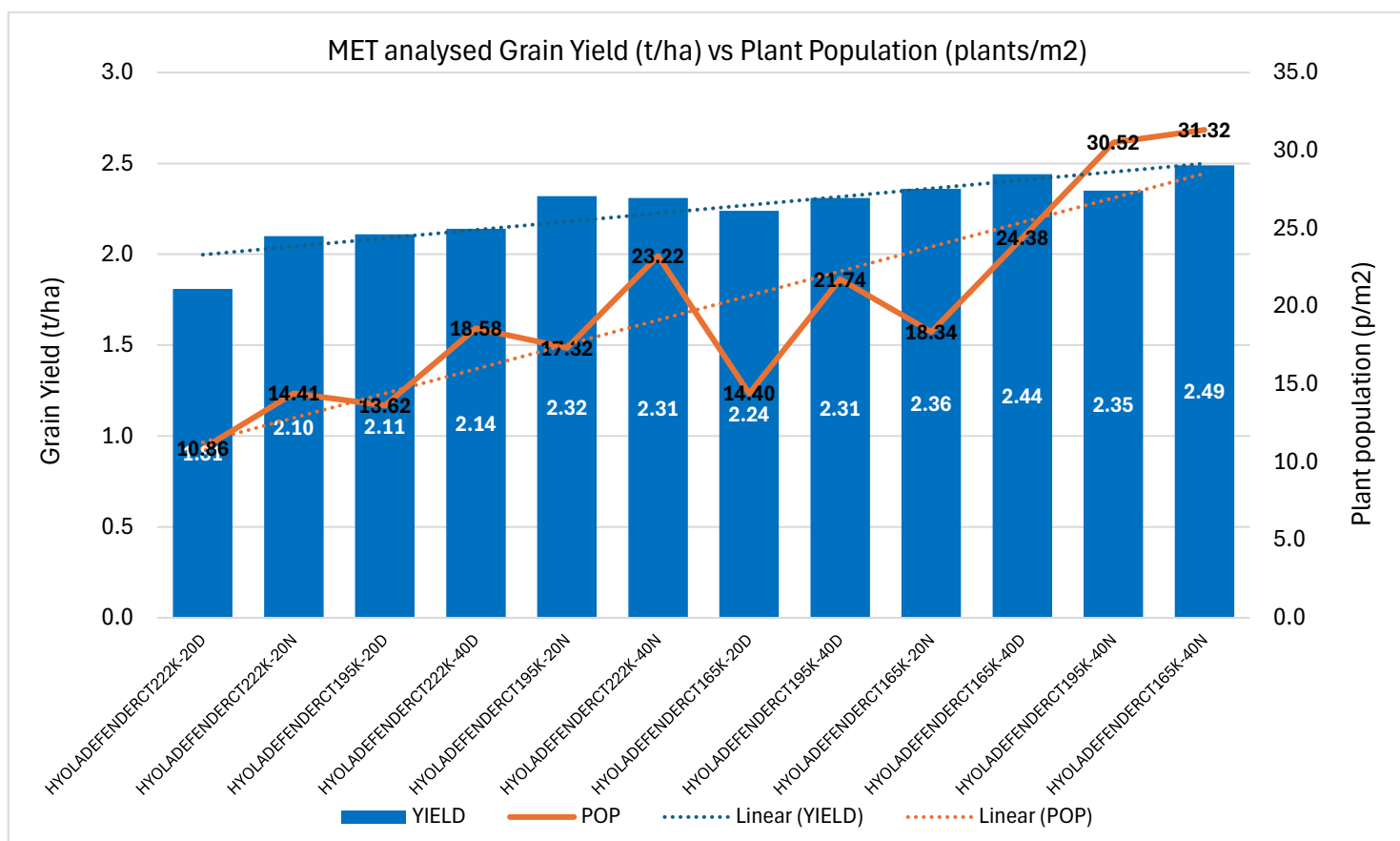
The 165,000 seeds per kg larger seed with a population target of 20 plants per m<sup>2</sup> sown at normal depth treatment showed grain yields not significantly different to 222,000 seeds per kg smaller seed sown at 40 plants per m<sup>2</sup> at normal depth. This result demonstrates the additional hybrid vigour associated with larger seed vs smaller seed and the ability of stronger growing plants to compensate for yield across many environments.

There was no significant difference between 165,000 seeds per kg sown at 20 or 40 plants per m<sup>2</sup> in normal depth and the 195,000 seeds per kg treatment sown at 40 plants per m<sup>2</sup> in the normal depth of 10-20mm across all the environments. The smaller 222,000 seeds per kg treatments sown at 20 or 40 plants per m<sup>2</sup> in deep levels or 20 plants per m<sup>2</sup> at normal depth showed significantly lower yields than smaller 222,000 seeds per kg at 40 plants per m<sup>2</sup> in normal depth.

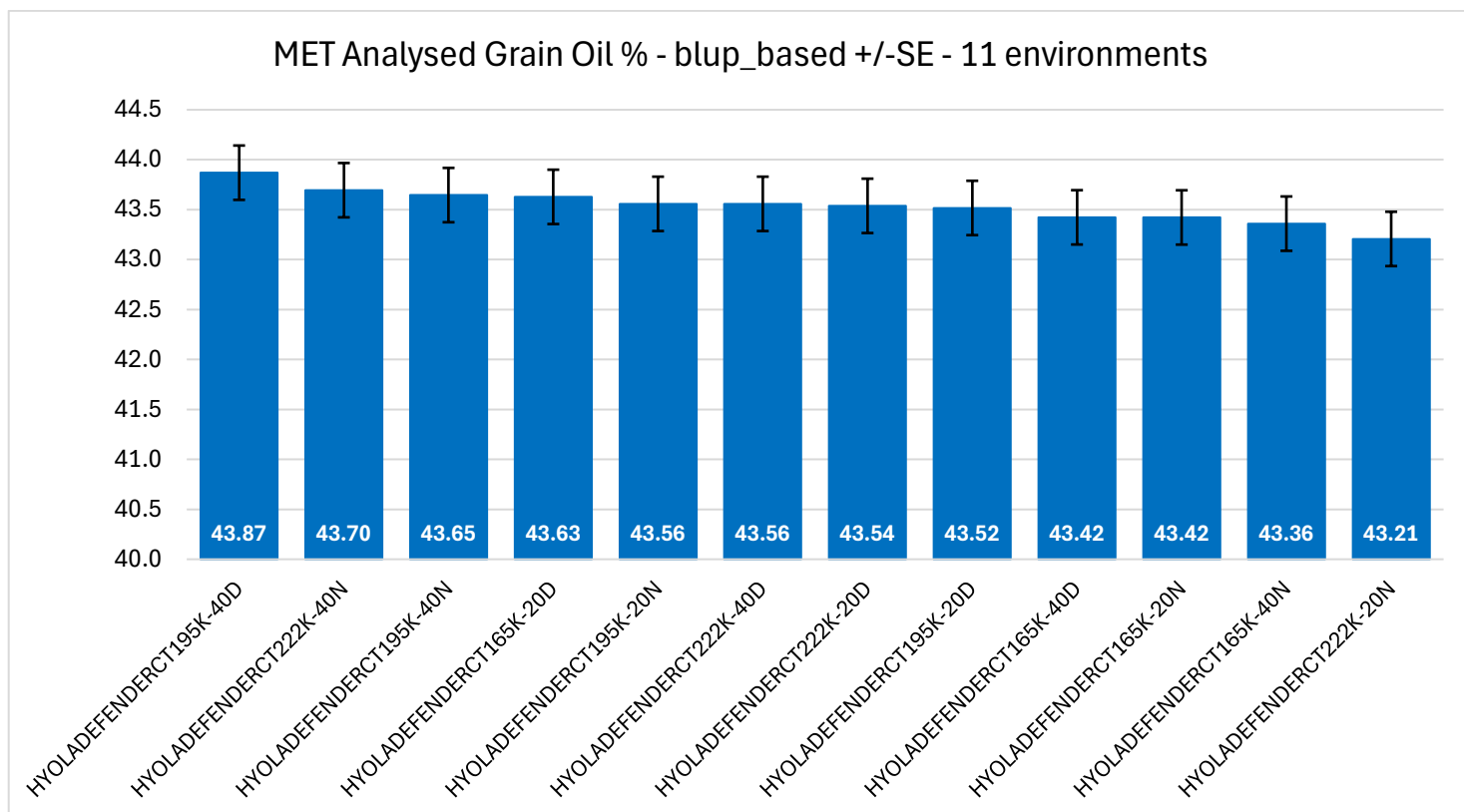
Graph 4 shows the decline in grain yield with greater depth and smaller seed size, which implies that a higher seeding rate would be required when sowing smaller seeds, especially at depth, to establish the equivalent plant density and potential yield as that of the larger seed treatments. Refer below to graphs 5 and 6 which show the complex relationships between MET analysed Grain yield to flowering maturity and comparing Grain yield to plants established.



Graph 9: MET analysed grain yield (t/ha) vs flowering maturity by seed size, seed depth and population targets.



Graph 10: MET analysed grain yield (t/ha) vs established plant population per m2 by seed size, seed depth and population targets.



Graph 11: MET analysed Oil% across all treatments, (Mean + SE,  $p < 0.05$ ).

Variety*Treatment	Oil %	SE_Significance
HYOLADEFENDERCT195K-40D	43.87	<i>a</i>
HYOLADEFENDERCT222K-40N	43.70	<i>ab</i>
HYOLADEFENDERCT195K-40N	43.65	<i>ab</i>
HYOLADEFENDERCT165K-20D	43.63	<i>ab</i>
HYOLADEFENDERCT195K-20N	43.56	<i>ab</i>
HYOLADEFENDERCT222K-40D	43.56	<i>ab</i>
HYOLADEFENDERCT222K-20D	43.54	<i>ab</i>
HYOLADEFENDERCT195K-20D	43.52	<i>ab</i>
HYOLADEFENDERCT165K-40D	43.42	<i>ab</i>
HYOLADEFENDERCT165K-20N	43.42	<i>ab</i>
HYOLADEFENDERCT165K-40N	43.36	<i>ab</i>
HYOLADEFENDERCT222K-20N	43.21	<i>b</i>

Table 17: MET analysed grain Oil % achieved across seed size, plant population and depth treatments.

The different seed size, plant population target and sowing depth treatments showed very few significant differences for final grain oil %, which suggests that oil content is driven by a range of interacting factors not limited to genetics, soil water holding capacity, seasonal rainfall, temperature, soil structural impediments, soil nutrition, relative humidities and timing of desiccation or windrowing.

These results show that throughout many environments, there was only a 0.66% difference in oil % values across all treatments.

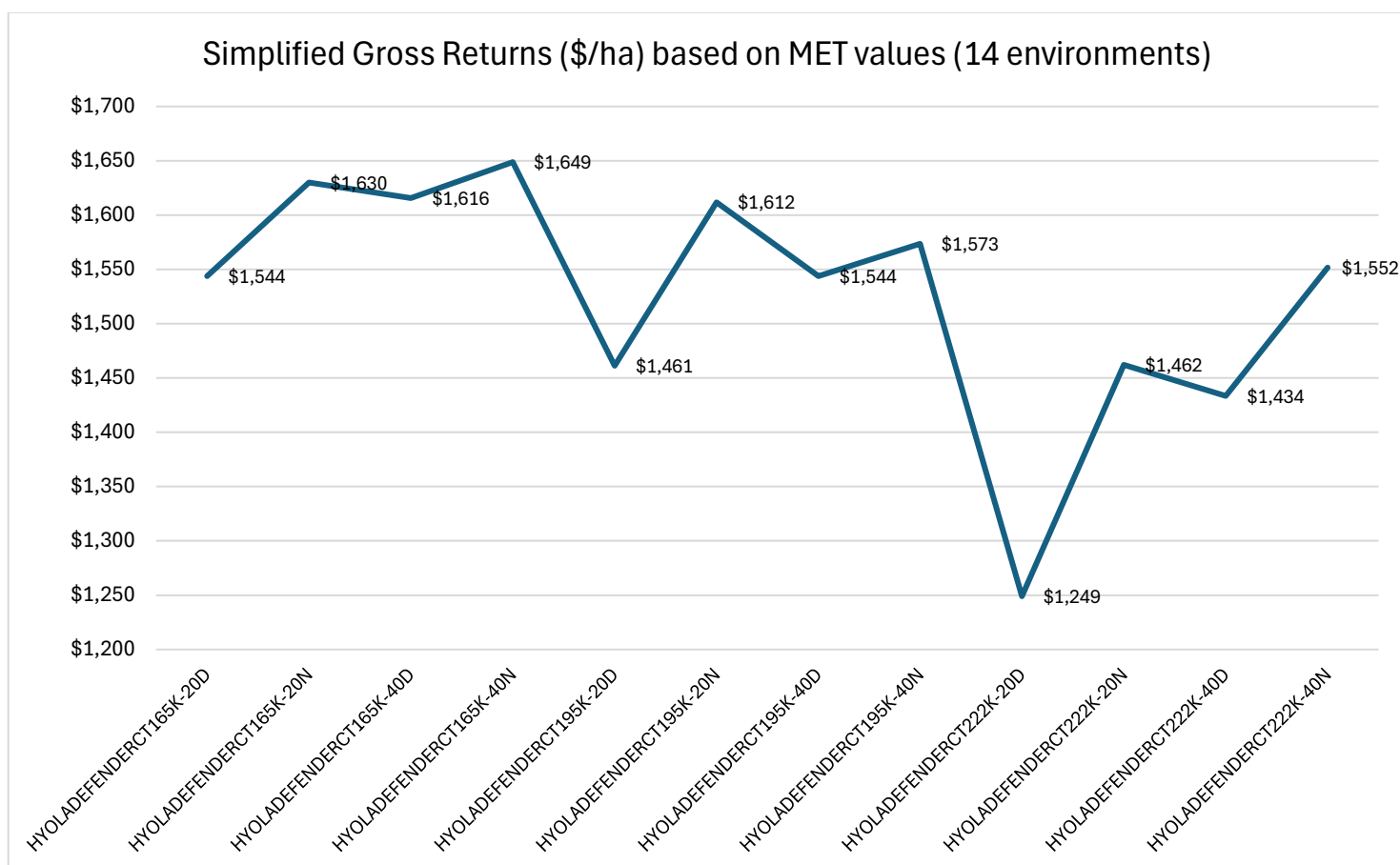


## Simplified gross margins

Variety*Treatment	Seed Count/kg	Sowing rate kg/ha	Seed cost \$/ha
HYOLADEFENDERCT165K-20D	165,000	1.80	\$ 72.00
HYOLADEFENDERCT165K-20N	165,000	1.80	\$ 72.00
HYOLADEFENDERCT165K-40D	165,000	3.60	\$ 144.00
HYOLADEFENDERCT165K-40N	165,000	3.60	\$ 144.00
HYOLADEFENDERCT195K-20D	195,000	1.50	\$ 60.00
HYOLADEFENDERCT195K-20N	195,000	1.50	\$ 60.00
HYOLADEFENDERCT195K-40D	195,000	3.00	\$ 120.00
HYOLADEFENDERCT195K-40N	195,000	3.00	\$ 120.00
HYOLADEFENDERCT222K-20D	222,000	1.30	\$ 52.00
HYOLADEFENDERCT222K-20N	222,000	1.30	\$ 52.00
HYOLADEFENDERCT222K-40D	222,000	2.70	\$ 108.00
HYOLADEFENDERCT222K-40N	222,000	2.70	\$ 108.00

Table 18: Seed size, sowing rate, and seed cost \$/ha for canola treatments.

Table 18 shows the distribution of seed cost per hectare based on seed count, sowing rate required to achieve the calculated target plant density of either 20 or 40 plants/m<sup>2</sup> and the value of seed. These values were determined from Tables 2 a-b.



Graph 12: Simplified Gross Returns based on MET analysed yield values for all treatments over 14 environments.

Variety*Treatment	Simplified Gross Returns \$/ha
HYOLADEFENDERCT165K-40N	\$1,649
HYOLADEFENDERCT165K-20N	\$1,630
HYOLADEFENDERCT165K-40D	\$1,616
HYOLADEFENDERCT195K-20N	\$1,612
HYOLADEFENDERCT195K-40N	\$1,573
HYOLADEFENDERCT222K-40N	\$1,552
HYOLADEFENDERCT195K-40D	\$1,544
HYOLADEFENDERCT165K-20D	\$1,544
HYOLADEFENDERCT222K-20N	\$1,462
HYOLADEFENDERCT195K-20D	\$1,461
HYOLADEFENDERCT222K-40D	\$1,434
HYOLADEFENDERCT222K-20D	\$1,249

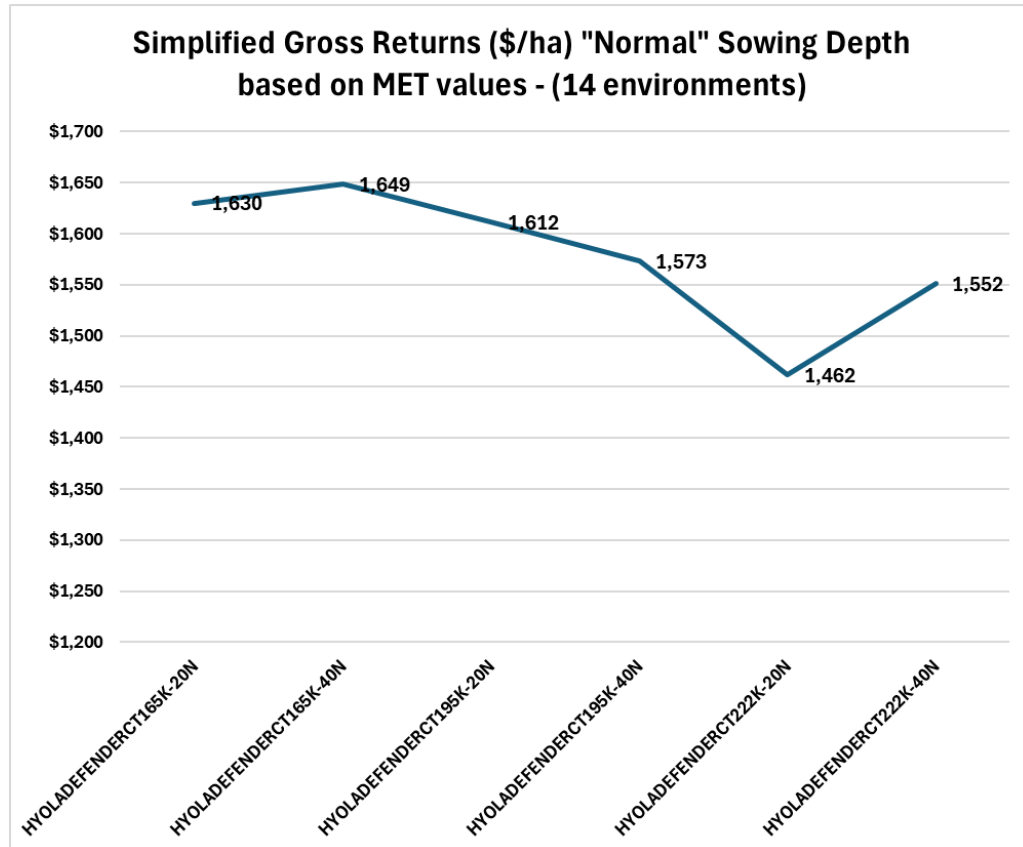
Table 19: Simplified Gross Returns in \$/ha across seed size, sowing rate, and plant population treatments.

Table 19 highlights the gross return differences across 14 environments for the different treatments. The larger seed size of 165,000 seeds per kg (>2mm) sown at normal depth, for 20 or 40 plants per m2 targets and the 165,000 seeds per kg (>2mm) sown at greater depth, for 40 plants per m2 targets, showed the highest SGM values and best value equations.

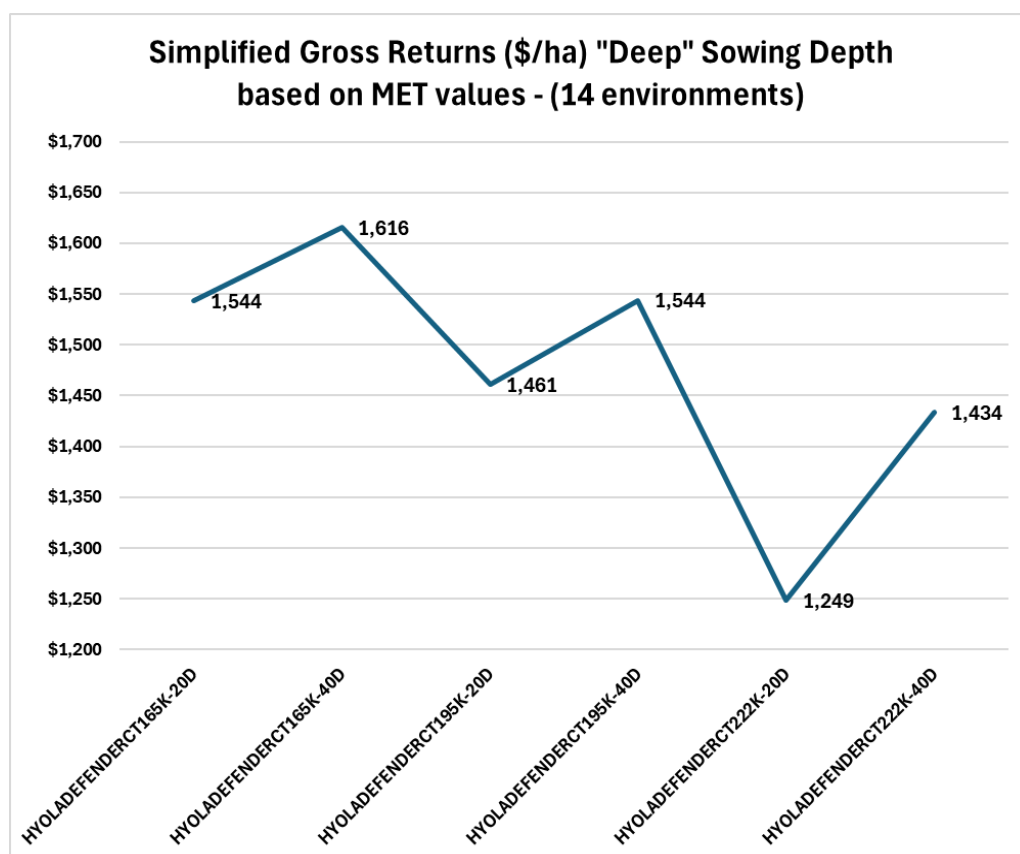
The mid-size 195,000 (=2mm) sown at normal depth for 20 or 40 plants per m2 targets and the smaller 222,000 seeds per kg (<2mm) sown at normal depth for 40 plants per m2 target, then showed the next best SGM values.

The 222,000 smaller seed along with the 195,000 mid-size seed sown at 20 plants per m2 deep showed the lowest SGM values and least value for money.

Graph 12 shows the declining trend in simplified gross returns with more depth and smaller seed size, which implies that a higher seeding rate would be required when sowing smaller seed especially at depth to establish the competitive plant densities and potential gross returns as that of the larger seed treatments.

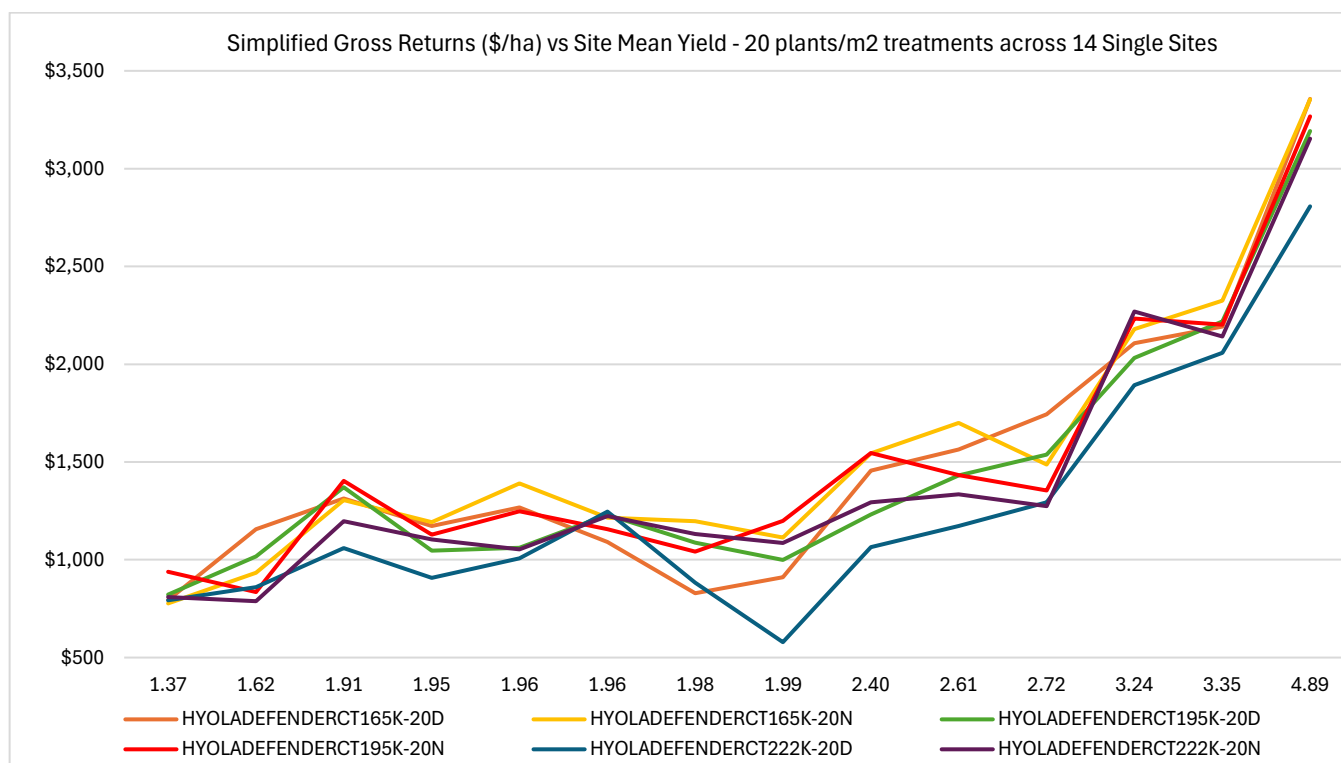


Graph 13: Simplified Gross Returns based on MET analysed yield values for all normal sowing depth treatments over 14 environments.

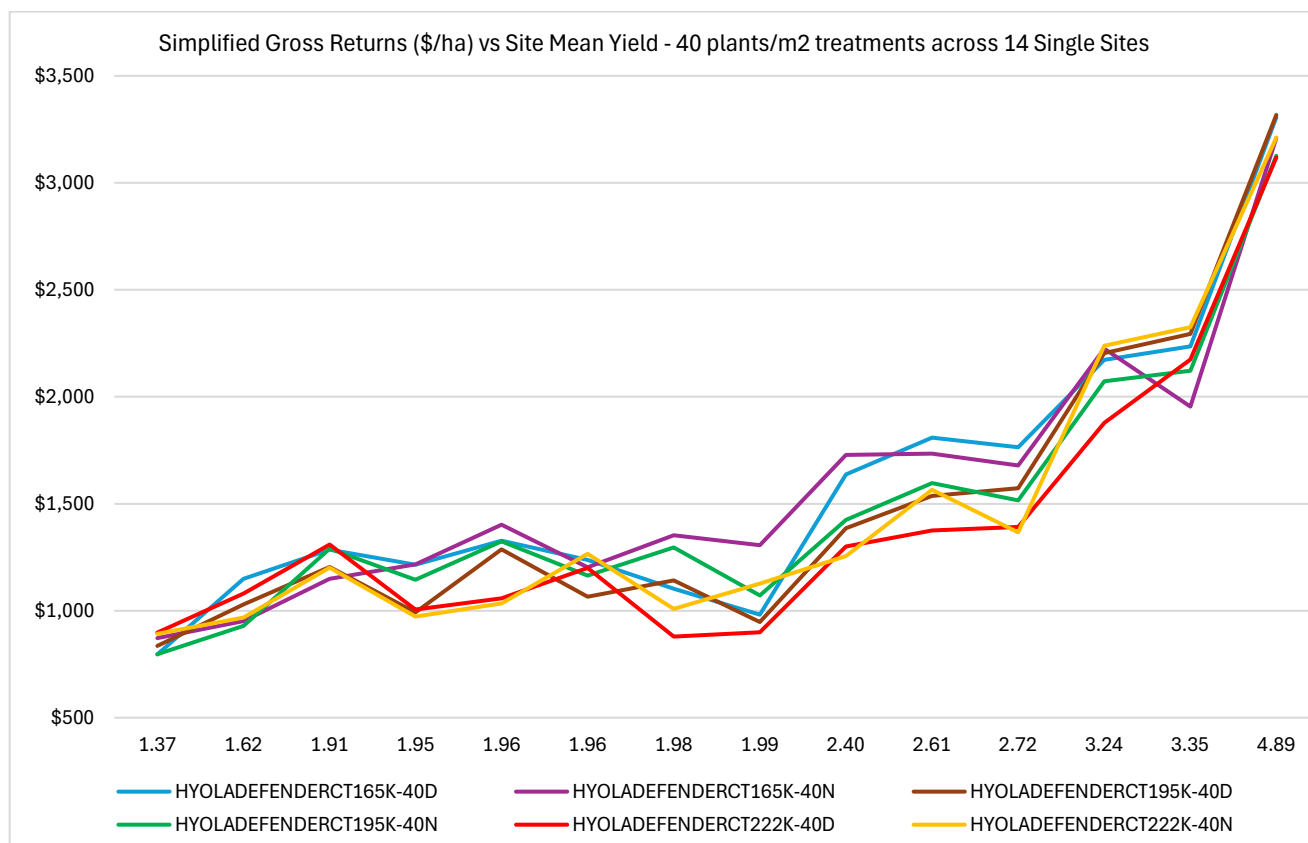


Graph 14: Simplified Gross Returns based on MET analysed yield values for all deeper sowing depth treatments over 14 environments.

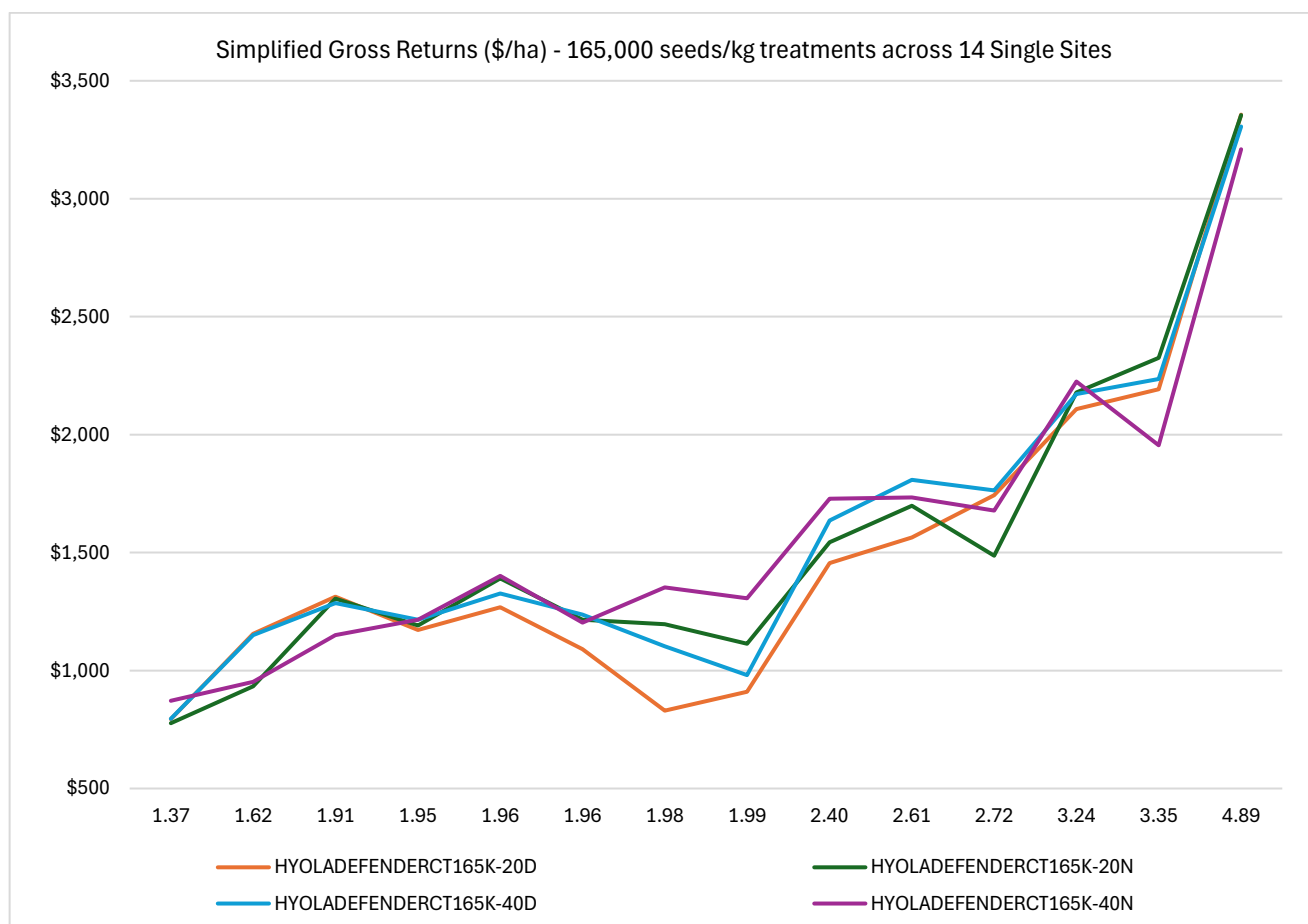
Refer below to graphs 15, 16, 17, 18 and 19 which show the specific relationships between Simplified gross returns across single sites and different types of treatments.



Graph 15: Simplified Gross Returns based on MET analysed yield values for all 20 plants per m2 treatments over 14 trials.

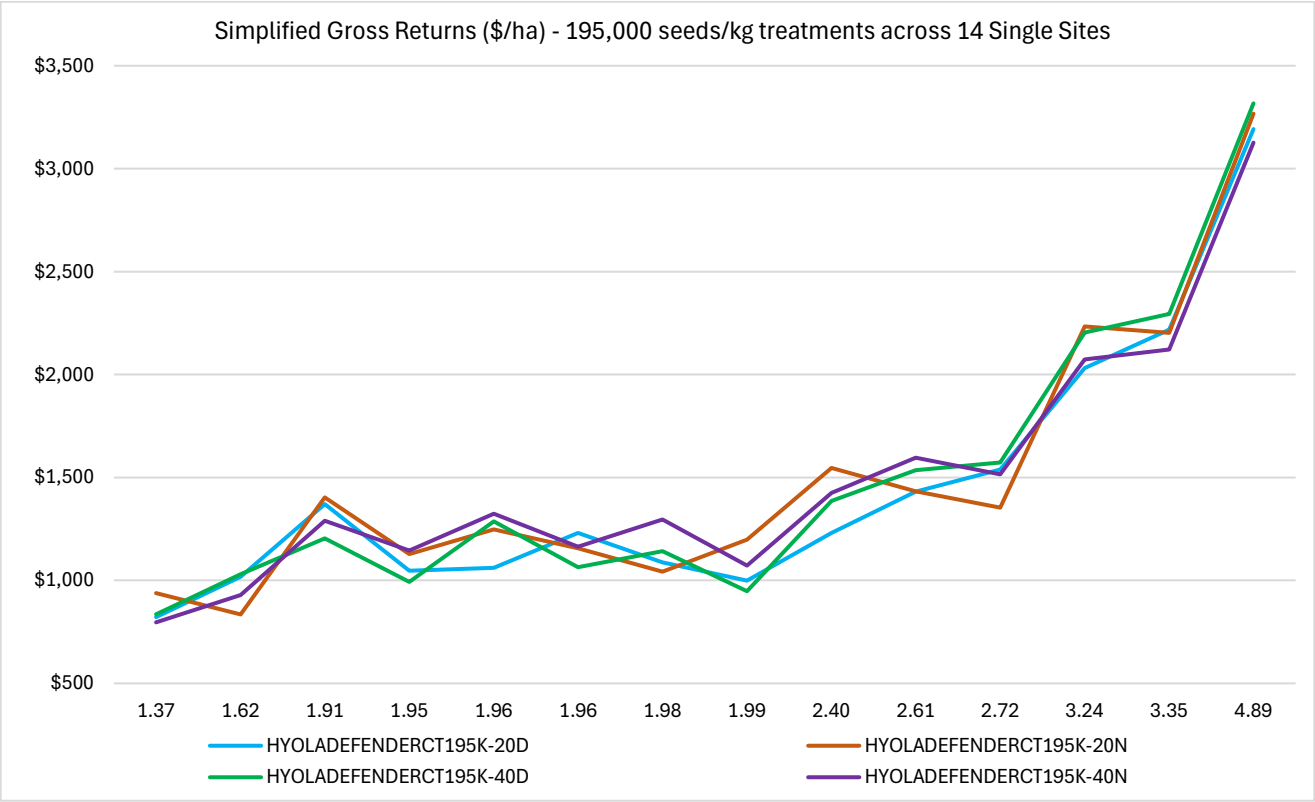


Graph 16: Simplified Gross Returns based on MET analysed yield values for all 40 plants per m2 treatments over 14 trials.

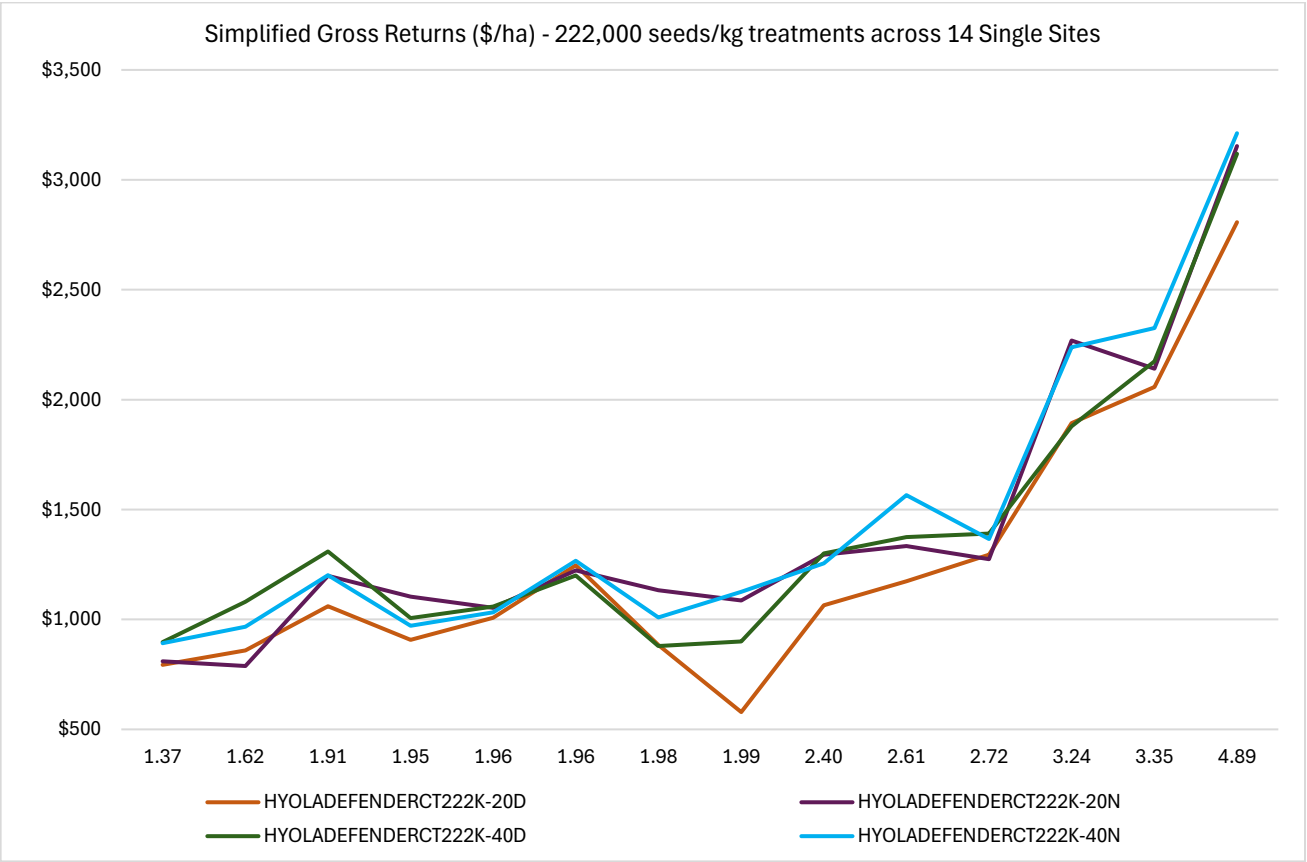


Graph 17: Simplified Gross Returns based on MET analysed yield values for all 165,000 seeds/kg treatments over 14 trials.





Graph 18: Simplified Gross Returns based on MET analysed yield values for all 195,000 seeds/kg treatments over 14 trials.



Graph 19: Simplified Gross Returns based on MET analysed yield values for all 222,000 seeds/kg treatments over 14 trials.

## Conclusion:

Sowing smaller sized canola seed, especially at depth, can lead to lower plant establishment, later flowering, decreased yields and gross returns to growers and their associated profitability.

Even though soil temperatures and daily maximum soil temperatures (Tmax) were not measured at these sites, previous research has shown that diurnal variation increased at shallower sowing depths. Tmax varies between sites according to differences in weather, soil colour and texture.

Fletcher et al. (2024) showed results that demonstrate the impact of sowing depth on conditions experienced by emerging canola seedlings but indicate the soil environment is more favourable at depth. Research to explore genetic and management strategies to capitalise on deeper sowing will improve the reliability of canola establishment.

The value equation associated with upfront seed cost per ha drives the notion of growers wanting to reduce the sowing rate to reduce the upfront costs and potentially optimise \$/ha returns. This research found that deeper sowing from 10-20mm down to 30-40mm across the different seed size treatments decreased plant establishment by 30% on average.

Established plant density for the larger seed size of 165,000 seeds per kg (>2mm) sown at normal depth showed some significantly greater ( $p < 0.05$ ) responses compared to mid-size 195,000 seeds per kg (=2mm) and the small size 222,000 seeds per kg (<2mm) treatments.

The relationship between flowering maturity to plants established showed a general trend of maturity decreasing as plant population targets increased, however the 165,000 larger seed at 20 plants per m<sup>2</sup> target also quickened up in maturity across all the environments.

The larger seed size of 165,000 seeds per kg (>2mm) sown at normal depth for 20 or 40 plants per m<sup>2</sup> targets showed some significantly greater ( $p < 0.05$ ) yield responses, compared to mid-size 195,000 seeds per kg (=2mm) sown at depth for 20 plants per m<sup>2</sup> target and the small size 222,000 seeds per kg (<2mm) sown either normal or at depth whether 20 or 40 plants per m<sup>2</sup> targets.

Across all the treatments, there was only a 0.66% difference in oil % values with very few significant differences.

The highest SGM values and best value equations for growers were identified from the larger seed size of 165,000 seeds per kg (>2mm) sown at normal depth 10-20mm, for 20 or 40 plants per m<sup>2</sup> targets and the 165,000 seeds per kg (>2mm) sown at more depth 30-40mm, for 40 plants per m<sup>2</sup> targets.

The 195,000 seeds per kg (=2mm) mid-sized seed sown at normal depth 10-20mm, for 40 plants per m<sup>2</sup> targets also provided competitive establishment, grain yields and gross returns for canola growers. These findings align well with previous research showing 150-200k seeds per kg is an optimal range for canola sowing seed and best value equations.

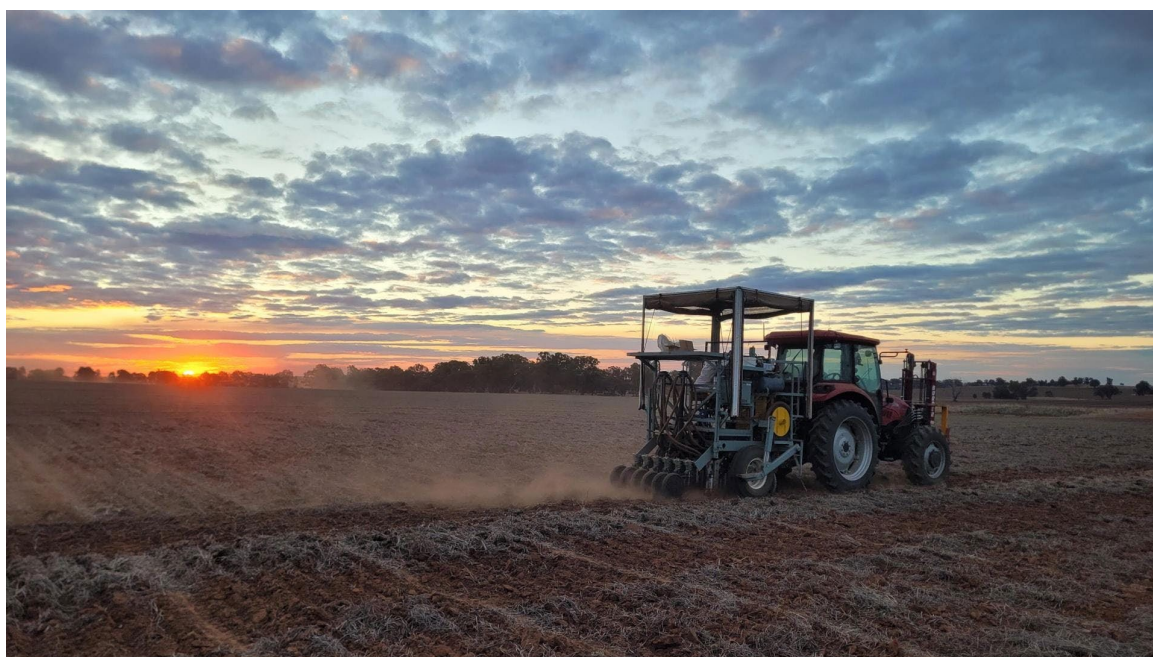


Image 2: Lockhart NSW 10-15mm sowing depth treatments being sown.

## References

- Rohan Brill<sup>1</sup>, Leigh Jenkins<sup>2</sup> and Matthew Gardner<sup>3</sup> (2014) GRDC Canola establishment; does size matter?
- Rohan Brill<sup>1</sup>, Matthew Gardner<sup>2</sup>, Leigh Jenkins<sup>3</sup> and Tim McNee<sup>4</sup> (2013) GRDC Canola establishment: effect of variety choice seeding depth and phosphorus rate
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