2022-23 Pacific Seeds Hyola agronomy - canola technology by populations research results

Optimising the value proposition when comparing canola varieties and different herbicide technologies against multiple population targets

Andrew Heinrich, Willow Liddle *Pacific Seeds Australia*

Key messages:

- Hybrid cultivars consistently outperformed OP (open pollinated) varieties in plant establishment, grain yield, and economic returns across herbicide technologies. Environmental conditions emerged as the primary influencing factor across multiple environments.
- CT® and TT hybrids with elevated genetic yield potential matched yields and returns of TruFlex®, TruFlex + Clearfield®, or Clearfield hybrids in specific environments.
- Significant yield improvements were evident when moving from 15 to 40 plants/m^2.
- Gross returns varied with population targets, seed prices, and GM (genetically modified) vs. non-GM grain commodity price differentials. Higher populations often led to improved returns, as depicted in figures and tables.

Aims

This study investigates differences between different canola herbicide technologies concerning plant establishment (plants/m^2), harvested grain yield (tonnes/ha), and oil %. 14 distinct hybrid cultivars are compared against 2 open-pollinated (OP) TT varieties (purchased seed source), with the aim of identifying optimal gross returns ($/ha) for growers.

Introduction

Australian canola growers and advisors seek comprehensive scientific insights on variety performance, at different population targets, while taking into account diverse herbicide technologies and hybrid vs OP varieties. This imperative arises due to the industry's rapid expansion of herbicide-tolerant hybrids, including GM and non-GM stacked options, necessitating optimal agronomic and financial strategies.

This study examines 14 hybrids alongside 2 OP TT varieties, focusing on plant establishment, grain yield, and oil % production. The aim is to determine best gross return ($/ha) propositions. The research encompasses 3 population targets and evaluates different genetic backgrounds, herbicide-tolerant technologies, and their interactions on yield, oil %, and gross returns.

Previous published literature has identified varying results. In 24 experiments conducted across a range of agricultural environments in Western Australia between 2010 and 2014, French et al. (2016) reported grain yield response to crop density was adequately described by an asymptotic model (where yield approaches but never quite reaches a ceiling at very high density). Zhang et al. (2016) demonstrated that relative yield and profit of an Australian hybrid compared with open-pollinated canola is largely determined by growing-season rainfall which forms a key component of environment (E).

This research, conducted across 3 Western Australian locations, compares 6 herbicide technologies (single trait or stacked) against 3 population targets. It seeks to explore genetics (G) by environment (E) by management (M) interactions.

Method

3 field research extension sites were established in Western Australia: Lake Hinds WA (CND), Tammin WA (TMN), and Corrigin WA (COR), each with a layout organised as randomised complete blocks with two replicates (RCB x 2 replicates, refer to figure 1 for trial layout and treatment list). These selected trial environments showcased diverse conditions encompassing seasonal rainfall, cropping histories, soil types, and soil pH. The trials encompassed a combination of both best management practice (BMP) and district standard practice (DSP) treatments for each location, providing a rich array of data points for meticulous comparative analysis (refer to table 1-3 and graphs 1-3).

A total of 16 canola varieties were subjected to comparison within this study. This set included 2 open-pollinated TT, 3 hybrid TT, 2 hybrid CT®, 1 hybrid LT, 4 hybrid CL, 1 hybrid XC®, and 3 hybrid TruFlex lines, categorised within their respective technology groups. These comparisons spanned 3 distinct target population treatments, specifically 15 plants per m^2, 25 plants per m^2, and 40 plants per m^2. These targets were calculated based on 90% germination and an estimated 75% establishment survival, necessitating adjustments in all seed packet weights. The corresponding effective sowing rates were 1.1 kg/ha, 1.8 kg/ha, and 2.85 kg/ha. The herbicide tolerance technologies under consideration encompassed CT (Clearfield + triazine tolerant), triazine tolerant, Liberty + triazine tolerant, Clearfield, TruFlex + Clearfield, and TruFlex.

Trial Design

2022 HYOLA TD - SYSTEMS POPULATION TRIALS (22STAGVL6)

5m	PLOTS	Buffer	XX + XC		Buffer	CL		Buffer	CT & TT & LT				Buffer
REP 2	12	Buffer XCT			Buffer XCT			Buffer XCT					Buffer XCT
	11	Buffer XCT			Buffer XCT			Buffer XCT					Buffer XCT
	10	Buffer XCT			Buffer XCT			Buffer XCT					Buffer XCT
	9	Buffer XCT			Buffer XCT			Buffer XCT					Buffer XCT
	8	Buffer XCT			Buffer XCT			Buffer XCT					Buffer XCT
	7	Buffer XCT			Buffer XCT			Buffer XCT					Buffer XCT
REP 1	6	Buffer XCT			Buffer XCT			Buffer XCT					Buffer XCT
	5	Buffer XCT			Buffer XCT			Buffer XCT					Buffer XCT
	4	Buffer XCT			Buffer XCT			Buffer XCT					Buffer XCT
	3	Buffer XCT			Buffer XCT			Buffer XCT					Buffer XCT
	2	Buffer XCT			Buffer XCT			Buffer XCT					Buffer XCT
	1	Buffer XCT			Buffer XCT			Buffer XCT					Buffer XCT
	RANGE	Buffer	XX + XC		Buffer	CL		Buffer	CT & TT & LT				Buffer
	ROWS	1	2	3	4	5	6	7	8	9	10	11	12

Hyola systems population trials - overall design entries by treatment

Treatment number	XX + XC	Treatment number	CL	Treatment number	CT + TT + LT
	12		12		24
1	Emu TF-15pm²	13	44Y94-15pm²	25	Hyola Blazer TT-15pm²
2	Emu TF-25pm²	14	44Y94-25pm²	26	Hyola Blazer TT-25pm²
3	Emu TF-40pm²	15	44Y94-40pm²	27	Hyola Blazer TT-40pm²
4	InVigor R 4520P-15pm²	16	Hyola Solstice CL-15pm²	28	HyTTec Trident TT-15pm²
5	InVigor R 4520P-25pm²	17	Hyola Solstice CL-25pm²	29	HyTTec Trident TT-25pm²
6	InVigor R 4520P-40pm²	18	Hyola Solstice CL-40pm²	30	HyTTec Trident TT-40pm²
7	XC210034-15pm²	19	Hyola Continuum CL-15pm²	31	HyTTec Trifecta TT-15pm²
8	XC210034-25pm²	20	Hyola Continuum CL-25pm²	32	HyTTec Trifecta TT-25pm²
9	XC210034-40pm²	21	Hyola Continuum CL-40pm²	33	HyTTec Trifecta TT-40pm²
10	Condor TF-15pm²	22	45Y95-15pm²	34	Hyola Defender CT-15pm²
11	Condor TF-25pm²	23	45Y95-25pm²	35	Hyola Defender CT-25pm²
12	Condor TF-40pm²	24	45Y95-40pm²	36	Hyola Defender CT-40pm²
				37	DG Bidgee-15pm²
				38	DG Bidgee-25pm²
				39	DG Bidgee-40pm²
				40	Hyola Enforcer CT-15pm²
				41	Hyola Enforcer CT-25pm²
				42	Hyola Enforcer CT-40pm²
				43	InVigor LT 4530P-15pm²
				44	InVigor LT 4530P-25pm²
				45	InVigor LT 4530P-40pm²
				46	ATR Bonito-15pm²
				47	ATR Bonito-25pm²
				48	ATR Bonito-40pm²

Figure 1. Replicated trial layouts showing technology blocks and treatment listings for each environment.

Trial Details	Lake Hinds WA (CND)			
Co-operator	Gary Whyte			
Location	Calingiri – Wongan Hills Rd, Lake Hind			
GPS location	-30.982138,116.584746			
Date sown	27 April 2022			
Crop type	Canola			
Paddock history	2021 oats for hay, 2020 wheat, 2019 wheat			
Seeding rate (kg/ha)	As per packaged seed provided			
Target density (plants/m²)	15 plants/m², 25 plants/m², 40 plants/m²			
Sowing depth (mm)	30 mm			
Soil moisture depth (mm)	25 mm			
Stubble loading	Low			
Soil type	Sandy gravel			
Sowing equipment	Precision trial cone seeder fitted with knife points and trailing press wheels			
Sowing speed (km/h)	2 km/hr			
Soil tests conducted	27 April 2022			
Soil test results	**Analyte**	**Unit**	**Result**	
	Sample depth	cm	0-10	
	Colour		YWGR	
	Gravel	%	5-10	
	Texture		1	
	Ammonium nitrogen	mg/kg	4	
	Nitrate nitrogen	mg/kg	16	
	Phosphorus Colwell	mg/kg	33	
	Potassium Colwell	mg/kg	94	
	Sulfur	mg/kg	6	
	Organic carbon	%	1.16	
	Conductivity	dS/m	0.094	
	pH Level ($CaCl_2$)		6.7	
	pH Level (H_20)		7.4	
Fertiliser applied	**Date**	**Product**	**Rate**	
	27 April 2022	Multi K starter	90 kg/ha	
	11 July 2022	Urea	60 kg /ha	
	15 June 2022	Urea	80 kg/ha	
Insecticide applications	Pre-emergent	Bifenthrin 250	100 ml/ha	
	10 November 2022	Chlorpyrifos	2 l/ha	
Herbicide applications	**Date**	**Product**	**Rate**	**Applied to herbicide technology block**
Application A	27 April 2022	Round Up	2 l/ha	XX + XC, CL, CT + TT
		Bifenthrin	500 ml/ha	XX + XC, CL, CT + TT
Application B	15 June 2022	Roundup	1.67 l/ha	XX + XC
		Imazamox	0.75 l/ha	CL
		Atrazine	2.2 kg/ha	CT + TT
Application C	2 July 2022	Clethodim	500 ml/ha	CT + TT
		Clopyralid	150 ml/ha	CT + TT
Application D				
Application E	26 October 2022	Diquat	3 l/ha	XX + XC, CL, CT + TT
Harvest	10 November 2022			

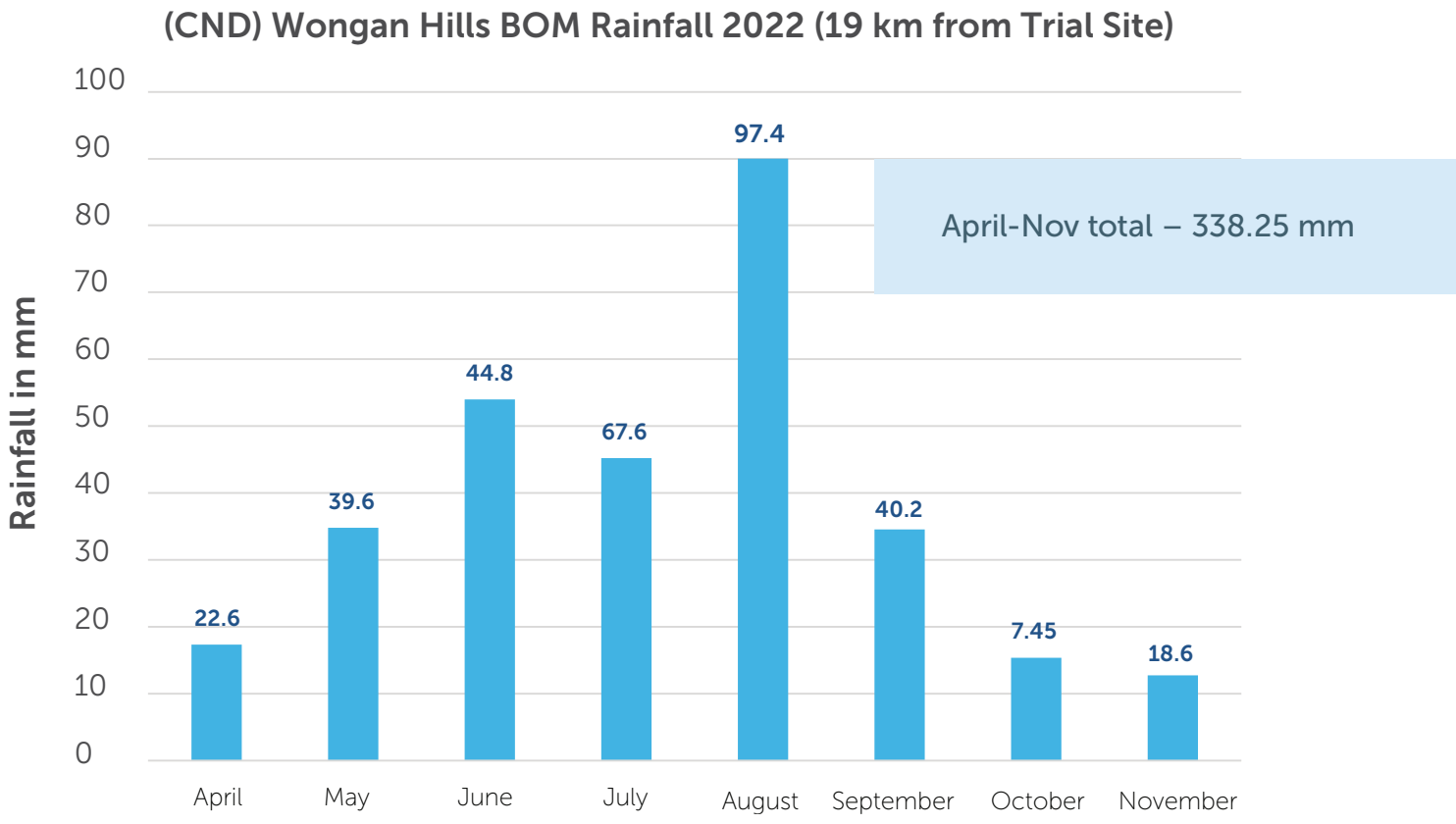
Table 1: 2022 Lake Hinds WA trial details and agronomic management.

Trial details	Corrigin WA (COR)			
Co-operator	Geoff Fisher			
Location	Old Kulin Road, Corrigin			
GPS location	-32.499523, 117.990491			
Date sown	22 April 2022			
Crop type	Canola			
Paddock history	2021 barley, 2020 oats for hay, 2019 wheat			
Seeding rate (kg/ha)	As per packaged seed provided			
Target density (plants/m^2)	15 plants/m^2, 25 plants/m^2, 40 plants/m^2			
Sowing depth (mm)	35 mm			
Soil moisture depth (mm)	25mm			
Stubble loading	Low			
Soil type	Gravelly sand			
Sowing equipment	Precision trial cone seeder fitted with knife points and trailing press wheels			
Sowing speed (km/h)	2 km/hr			
Soil tests conducted	22 April 2022			
Soil test results	**Analyte**	**Unit**	**Result**	
	Sample Depth	cm	0-10	
	Colour		GR	
	Gravel	%	15-20	
	Texture		2	
	Ammonium nitrogen	mg/kg	2	
	Nitrate nitrogen	mg/kg	21	
	Phosphorus Colwell	mg/kg	36	
	Potassium Colwell	mg/kg	41	
	Sulfur	mg/kg	5.8	
	Organic carbon	%	1.28	
	Conductivity	dS/m	0.069	
	pH Level ($CaCl_2$)		5.8	
	pH Level (H_20)		6.4	
Fertiliser applied	**Date**	**Product**	**Rate**	
	22 April 2022	Multi K starter	100 kg/ha	
	15 June 2022	Urea	60 kg/ha	
	14 July 2022	Urea	60 kg/ha	
Insecticide applications	Pre-emergent	Bifenthrin 250	100 ml/ha	
	29 November 2022	Chlorpyrifos	2 l/ha	
Herbicide applications	**Date**	**Product**	**Rate**	**Applied to herbicide technology block**
Application A	22 April 2022	Round Up	2 l/ha	XX + XC, CL, CT + TT
Application B	1 June 2022	Roundup	1.67 l/ha	XX + XC
		Imazamox	0.75 l/ha	CL
		Atrazine	2.2 kg/ha	CT + TT
Application C	15 June 2022	Clethodim	500 ml/ha	CT + TT
		Clopyralid	150 ml/ha	CT + TT
Application D	25 July 2022	Roundup	1.67 l/ha	XX + XC
Application E	13 October 2022	Diquat	3 l/ha	XX + XC, CL, CT + TT
Harvest	29 November 2022			

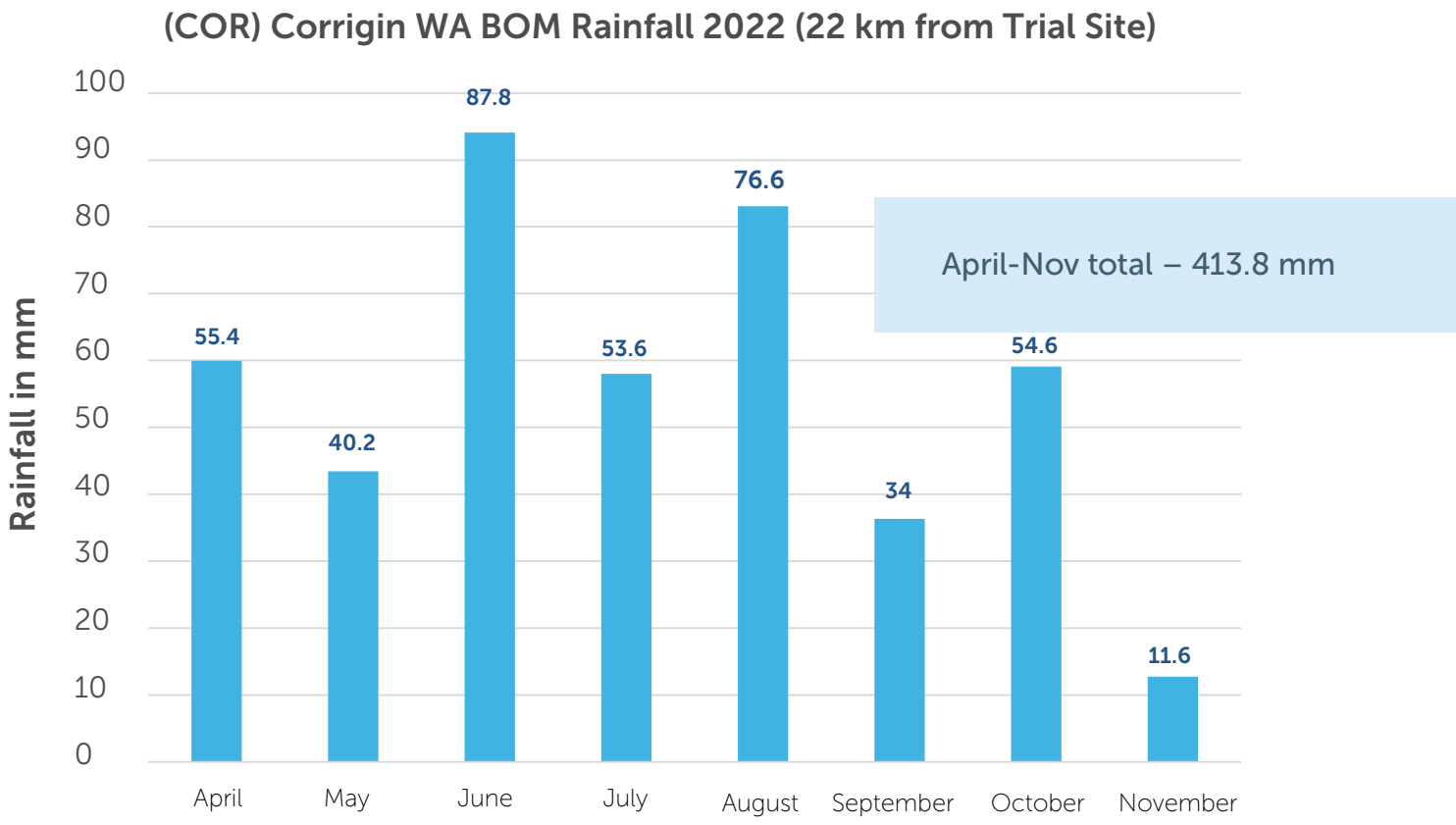
Table 2: 2022 Corrigin WA trial details and agronomic management.

Trial details	Tammin WA (TMN)			
Co-operator	Rod Stokes			
Location	Bolton Rd, Tammin			
GPS location	-31.607713, 117.442548			
Date sown	26 April 2022			
Crop type	Canola			
Paddock history	2021 wheat, 2020 wheat, 2019 clover			
Seeding rate (kg/ha)	As per packaged seed provided			
Target density (plants/m^2)	15 plants/m^2, 25 plants/m^2, 40 plants/m^2			
Sowing depth (mm)	30 mm			
Soil moisture depth (mm)	25 mm			
Stubble loading	Low			
Soil type	Sand			
Sowing equipment	Precision trial cone seeder fitted with knife points and trailing press wheels			
Sowing speed (km/h)	2 km/hr			
Soil tests conducted	26 April 2022			
Soil test results	**Analyte**	**Unit**	**Result**	
	Sample Depth	cm	0-10	
	Colour		GR	
	Gravel	%	0	
	Texture		1.5	
	Ammonium nitrogen	mg/kg	1	
	Nitrate nitrogen	mg/kg	42	
	Phosphorus Colwell	mg/kg	28	
	Potassium Colwell	mg/kg	135	
	Sulfur	mg/kg	24.1	
	Organic carbon	%	0.73	
	Conductivity	dS/m	0.166	
	pH Level ($CaCl_2$)		5.5	
	pH Level (H_20)		6	
Fertiliser applied	**Date**	**Product**	**Rate**	
	26 April 2022	Multi K starter	90 kg/ha	
	13 June 2022	Urea	70 kg/ha	
	10 August 2022	Urea	60 kg/ha	
Insecticide applications	Pre-emergent	Bifenthrin 250	100 ml/ha	
	4 November 2022	Chlorpyrifos	2 l/ha	
Herbicide Applications	**Date**	**Product**	**Rate**	**Applied to herbicide technology block**
Application A	26 April 2022	Round Up	2 l/ha	XX + XC, CL, CT + TT
		Bifenthrin	500 ml/ha	XX + XC, CL, CT + TT
Application B	27 May 2022	Roundup	1.67 l/ha	XX + XC
		Imazamox	0.75 l/ha	CL
		Atrazine	2.2 kg/ha	CT + TT
Application C	13 June 2022	Clethodim	500 ml/ha	CT + TT
		Clopyralid	150 ml/ha	CT + TT
Application D	6 July 2022	Roundup	1.67 l/ha	XX + XC
Application E	24 October 2022	Diquat	3 l/ha	XX + XC, CL, CT + TT
Harvest	4 November 2022			

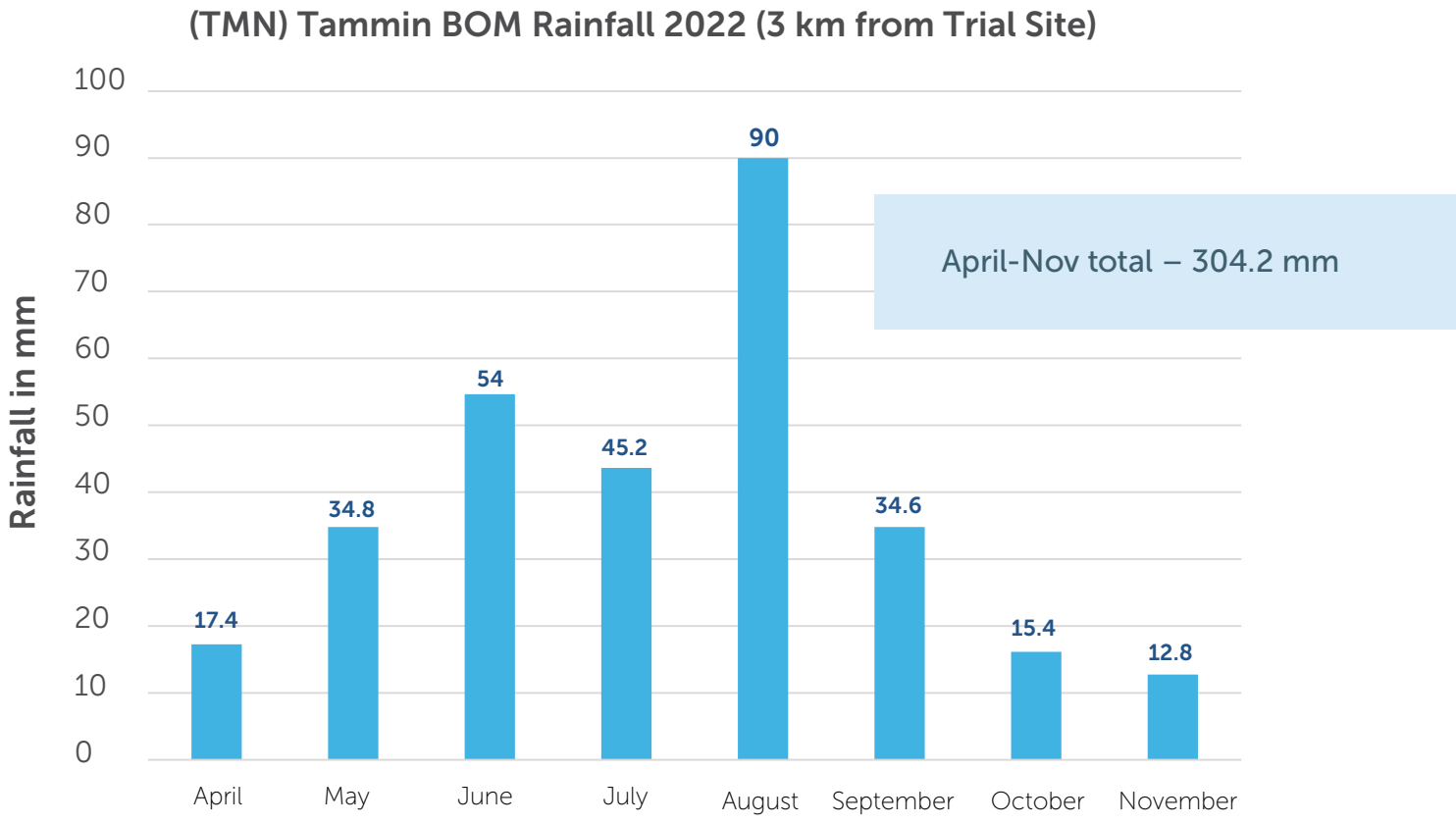
Table 3: 2022 Tammin WA Trial Details and Agronomic Management.



Graph 1: 2022 Wongan Hills (Lake Hinds) WA rainfall data



Graph 2: 2022 Corrigin WA rainfall data.



Graph 3: 2022 Tammin WA rainfall data.

The assessment encompassed comprehensive measurements across all replicates and environments. Plants per m^2 were quantified through 4x1m row counts per plot, performed at 14 days after sowing (DAS) and 28 DAS. These measurements were further validated by stem counts post-harvest, accompanied by visual subjective vigour ratings at the 4-6 leaf stage, in addition to visual maturity ratings at both flowering and maturity stages.

Quantification of grain yield (t/ha) occurred using plot harvesters, while oil % was gauged employing near-infrared spectroscopy (NIR). Gross return calculations used foundational assumptions from Table 4.

Population, yield, and oil % analyses for individual sites were meticulously executed. This involved fitting entry, IPP (Popm2), and TargetPop as fixed linear factors, complemented by spatial adjustments implemented through the auto-regressive model. This framework yielded best linear unbiased estimators (BLUE) outputs for each site. The statistical framework employed ASReml (Gilmour et al. (2010)).

A deeper exploration of yield entailed the application of single step factor analytic MET (multiple environment trial) analysis. Here, the model integrated plants/m2 as a linear fixed factor alongside composite entry as a random factor, culminating in best linear unbiased predictors (BLUP) for each site. Spatial adjustments were determined via the auto-regressive model. The MET analysis discerned significant GxExM effects. As a statistical reference, ASReml was employed, aligning with the framework established by Gilmour et al. (2010).

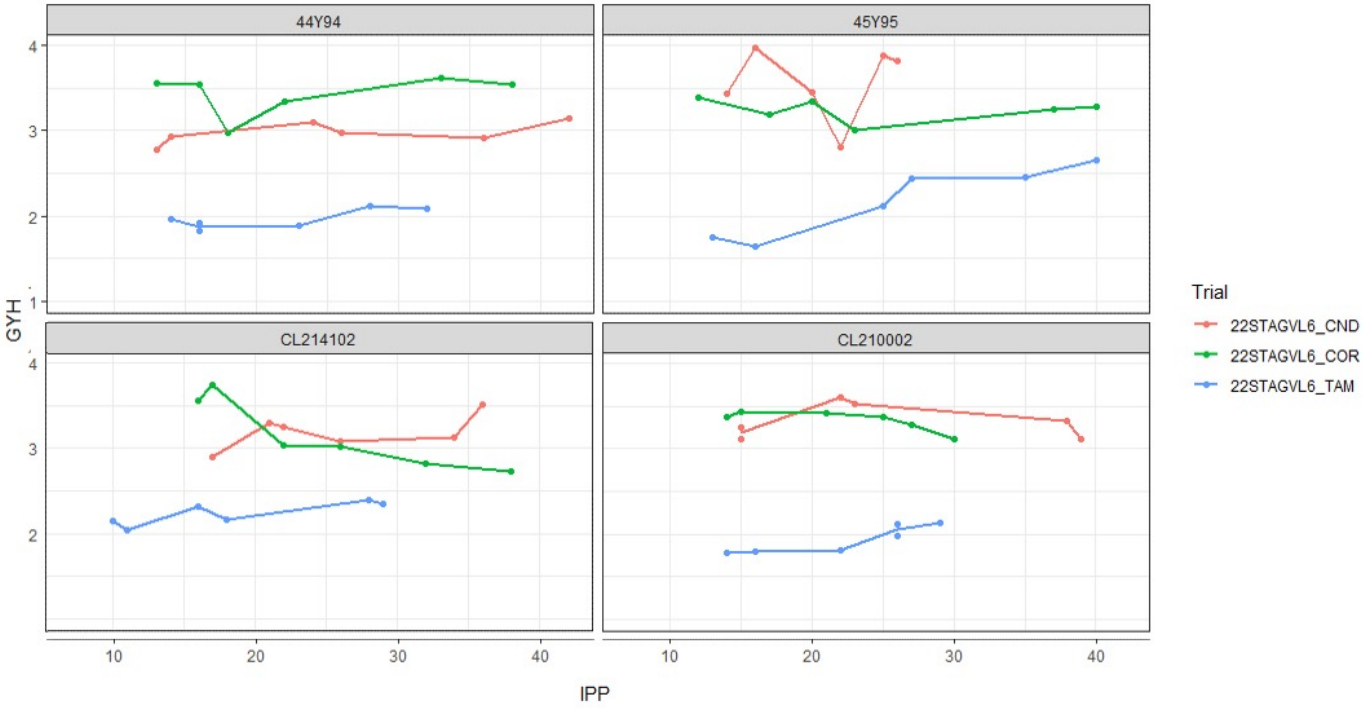
Variety details	Hybrid or OP	Herbicide technology	Seed cost ($/kg)	End point royalty ($/MT)	Base price ($/MT)
Nuseed Emu TF	Hybrid	TruFlex	$40	NA	$800
InVigor R 4520P	Hybrid	TruFlex	$50	NA	$800
XC210034 (EXP)	Hybrid	TruFlex + Clearfield	$40	NA	$800
Nuseed Condor TF	Hybrid	TruFlex	$40	NA	$800
Pioneer 44Y94	Hybrid	Clearfield	$32	NA	$850
Hyola Solstice CL	Hybrid	Clearfield	$32	NA	$850
Hyola Continuum CL	Hybrid	Clearfield	$32	NA	$850
Pioneer 45Y95	Hybrid	Clearfield	$32	NA	$850
Hyola Blazer TT	Hybrid	Triazine	$32	NA	$850
HyTTec Trident TT	Hybrid	Triazine	$28	$5	$850
HyTTec Trifecta TT	Hybrid	Triazine	$28	$5	$850
Hyola Defender CT	Hybrid	Clearfield + Triazine	$32	NA	$850
Hyola Enforcer CT	Hybrid	Clearfield + Triazine	$32	NA	$850
InVigor LT 4530P	Hybrid	Liberty + Triazine	$35	NA	$850
DG Bidgee TT	OP	Triazine	$18	$5	$850
ATR Bonito	OP	Triazine	$18	$5	$850

Table 4: 2022 variety details and gross return foundation assumptions.

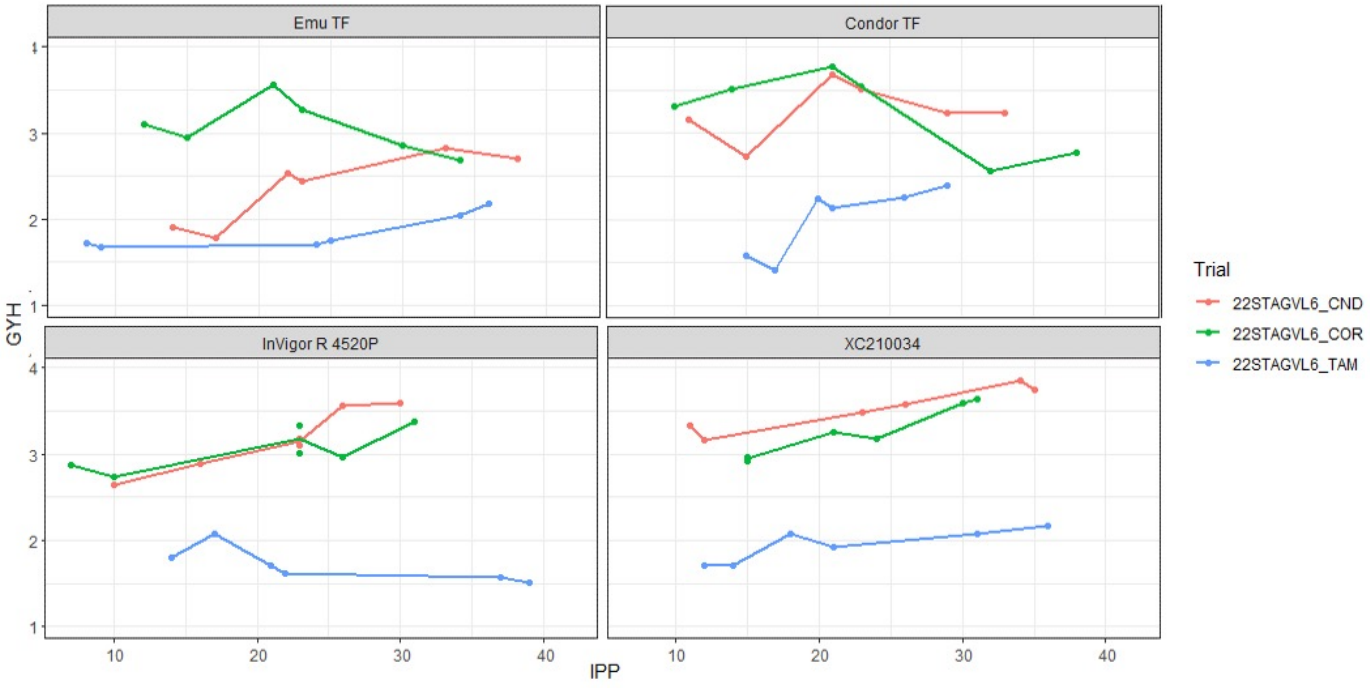
Results and discussion

French et al. (2016) noted canola field establishment ranging from 0.3 to 1, with greater rates at lower target densities and a median of 0.585 at 40 plants/m^2. In this study, variety mean field establishment spanned 0.35 to 1.26 (15 plants/m^2), 0.31 to 1.24 (25 plants/m^2), and 0.23 to 1.2 (40 plants/m^2).

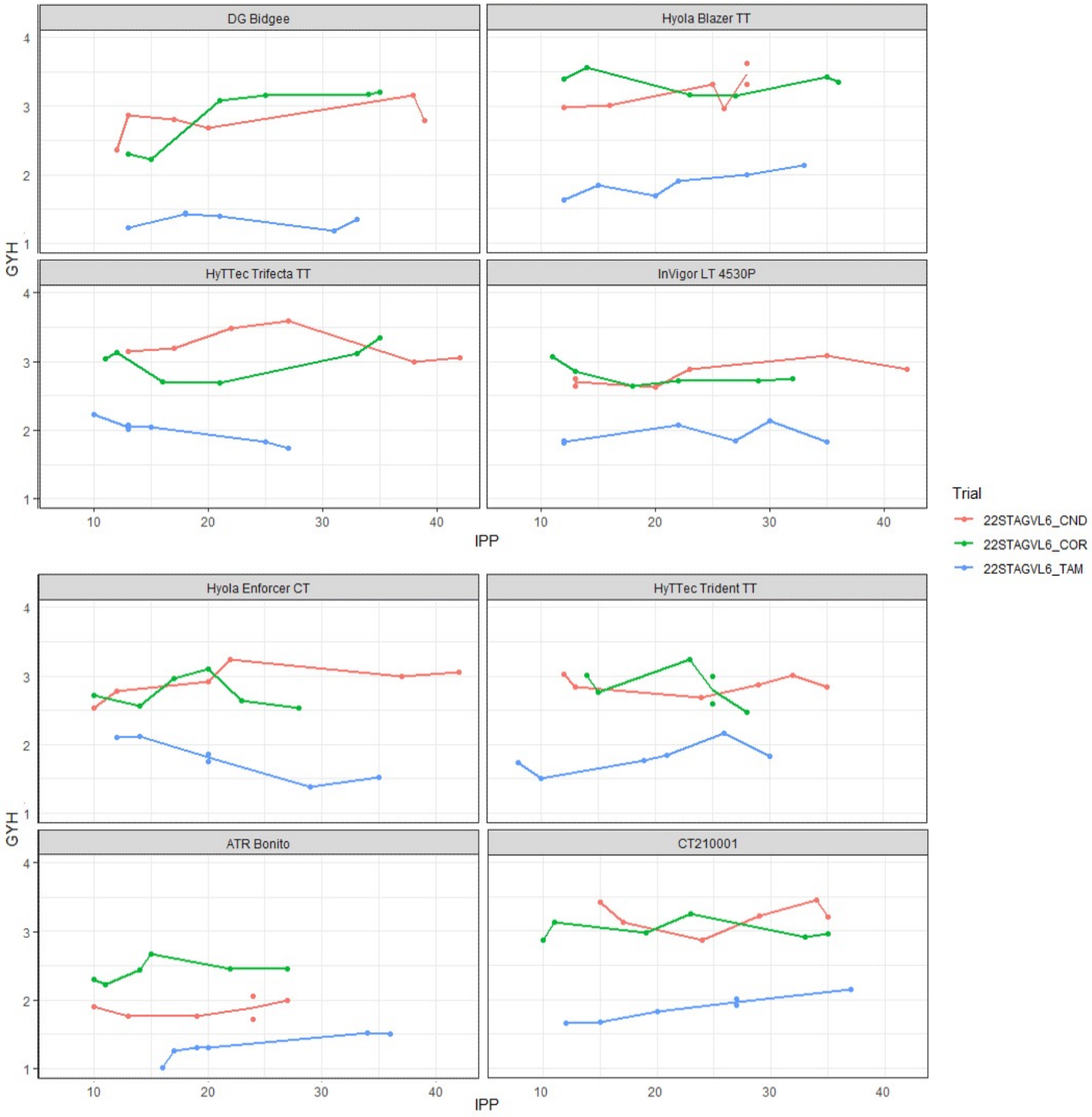
Graphs 4 and 5 depict relationships for Clearfield, TruFlex + Clearfield, and TruFlex hybrids between actual plant populations and harvested grain yields. Some hybrids positively responded to increased plant numbers, while others plateaued or showed no response. Experimental hybrid XC210034 consistently displayed rising yield responses with increased plant populations across all locations.



Graph 4: 2022 grain yield relationships by actual plant populations achieved compared for Clearfield hybrids.
CL214102 is now commercially release as Hyola Solstice CL.
CL210002 is now commercially released as Hyola Continuum CL.



Graph 5: 2022 grain yield relationships by actual plant populations achieved compared for TruFlex and TruFlex + Clearfield stacked hybrids.



Graph 6: 2022 grain yield relationships by actual plant populations achieved compared for triazine and triazine + Clearfield stacked hybrids, Liberty + triazine stacked hybrid vs open pollinated TT varieties. CT210001 is now commercially released as Hyola Defender CT.

Graph 6 illustrates relationships for Clearfield + triazine, triazine, and Liberty + triazine hybrids, as well as OP triazine varieties, showcasing actual plant populations and harvested grain yields.

Experimental line CT210001 (Hyola Defender CT) and OP variety DG Bidgee TT responded positively to increased plant numbers, yielding more in specific locations. ATR Bonito and InVigor LT4530P displayed more of a flat-lined response in certain locations.

Hyola Enforcer CT showed negative yield responses in some locations with increasing plant numbers. Hybrids generally outperformed OP variety ATR Bonito TT in yield at most sites. Newer OP variety DG Bidgee TT demonstrated better overall performance relative to hybrids in higher yielding environments.

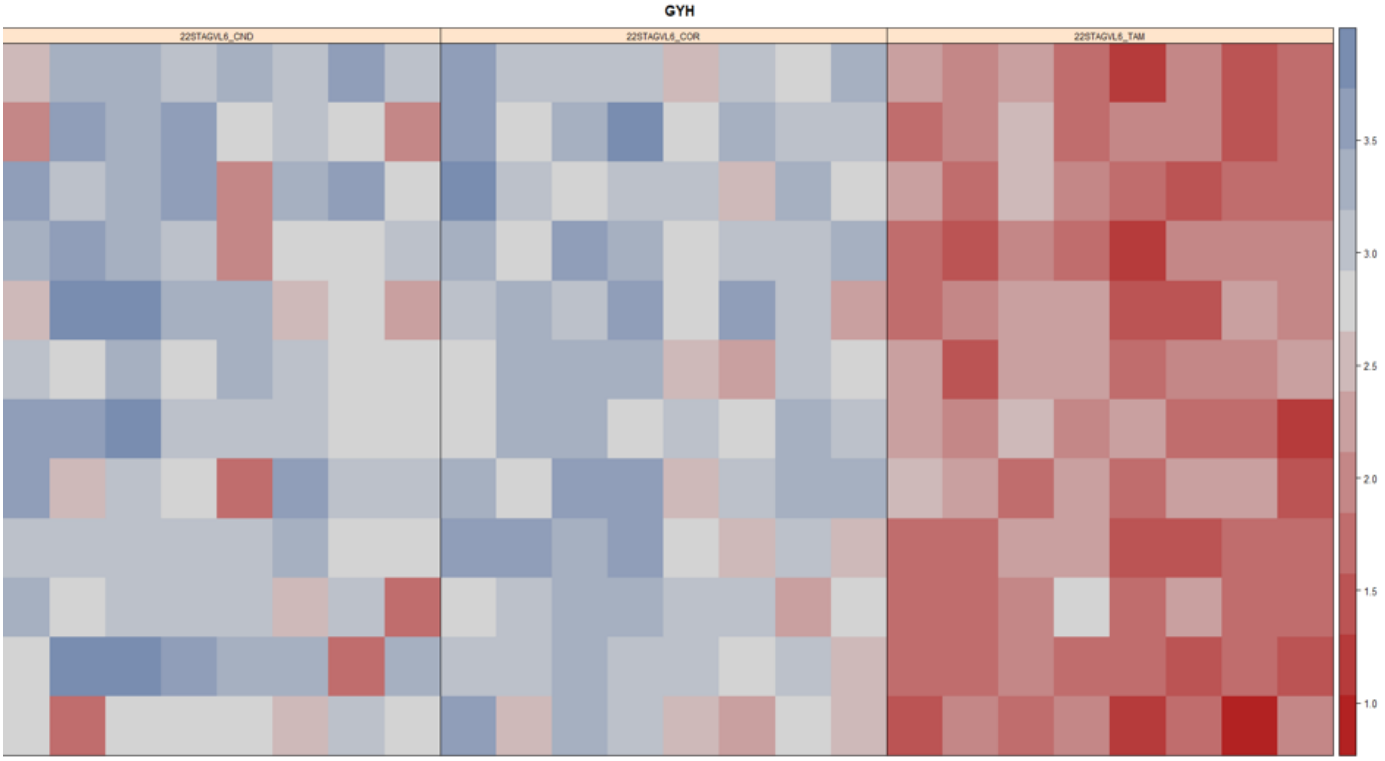
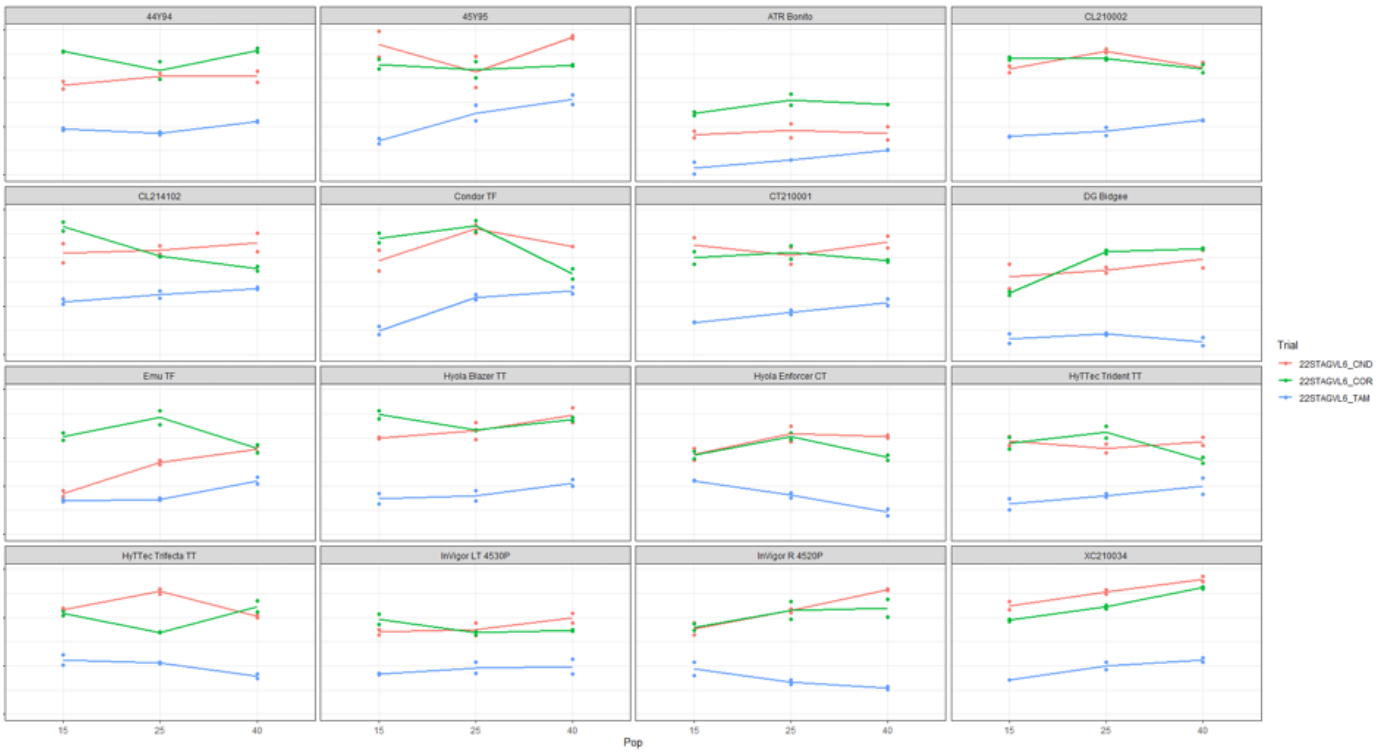


Figure 2: Heat maps of analysed grain yields of all varieties and technologies at each of the 3 trial locations. LHS represents CND Trial, then the COR Trial in the center with the TMN Trial on the RHS.



Graph 7: 2022 grain yield relationships by plant population targets compared for all herbicide technologies across all 3 environments. CL214102 is commercially released as Hyola Solstice CL, CL210002 is commercially released as Hyola Continuum CL and CT210001 is commercially released as Hyola Defender CT.

Photo 1: 2022 Corrigin WA Hyola technology by population Trial XX, XC herbicide Section.

Graph 7 illustrates the correlation between grain yield and plant population targets. Varieties exhibited diverse responses: some positive, some neutral, and others negative due to environmental influences.

French et al. (2016) found slight differences in optimal densities for hybrid and open-pollinated cultivars. High rainfall zones had approximately 10 plants/m^2 higher optimal densities than low and medium rainfall zones.

Catalier (2019) reported mixed findings: yield increased with seeding rates in some studies (Harker et al., 2012a, 75 and 150 seeds/m^2), but not in others (Kutcher et al., 2013).

Gan et al. (2016) noted yield responses to seeding rates were influenced by environment and the specific rates or densities compared; lower seeding rates were more likely to show yield responses than higher rates.

This research identified E as the primary factor influencing grain yield responses across all 3 locations, followed by genetics (Table 5). G x E and G x IPP (Population) x E interactions contributed less to variance.

At individual sites, G often explained a significant percentage of variation, followed by G x IPP. IPP had the least impact on variance accountability across locations.

ANALYSIS FACTOR	Trials - % variance accounted for by factor on yield			
	MET ALL	CND	COR	TMN
Site	77.41%			
IPP	0.38%	3.81%	11.24%	1.74%
IPP: Site	0.0%			
Entry	11.3%	86.35%	59.47%	49.04%
Entry: IPP	0.55%	9.85%	29.29%	49.22%
Entry: Site	4.84%			
Entry: IPP: Site	5.52%			

Table 5: 2022 MET analysis for grain yield (t/ha) showing % variance factors comparisons where IPP = Plant population, Entry = (G) Genetics, and Site = (E) Environment.

Photo 2: 2022 Lake Hinds WA Hyola technology by population trial CT, TT and LT herbicide Section.

	Variety Technology Entry	Population Target Plants per m2	Mean Yield (t/ha) CND	Mean Oil %	Mean Yield (t/ha) COR	Mean Oil %	Mean Yield (t/ha) TMN	Mean Oil %
CLEARFIELD TECHNOLOGY	44Y94	15	3.013	50.60	3.620	50.09	1.947	48.92
	44Y94	25	2.948	50.50	3.116	50.16	1.848	48.98
	44Y94	40	3.010	50.36	3.549	50.69	2.095	48.88
	45Y95	15	3.638	49.23	3.445	48.55	1.729	47.65
	45Y95	25	3.253	48.68	3.274	48.48	2.274	47.85
	45Y95	40	3.765	49.82	3.266	48.94	2.540	48.63
	Hyola Continuum CL	15	3.119	51.79	3.452	51.50	1.784	50.48
	Hyola Continuum CL	25	3.376	50.88	3.415	51.64	1.891	50.62
	Hyola Continuum CL	40	3.274	51.76	3.206	52.14	2.112	50.40
	Hyola Solstice CL	15	3.289	51.30	3.581	51.37	2.115	50.18
	Hyola Solstice CL	25	3.167	50.61	3.000	52.00	2.229	48.53
	Hyola Solstice CL	40	3.321	50.79	2.761	52.09	2.372	49.65
TRUFLX OR TRUFLEX + CLEARFIELD TECHNOLOGY	Condor TF	15	2.964	52.57	3.358	52.84	1.488	52.23
	Condor TF	25	3.567	51.78	3.636	53.17	2.181	51.38
	Condor TF	40	3.231	53.04	2.724	53.28	2.320	51.13
	InVigor R 4520P	15	2.755	51.08	2.700	50.01	1.949	49.38
	InVigor R 4520P	25	3.101	51.33	3.090	49.95	1.695	48.58
	InVigor R 4520P	40	3.583	51.01	3.255	49.58	1.535	48.74
	XC210034	15	3.265	51.22	2.893	51.08	1.723	51.27
	XC210034	25	3.597	51.60	3.264	50.99	1.999	50.07
	XC210034	40	3.788	51.77	3.725	51.68	2.113	49.65
	Emu TF	15	1.937	48.30	3.000	49.56	1.674	49.68
	Emu TF	25	2.553	48.55	3.420	50.17	1.729	50.14
	Emu TF	40	2.645	49.29	2.737	50.83	2.112	48.67
TRIAZINE, CLEARFIELD + TRIAZINE OR LIBERTY + TRIAZINE TECHNOLOGY	Hyola Blazer TT	15	3.088	50.42	3.521	50.21	1.744	49.54
	Hyola Blazer TT	25	3.157	50.86	3.151	50.64	1.819	49.41
	Hyola Blazer TT	40	3.436	50.81	3.325	49.93	2.062	50.17
	Hyola Defender CT	15	3.224	49.06	2.988	49.73	1.658	48.50
	Hyola Defender CT	25	3.140	50.00	3.099	50.11	1.884	49.14
	Hyola Defender CT	40	3.229	50.03	2.964	49.64	2.095	49.38
	Hyola Enforcer CT	15	2.776	48.57	2.646	49.48	2.130	47.61
	Hyola Enforcer CT	25	2.988	49.77	2.979	48.90	1.785	48.36
	Hyola Enforcer CT	40	2.956	49.64	2.603	50.48	1.454	47.00
	HyTTec Trident TT	15	2.947	49.09	2.899	49.64	1.615	47.83
	HyTTec Trident TT	25	2.860	49.29	3.148	48.85	1.806	48.04
	HyTTec Trident TT	40	2.838	49.17	2.610	48.36	1.981	48.26
	HyTTec Trifecta TT	15	3.294	50.34	3.113	50.26	2.147	49.29
	HyTTec Trifecta TT	25	3.603	50.20	2.689	50.95	2.059	47.77
	HyTTec Trifecta TT	40	3.024	49.36	3.254	50.12	1.770	47.81
	InVigor LT 4530P	15	2.814	47.78	2.964	48.05	1.810	46.71
	InVigor LT 4530P	25	2.753	47.11	2.702	47.25	1.957	47.99
	InVigor LT 4530P	40	2.934	47.43	2.730	48.71	1.988	48.25
	ATR Bonito	15	1.900	48.76	2.309	49.79	1.135	49.25
	ATR Bonito	25	1.826	49.58	2.525	49.81	1.306	49.95
	ATR Bonito	40	1.822	49.56	2.517	50.26	1.516	49.05
	DG Bidgee	15	2.600	48.37	2.300	48.19	1.321	46.00
	DG Bidgee	25	2.714	48.09	3.120	47.48	1.434	45.43
	DG Bidgee	40	2.956	47.66	3.219	47.57	1.266	45.26
	Mean Analysed Yield (t/ha) and Oil %		**3.022**	**49.98**	**1.480**	**50.11**	**2.610**	**48.91**
	ASReml Statistical Analysis	**CV%**	6.1	0.917	4.3	0.917	5.8	1.113
		AVSED	0.147459	0.41	0.110404	0.38	0.106088	0.689
		LSD (5%)	0.296487	0.927	0.221983	0.926	0.213304	1.109

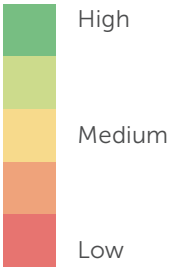


Table 6: 2022 statistical analysis heatmap for all treatments mean grain yield (t/ha) and oil % across 3 trial environments in Western Australia.

For the single site analyses within the Clearfield technology group (Table 6), the four hybrids demonstrated relatively stable and competitive grain yield performance, with only a few cases where higher populations didn't yield higher results. However, some of these instances of higher yields for different varieties with increased populations were not statistically significant. Oil % relationships often did not display a significant response across the various variety population targets.

In the TruFlex and TruFlex + Clearfield technology group, the four hybrids exhibited strong environmental responses to each other in terms of grain yield. Condor TF and XC210034 consistently demonstrated the highest and most consistent yield outcomes across the 3 locations. The variety Emu TF became more competitive for grain yield in lower rainfall environments (TMN) at higher population levels, where its earlier maturity phenology suited the prevailing environmental conditions. Similar to the prior cases, some of these instances of higher yields for different varieties with higher populations were not statistically significant. Oil % relationships also often did not show a significant response across the various variety population targets.

Within the Clearfield + triazine, triazine, Liberty + triazine hybrids, as well as OP triazine group, the hybrids displayed strong environmental responses to each other for grain yield. Hyola Blazer TT, HyTTec Trifecta, CT210001, and HyTTec Trophy consistently demonstrated the highest and most consistent yield outcomes across the 3 locations. Hyola Enforcer CT and InVigor LT 4530P exhibited moderate yield responses across locations, with the OP varieties often displaying the lowest yield responses. The OP TT variety DG Bidgee TT demonstrated enhanced competitiveness for grain yield in higher rainfall environments (CND & COR), where its phenology suited the softer environmental conditions. Similar to the previous cases, some of these instances of higher yields for different varieties with higher populations were not statistically significant. Oil % relationships also often did not show a significant response across the different variety population targets.

Photo 3: 2022 Tammin WA Hyola technology by population trial with Western Australian agronomists listening to technical extension presentations at the site during flowering stages.

	Variety Technology Entry	Population Target Plants per m2	Gross Return ($/ha) CND	Gross Return ($/ha) COR	Gross Return ($/ha) TMN
CLEARFIELD TECHNOLOGY	44Y94	15	$2,746	$3,291	$1,734
	44Y94	25	$2,661	$2,807	$1,623
	44Y94	40	$2,681	$3,188	$1,812
	45Y95	15	$3,281	$3,085	$1,517
	45Y95	25	$2,892	$2,905	$1,988
	45Y95	40	$3,360	$2,878	$2,211
	Hyola Continuum CL	15	$2,875	$3,178	$1,610
	Hyola Continuum CL	25	$3,066	$3,125	$1,688
	Hyola Continuum CL	40	$2,963	$2,910	$1,855
	Hyola Solstice CL	15	$3,020	$3,294	$1,909
	Hyola Solstice CL	25	$2,866	$2,747	$1,960
	Hyola Solstice CL	40	$2,980	$2,493	$2,080
TRUFLX OR TRUFLEX + CLEARFIELD TECHNOLOGY	Condor TF	15	$2,578	$2,934	$1,268
	Condor TF	25	$3,061	$3,162	$1,836
	Condor TF	40	$2,756	$2,311	$1,912
	InVigor R 4520P	15	$2,360	$2,289	$1,630
	InVigor R 4520P	25	$2,640	$2,597	$1,373
	InVigor R 4520P	40	$3,011	$2,687	$1,197
	XC210034	15	$2,809	$2,480	$1,463
	XC210034	25	$3,082	$2,773	$1,656
	XC210034	40	$3,212	$3,154	$1,706
	Emu TF	15	$1,603	$2,538	$1,398
	Emu TF	25	$2,104	$2,887	$1,424
	Emu TF	40	$2,157	$2,269	$1,688
TRIAZINE, CLEARFIELD + TRIAZINE OR LIBERTY + TRIAZINE TECHNOLOGY	Hyola Blazer TT	15	$2,811	$3,204	$1,559
	Hyola Blazer TT	25	$2,863	$2,851	$1,602
	Hyola Blazer TT	40	$3,087	$2,959	$1,805
	Hyola Defender CT	15	$2,899	$2,701	$1,465
	Hyola Defender CT	25	$2,825	$2,790	$1,658
	Hyola Defender CT	40	$2,874	$2,621	$1,821
	Hyola Enforcer CT	15	$2,479	$2,382	$1,877
	Hyola Enforcer CT	25	$2,679	$2,649	$1,556
	Hyola Enforcer CT	40	$2,613	$2,309	$1,206
	HyTTec Trident TT	15	$2,636	$2,607	$1,414
	HyTTec Trident TT	25	$2,544	$2,794	$1,569
	HyTTec Trident TT	40	$2,491	$2,266	$1,699
	HyTTec Trifecta TT	15	$2,986	$2,818	$1,916
	HyTTec Trifecta TT	25	$3,246	$2,427	$1,791
	HyTTec Trifecta TT	40	$2,665	$2,894	$1,503
	InVigor LT 4530P	15	$2,347	$2,479	$1,481
	InVigor LT 4530P	25	$2,257	$2,217	$1,601
	InVigor LT 4530P	40	$2,384	$2,239	$1,599
	ATR Bonito	15	$1,724	$2,084	$1,009
	ATR Bonito	25	$1,645	$2,269	$1,160
	ATR Bonito	40	$1,622	$2,253	$1,321
	DG Bidgee	15	$2,318	$2,044	$1,141
	DG Bidgee	25	$2,401	$2,750	$1,222
	DG Bidgee	40	$2,589	$2,821	$1,054
	Mean Gross Return ($/ha)		**$2,662**	**$2,697**	**$1,595**
	Oil Bonification / Deduction		1.5% for every 1% Gross Price		
	Gross Price Assumption per MT		$850 - nonGM & $800 for GM		
	Effective Sowing Rates		1.1kg/ha, 1.8kg/ha & 2.85kg/ha		

High
Medium
Low

Table 7: 2022 statistical analysis heatmap for grain yield (t/ha) and mean oil % converted to gross returns $/ha across 3 trial environments in Western Australia.

The gross returns were calculated using the assumptions from Table 4. The Clearfield, TruFlex + Clearfield, and TruFlex hybrids often exhibited the highest returns across all 3 locations (Table 7). However, Hyola Blazer TT and CT210001 also demonstrated competitive gross returns relative to the Clearfield, TruFlex + Clearfield, and TruFlex hybrids at certain locations.

The top 10 hybrids frequently displayed gross returns within the range of $2500 to $3500, while the two OP (OP) varieties yielded gross returns ranging from $1009 to $2821 across various population treatments and locations.

Increased population targets of hybrids often did not result in significantly higher gross returns compared to lower plant population targets due to the higher costs associated with seed prices. The gross returns of genetically modified (GM) hybrids were also influenced by the grain price differential between non-GM and GM commodities.

The new XC and CT hybrid technologies showcased the capacity to yield and provide competitive gross returns, comparable to single tolerance technologies like TruFlex, Clearfield, and triazine tolerant hybrids.

Oil % results generally exhibited higher values for TruFlex, Clearfield, and TruFlex + Clearfield technologies (Table 6), which had a more pronounced positive impact on gross returns when contrasted with the lower Oil % values of the two OP varieties.

Photo 4: 2022 Tammin WA Hyola technology by population trial CL herbicide section.

2022 MET Analysis across sites for Grain Yield (t/ha)

Variety by Target Population

	Variety	IPP	Yield (t/ha)
CLEARFIELD TECHNOLOGY	44Y94	15	3.244
	44Y94	25	2.980
	44Y94	40	3.310
	45Y95	15	3.325
	45Y95	25	3.302
	45Y95	40	3.566
	Hyola Continuum CL	15	3.176
	Hyola Continuum CL	25	3.291
	Hyola Continuum CL	40	3.283
	Hyola Solstice CL	15	3.354
	Hyola Solstice CL	25	3.218
	Hyola Solstice CL	40	3.255
TRUFLX OR TRUFLEX + CLEARFIELD TECHNOLOGY	Condor TF	15	3.011
	Condor TF	25	3.544
	Condor TF	40	3.172
	InVigor R 4520P	15	2.871
	InVigor R 4520P	25	2.985
	InVigor R 4520P	40	3.149
	XC210034	15	3.009
	XC210034	25	3.371
	XC210034	40	3.625
	Emu TF	15	2.633
	Emu TF	25	2.976
	Emu TF	40	2.896
TRIAZINE, CLEARFIELD + TRIAZINE OR LIBERTY + TRIAZINE TECHNOLOGY	Hyola Blazer TT	15	3.145
	Hyola Blazer TT	25	3.061
	Hyola Blazer TT	40	3.333
	Hyola Defender CT	15	2.939
	Hyola Defender CT	25	3.083
	Hyola Defender CT	40	3.145
	Hyola Enforcer CT	15	2.882
	Hyola Enforcer CT	25	3.019
	Hyola Enforcer CT	40	2.706
	HyTTec Trident TT	15	2.859
	HyTTec Trident TT	25	2.926
	HyTTec Trident TT	40	2.907
	HyTTec Trifecta TT	15	3.173
	HyTTec Trifecta TT	25	3.145
	HyTTec Trifecta TT	40	3.014
	InVigor LT 4530P	15	2.884
	InVigor LT 4530P	25	2.866
	InVigor LT 4530P	40	2.954
	ATR Bonito	15	2.108
	ATR Bonito	25	2.246
	ATR Bonito	40	2.385
	DG Bidgee	15	2.427
	DG Bidgee	25	2.801
	DG Bidgee	40	2.890
		AVSED	0.238
		LSD (5%)	0.466

Variety (G) only

Variety	Yield (t/ha)
44Y94	3.178
45Y95	3.398
Hyola Continuum CL	3.250
Hyola Solstice CL	3.276
Condor TF	3.243
InVigor R 4520P	3.002
XC210034	3.335
Emu TF	2.835
Hyola Blazer TT	3.180
Hyola Defender CT	3.056
Hyola Enforcer CT	2.869
HyTTec Trident TT	2.898
HyTTec Trifecta TT	3.111
InVigor LT 4530P	2.901
ATR Bonito	2.247
DG Bidgee	2.706
AVSED	0.141
LSD (5%)	0.276

Population Target (IPP) only

IPP	Yield (t/ha)
15	2.940
25	3.051
40	3.099
AVSED	0.059
LSD (5%)	0.115

High

Medium

Low

Table 8: 2022 MET analysis heatmap for grain yield (t/ha) showing variety x population interaction, variety and population responses across 3 trial environments in Western Australia.

The MET site analyses (Table 8) of variety (G) by population targets indicated variable responses among different varieties.

Within the Clearfield, TruFlex, and TruFlex + Clearfield technology groups, one out of the 8 hybrids displayed a significant positive response between 15 plants and 25 plants per m^2 population targets. Another hybrid out of the 8 exhibited a significant positive response between 15 plants and 40 plants per m^2 population targets.

Within the Clearfield + triazine, triazine, and Liberty + triazine hybrids, as well as the OP triazine group, no significant response was observed across the 3 sites for increased plant populations.

The MET site analyses of G only, indicated no significant difference between the four Clearfield hybrids for grain yield. Some significant differences emerged between TruFlex and TruFlex + Clearfield hybrids, although Condor TF and XC210034 exhibited no significant difference. In the TT, CT & LT technology group, notable differences existed between hybrids and OP varieties, with HyTTec Trifecta TT, Hyola Blazer TT, and CT210001 yielding the highest across all 3 sites.

The MET analysis of population target only demonstrated a significant yield increase from 15 plants per m^2 to 40 plants per m^2.

Conclusion

These comparisons of canola varieties with 6 different herbicide technologies (single trait or stacked) at 3 population targets across 3 locations in Western Australia have yielded valuable insights into how strong E can impact final agronomic and economic performance.

This research underscores the findings of Kudnig (2021), which determined that G X E X M interactions are exceedingly complex and dynamic. G stands as the most significant controllable factor, i.e., varietal choice; E, on the other hand, emerges as the most influential and least controllable factor. In this context, M and plant population exert a minor influence in certain environments, yet for every environment where M significantly affects outcomes, there are many where it doesn't.

From a profitability perspective, the primary consideration is the "genetics by multi-environment" relationships.

Regarding G, irrespective of varying herbicide technologies, whether single or stacked, the genetic yield potential of the base germplasm remains a pivotal factor influencing yield, oil, and gross return outcomes at individual locations. However, across multiple locations, E takes precedence as the main driver.

CT or TT hybrids with higher-yielding genetic backgrounds now present a strong positive value proposition in terms of $ per hectare for canola growers in specific environments. In comparison, XX, XC, and CL technologies largely offer consistently adapted performance and returns.

The two OP TT varieties evaluated often displayed significantly lower yields and oil content, resulting in the lowest gross returns in many population treatment comparisons, especially against most of the different herbicide-tolerant technology hybrids.

Key words

Canola, varieties, Hybrid, CT, Clearfield + triazine tolerant, triazine tolerant, Liberty + triazine tolerant, Clearfield, XC, TruFlex + Clearfield, TruFlex, open pollinated, cultivar type, plant populations, grain yield, gross returns, value proposition.

Acknowledgments

2022 Trial development, design and analysis by Willow Liddle, R&D Research Assistant (Canola), Advanta Seeds
2022 Trial planting, maintenance, spraying and harvest across Western Australia by Synergy (SLR research & Extension).

References

Brill R., Jenkins M. L., Gardner M. J., Lilley J. M., Orchard B. A. (2016) Optimizing canola establishment and yield in south-eastern Australia with hybrids and large seed. Crop and Pasture Science 67, 409-418.

Brill RD, Jenkins L, Gardner M (2014) Canola establishment; does size matter? In 'Grains Research and Development Corporation Advisor Update.

Catellier C, (2019) M.Sc. P.Ag., Research Associate Optimal Seeding rate based on seed size in canola. Project #Carp SCDC 20 18-084, The Saskatchewan Canola Development Commission.

French RJ, Seymour M, Malik RS (2016) Plant density response and optimum crop densities for canola (Brassica napus L.) in Western Australia. Crop & Pasture Science 67, 397–408.

Gan Yantai, a K. Neil Harker, b H. Randy Kutcher, c Robert H. Gulden, d Byron Irvine, e William E. May, f John T. O'Donovanb, (2016) Canola seed yield and phenological responses to plant density, Canadian Journal of Plant Science 96(1): 151-159

Hanson BK, Johnson BL, Henson RA, Riverland NR (2008) Seeding rate, seeding depth, and cultivar influence on spring canola performance in the Northern Great Plains. Agronomy Journal 100, 1339–1346.

Harker KN, O'Donovan JT, Smith EG, Johnson EN, Peng G, Willenborg CJ, Gulden RH, Mohr R, Gill KS, Grenkow LA (2015) Seed size and seeding rate effects on canola emergence, development, yield and seed weight. Canadian Journal of Plant Science 95, 1–8.

Kudnig RJ, Tabah D, (2020) Exploring the effects of seed size and target plant densities on the yield of hybrid canola across Australia. 2020 Western Region GRDC Grains Research Updates.

Kudnig RJ, (2021) Optimizing the Gross Return value proposition when comparing Farmer Retained OP TT vs Hybrid CT® and TT canola with varying seed sizes and plant population targets. 2021 Western Region GRDC Grains Research Updates.

Kutcher HR,1 T. K. Turkington,2 G. W. Clayton,3 K. N. Harker2 (2013) Response of herbicide-tolerant canola (Brassica napus L.) cultivars to four row spacings and three seeding rates in a no-till production system. Canadian Journal of Plant Science, 2013, 93(6): 1229-1236

Zhang H, Berger JD, Milroy SP (2013) Genotype × environment interaction studies highlight the role of phenology in specific adaptation of canola (Brassica napus) to contrasting Mediterranean climates. Field Crops Research 144, 77– 88.

Zhang H, Berger JD, Seymour M, Brill R, Herrmann C, Quinlan R, Knell G (2016) Relative yield and profit of Australian hybrid compared with open-pollinated canola is largely determined by growing-season rainfall. Crop & Pasture Science 67, 323–331.

Paper reviewed by

Mr. Justin Kudnig, National Technical Canola Manager – Pacific Seeds Australia — a Subsidiary of Advanta Seeds.

Disclaimer