Plant density of canola in the low and medium rainfall regions of Western Australia

Mark Seymour, Dr Bob French, Dr Raj Malik and Jackie Bucat, Department of Agriculture and Food, Western Australia

Key messages

- Field establishment rates of canola can vary widely depending on soil moisture, soil temperature and variety
- Open pollinated TT canola has higher economic optimum plant densities than other types of canola such as hybrids or RR canola – due to differences in seed costs
- RR hybrids have the lowest economic optimum plant densities as a result of both higher seed costs and the capacity to adapt to low plant densities. RR hybrid maximised gross margins in most experiments

Aim

To compare the plant density response of hybrid and open pollinated TT and RR canola

Method

12 variety x density experiments were conducted in low (LRZ) and medium rainfall (MRZ) zones throughout WA in 2013. LRZ trials were located at Grass Patch (excluded from META analysis due to bird damage), Holt Rock, Merredin, Miling, Moorine Rock (abandoned due to drought), Mullewa and Salmon Gums. MRZ trials were located at Chapman Valley, Cunderdin, Katanning, Pingrup and Wongan Hills.

Each experiment consisted of 32 treatments in a split plot design with 3 replications. The 32 treatments consisted of 2 herbicide tolerance systems x 4 Cultivars x 8 densities. The two herbicide tolerance systems tested were triazine tolerant varieties (TT) and RoundupReady varieties (RR). The cultivars tested in the RR system were the open-pollinated variety GT Viper RR and the hybrid variety Hyola 404RR. The cultivars tested in the TT system were the hybrid variety Hyola 450TT and either the open pollinated variety CB Telfer in the LRZ or the open pollinated variety ATR Stingray in the MRZ.

The 8 target density treatments were - 5, 10, 15, 20, 30, 40, 60 and 80 plants/m².

Each replicate block was split for herbicide tolerance and treated with the appropriate herbicides throughout the season. Within each herbicide block combinations of variety x density were randomised.

For each seed lot we measured the seed size. Due to the short time between receiving seed and sowing the trials we assumed seed had 90% germination tests in the lab, whilst subsequent tests showed germinations of 97-100% in the laboratory. We also assumed field establishment of 85% for Hyola 404RR and 75% for the other varieties. This is a higher field establishment than we normally expect from canola, and we usually plan for 50-65% field establishment. However we used the higher field establishment rates to ensure we did not end up with too many plants in our low density treatments if conditions were better than we anticipated. The seed size, germination and field establishment information was used to adjust the seeding rate of each variety in order to sow the same number of viable seeds for each density treatment.

At each site we counted the number of plants per m² approximately 4 to 6 weeks after sowing and at harvest. At most sites we determined above ground biomass at 100% flowering and at maturity. Grain was retained at harvest, hand cleaned and the oil%, protein% and moisture% was measured using CBH Infratech machines. Grain yields were adjusted to a standard moisture content of 6%. Seed size was assessed using a Pfeuffer electronic seed counter.

Optimum economic plant densities were obtained using the marginal economic theory as described in French *et. al* (1994) for lupins and Seymour *et. al* (2002) for vetches. Assumptions used in calculating optimum densities were:

> Oil bonus +/- 1.5% per unit of oil (%) either side of 42%, with no oil ceiling. Field establishment of hybrids 65% and OP's 50%, germination 90% and seed size the same as the seed lots in the experiments.

RR costs – Hyola 404RR seed $31/kg, GT Viper $25/kg, herbicides $28/ha and grain prices of $479 to 482/t (dependent on port zone, CBH Pools 5/11/13).

TT costs – Hyola 450TT seed $24/kg and ATR Stingray or CB Telfer $2/kg which assumed farmers purchase new seed every 3 years at $11/kg and bulk up seed on 25% of their canola program. Herbicides $47/ha and grain prices of $499 to $502/t.

For gross margin analysis we assumed non treatment costs of $100 to $171/ha (site dependent).

Statistical analysis of plot data included ANOVA, REML and/or ASREML in Genstat, whilst regression analysis for optimisation of economic plant density occurred in either Genstat or Sigmaplot. Across site mean data was calculated using META analysis in Genstat.

Results

Establishment

Plant establishment varied widely between the sites. The Liebe group site at Miling had the lowest establishment at 30% due to the seeding operation drying out what little soil moisture was present. Similarly dry conditions at Cunderdin both before and after seeding reduced field establishment to 43%. Despite reasonable moisture conditions plant establishment at the sites in the Great Southern, was low, ranging from 37% at Katanning to 47% at Pingrup and Holt Rock, which may be due to slightly later sowing date than other sites and consequently lower soil temperatures. Meanwhile the same seed lots at Salmon Gums, Grass Patch and Wongan Hills had relatively good field establishment in the range of 68 to 81%.

Both variety and target density/seed rate had an effect on field establishment. In general Hyola 404RR had the highest field establishment (54%) and GT Viper the lowest (39%) with other varieties averaging 47 to 48%. These observations fit in with our previous experience.

Low target densities of 5 and 10 plants/m² had the highest field establishment rates (55%) whilst target densities above 40 plants/m² had field establishment rates below 45%.

Table 1 Summary information for 11 canola density experiments conducted throughout WA in 2013.

Location	Sowing date	Rainfall (mm)			Field establishment (% of viable seeds sown)	Site mean (t/ha)		
		Growing season rainfall (May to Oct.)	In the month prior to seeding	For the 6 weeks after sowing		Dry matter at flowering	Dry matter at maturity	Grain yield
Chapman Valley	6-May	277	5	79	66	2.5	5.2	1.4
Cunderdin	7-May	160	9	25	43	no data	no data	1.4
Grass Patch	17-Apr	224	44	94	79	4.7*	5.1	0.8
Holt Rock	16-May	256	33	48	47	2.6	8.4	1.8
Katanning	21-May	349	49	39	37	2.2	8.6	2.0
Merredin	3-May	193	11	43	59	2.0	5.2	0.8
Miling	9-May	204	4	60	30	-	-	1.0
Mullewa	9-May	91	8	43	66	2.4	2.4	0.4
Pingrup	20-May	315	30	76	47	2.6	5.2	1.5
Salmon Gums	16-Apr	206	60	38	68	4.4*	5.8	1.2
Wongan Hills	13-May	221	13	67	81	2.3	6.6	1.5

* Low density treatments of 5, 10 and 15 plants/m² were not sampled at flowering at Salmon Gums and Grass Patch

Gross margins

In 10 out of 11 trials Hyola 404RR produced the highest or equal highest gross margins (data not shown). GT Viper consistently grossed less $/ha than Hyola 404RR.

In 6 out of 11 trials Hyola 450TT produced higher gross margins than open pollinated TT canola and in one trial (Katanning) they produced equal gross margins. The sites where Hyola 450TT outperformed open pollinated TT varieties were the medium rainfall sites Eradu, Miling, Pingrup and Wongan Hills and the low rainfall sites Salmon Gums and Holt Rock.

Grain yield - example site at Salmon Gums

Grain yields of most canola varieties at Salmon Gums started to plateau at ~ 20 plants/m² (Figure 1). Taking into account the costs of increasing plant density we calculated the economic optimum for higher cost seed types such as RR and hybrid TT to be 25 plants/m² or less (Table 2). Hyola 404RR had the flattest response indicating its yields were less affected by lower plant densities.

CB Telfer was the lowest yielding variety at Salmon gums in 2013, which may be attributed to its earlier maturity not making use of late spring rains to the same degree as other varieties. In spite of a long slow increase in yield with increasing plant density, the low cost of seed for CB Telfer ensured a slighter higher economic density of 31 plants/m².

Hyola 450TT was the highest yielding variety at Salmon Gums and produced the highest gross margins of $473/ha. Gross margins of all other varieties were in the range of $343 to $379/ha (averaged over densities)

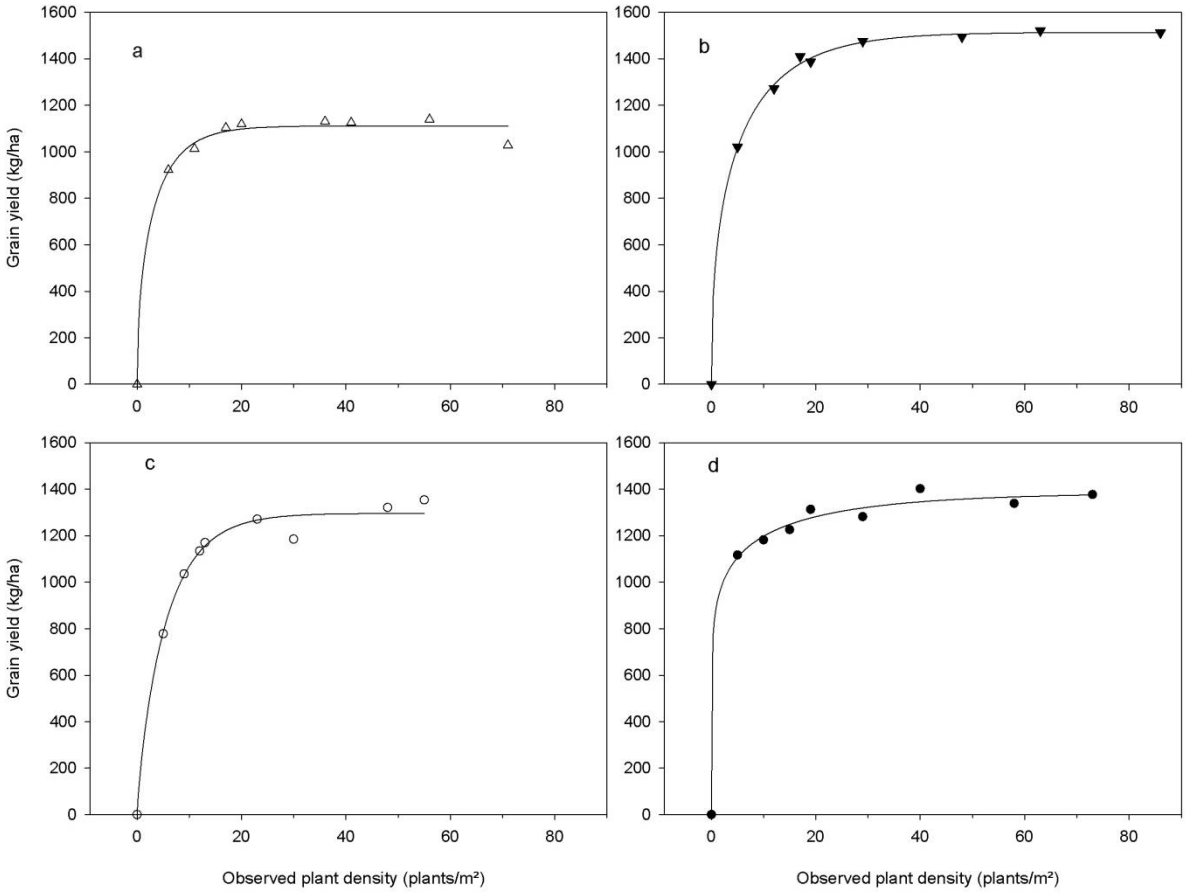

Figure 1 Relationship between plant density (observed, plants/m²) and the grain yield of (a) CB Telfer, (b) Hyola 450TT, (c) GT Viper and (d) Hyola 404RR at Salmon Gums in 2013 (13ED09)

Economic optimum target densities

In the majority of instances open pollinated TT canola had higher optimum economic plant densities than the other canola types (Table 2). This is primarily due to the relatively low cost of open pollinated TT canola seed, rather than different responses to density. Averaged over all sites (META analysis, excluding Grass Patch) open pollinated TT canola (CB Telfer or ATR Stingray) had an economic optimum of 31 plants/m² - equivalent to a seed rate (SR) of ~ 2.1 kg/ha for ATR Stingray or 2.4 kg/ha for CB Telfer. There was a trend for ATR Stingray to have higher optimum densities in medium rainfall areas than CB Telfer in low rainfall areas, but this was not consistent ($P > 0.05$, Table 3).

In most instances hybrid TT canola variety Hyola 450TT had lower economic optimum density than open pollinated TT canola. Averaged over all sites Hyola 450TT had an optimum density of 23 plants/m² (SR of ~ 1.4 kg/ha). There was a trend for Hyola 450TT to have higher optimum densities in medium rainfall areas, but this was not consistent ($P > 0.05$).

Hyola 404RR had consistently lower optimum densities than open pollinated TT canola. Averaged over all sites Hyola 404RR had an economic optimum of 20 plants/m² equivalent to a seed rate of ~ 2.1 kg/ha, with no consistent difference between rainfall zones. The low optimum density of Hyola 404RR appears to be a combination of higher seed costs and relatively high yields at low densities.

The open pollinated RR variety GT Viper also had lower optimum densities than open pollinated TT canola, averaging 24 plants/m² (SR = 2.2 kg/ha). There was a trend for GT Viper to have higher optimum densities in medium rainfall areas, but this was not consistent ($P > 0.05$).

Table 2 Summary of economic optimum density (plants/m²) of canola from 11 experiments conducted throughout WA in 2013.

Location	CB Telfer or ATR Stingray	Hyola 450TT	GT Viper	Hyola 404RR	Comments
Cunderdin	25	22	28	17	
Eradu	34	33	24	16	
Grass Patch#	53	71	53	41	Low density treatments targeted by birds
Holt Rock	39	20	30	38	
Katanning	39	24	39	21	TT blocks weedier – more ryegrass in low density
Merredin	22	20	17	18	TT blocks weedier, more ryegrass in low density
Miling	36	27	20	12	Low establishment, low density = more ryegrass
Mullewa	19	12	10	14	Extended dry period and aphids
Pingrup	29	23	19	18	
Salmon Gums	31	25	22	18	Late emerging barley grass understory in RR blocks
Wongan Hills	40	35	34	21	TT blocks weedier, more ryegrass in low density

Low density treatments at Grass Patch were preferentially attacked by birds; therefore this site was excluded from META analysis

Table 3 Optimum density (plants/m²) of canola in low and medium rainfall sites (META analysis of 10 experiments conducted throughout WA in 2013).

	Low		Medium		All sites	
	TT	RR	TT	RR	TT	RR
OP	27.8	19.8	33.8	27.3	30.8	23.5
Hybrid	19.4	22.0	27.3	17.5	23.3	19.7
		REML P		l.s.d		
Var		<0.001		4.1		
Rfall		0.282		7.4		
Var.Rfall		0.023		5.4		
				9.0	same Var	
				5.4	same Rfall	

Conclusion

The economic optimum plant density of canola appears to be different for each type of canola and in some instances may need to be altered for rainfall zones. Open pollinated TT canola which dominates the WA industry had higher optimum densities primarily because of the low cost of increasing density.

Optimum target densities and suggested seeding rates based on 2013 experiments are:

OP TT - 31 plants/m² which equates to a seeding rate of 2.1 kg/ha for ATR Stingray and 2.4 kg/ha for CB Telfer - but there is no economic reason not to go higher with farmer retained seed.

Hybrid TT - 23 plants/m² (seed rate of ~ 1.4 kg/ha). Using such a low seed rate may be risk so it may pay to increase seed rate if conditions are questionable or machine is not calibrated for low seeding rates

OP RR – 24 plants/m² (seed rate of 2.2 kg/ha)

Hybrid RR - 20 plants/m² equivalent to a seed rate of ~ 2.1 kg/ha. Adjust seed rate for variety/seed lot seed size differences

Note that all optimum densities calculated here assume a given field establishment of 50% for OP's and 65% for hybrids and 90% germination test. As observed field establishment rates can vary due to soil moisture, temperature and seeding errors. Similarly seed size may vary from those used in our trials. Farmer retained seed of TT OP's in dry areas is often smaller than purchased seed and it is our experience that hybrid seed size varies markedly from year to year. Therefore seed rates should be adjusted to suit individual circumstances. Variations in grain prices, seed size, germination and field establishment may also affect our optimum density calculations, particularly if the calculated optima are not on the plateau of the response curve. In most instances for OP TT's and RR hybrids the calculated optima are on the plateau of the response curve and variations in assumptions and changing crop density will affect gross margins slightly. However for TT hybrids and RR OP's the crop gross margins may be more sensitive to variations in density.

Key words

Canola, plant density, seed rate, RoundupReady, hybrid

References

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Acknowledgments

Thanks to the farmers who hosted the experiments and the numerous growers who provided feedback to our researchers. Seed was supplied by Nuseed, Pacific Seeds and Canola Breeders. Trials were well managed by the DAFWA RSU teams at Esperance, Katanning, Merredin, Northam, Wongan Hills and Geraldton. Our technical officer team of Pam Burgess, Laurie Maiolo, Andy Sutherland and Allen

Randell assisted the researchers in gathering samples and measurements. Jo Walker (DAFWA, Geraldton) deserves special thanks for looking after the Geraldton trials which was above and beyond her normal job.

This trial series is funded in partnership with DAFWA and GRDC as part of the GRDC project “Tactical break crop agronomy in Western Australia” which runs from 2013 to 2018.

GRDC Project No.: DAW00277

Paper reviewed by: Heping Zhang