Achieving 4 t/ha of irrigated canola in southern New South Wales

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Abstract
Irrigated canola production is expanding in the southern irrigation regions of NSW with yields of greater than 4 t/ha commonly targeted but rarely achieved. The majority of agronomic research on canola is currently focused on dryland production where average yields are much lower than for irrigated production. The aim of these experiments is to determine management factors required to achieve maximum yields for canola under irrigation systems. The effect of varietal selection, plant population, sowing date and nitrogen (N) management on grain yield, quality and lodging were evaluated in three experiments at Leeton, in southern NSW, in 2016. Sowing on the 5 April in this environment, resulted in a higher grain yield, reduced lodging and lower oil content when compared to the later sowing on 26 April. A plant population range of 35–56 plants/m^2 resulted in higher grain yields than populations of 18 plants/m^2, and 68 plants/m^2. Increases in crop lodging were associated with higher populations. Low rates of applied nitrogen of 150 kg N/ha resulted in reduced grain yield, compared to increased rates of applied N, although lodging increased and oil content declined with increasing rates of applied N. Varietal selection was observed to be one of the most important factors driving yield potential with the highest yielding variety Pioneer® 45Y88 (CL) achieving over 4 t/ha grain yield in all three experiments.

Keywords
Variety, agronomy, nitrogen, plant population.

Introduction
The yield potential of irrigated canola crops is influenced by varietal selection and corresponding agronomic management. Results from the 'Southern irrigated cereal and canola varieties achieving target yields' project have demonstrated that varietal selection in combination with tactical agronomic management can result in canola grain yields of greater than 4 t/ha in the Murrumbidgee Valley, New South Wales, Australia (Napier et al. 2015). Agronomic factors that have been shown to influence grain yield, oil content and lodging, include N management, plant population and sowing date. Choosing the correct variety with appropriate crop management for targeted sowing times, optimises the probability of achieving high grain yield potentials. The third year of experiments was conducted in the winter growing season of 2016 with results reported in this paper.

Methods
Three irrigated canola experiments were conducted at Leeton Field Station in the Murrumbidgee Valley in 2016 (Table 1). Soil moisture was monitored in all three experiments so irrigation could be scheduled to avoid any moisture stress during the entire growing season. The impact of varietal selection, sowing date, plant population and nitrogen management on grain yield, oil content and lodging were evaluated. The experiments were sown and harvested using small plot machinery. Sub samples of harvested grain were used to calculate oil content. Lodging assessments were conducted using a scale of 0 to 9, with 0 indicating no lodging and 9 indicating that the crop was flat on the ground. Each experiment contained three replicates; the N management and population experiments were randomised block designs, whilst the population by sowing date experiment was a split plot design based on sowing date (SD). Individual experiments were analysed using Genstat 18th edition (VSN International 2015).

Results
Grain yield
Variety had a significant effect on grain yield in each of the three experiments, with plant population and rate of applied N also significantly influencing yield. Pioneer® 45Y88 (CL) achieved over 4 t/ha in all three experiments (Table 2), with, Pioneer® 45Y25 (RR) and Nuseed Diamond also achieving grain yields close to

4 t/ha or above in each of their experiments. The lowest yielding was the TT variety ATR-Bonito, which had reductions in yield ranging from 24% to 27% below that of Pioneer® 45Y88 (CL). The large reductions in yield through poor variety selection, having the capability to significantly lower water use efficiency and hence profitability.

Table 1. Canola experiment site details at Leeton Field station, 2016.

	Population by Sowing Date	**N management**	**Population**
Experimental design	Variety (12) x plant population (2) x sowing date (2) x 3 reps	Variety (12) x nitrogen management (4) x 3 reps	Variety (6) x plant population (5) x 3 reps
Varieties	Hyola® 600RR Pioneer® 45Y88 (CL) ATR-Bonito AV-Garnet ATR-Gem Nuseed Diamond Nuseed GT-50 Hyola® 559TT Victory® V3002 Hyola® 575CL Pioneer® 44Y89 (CL) Pioneer® 45Y25 (RR)	Hyola® 600RR Pioneer® 45Y88 (CL) ATR-Bonito AV-Garnet ATR-Gem Nuseed Diamond Nuseed GT-50 Hyola® 559TT Victory® V3002 Hyola® 575CL Pioneer® 44Y89 (CL) Pioneer® 45Y25 (RR)	Hyola® 600RR Pioneer® 45Y88 (CL) ATR-Bonito AV-Garnet ATR-Gem Nuseed Diamond
Sowing date	SD1: 5 April 2016 SD2: 26 April 2016	18 April 2016	18 April 2016
Target plant population (actual plant population in brackets)	Low: 20 plants/m^2 (23/m^2) Medium: 40 plants/m^2 (44/m^2)	40 plants/m^2	Very low: 10 plants/m^2 (18/m^2) Low: 25 plants/m^2 (35/m^2) Medium: 40 plants/m^2 (42/m^2) High: 55 plants/m^2 (56/m^2) Very high: 70 plants/m^2 (68/m^2)
Base fertiliser	P = 67 kg/ha N = 147 kg/ha	P = 67 kg/ha N = 147 kg/ha	P = 67 kg/ha N = 147 kg/ha
Topdressed fertiliser	N = 100 kg/ha	VL = zero, L = 50 kg/ha M = 100 kg/ha, H = 150 kg/ha	N = 100 kg/ha
Fungicides	Prosaro® at 400 mL/ha x 2	Prosaro® 400 mL/ha x 2	Prosaro® 400 mL/ha x 2

Table 2. Grain yield (t/ha) of 12 canola varieties in the three irrigated canola experiments at Leeton in2016.

Variety	**Population by Sowing Date**	**N management**	**Population**
ATR-Bonito	3.11 h	3.24 h	3.20 d
ATR-Gem	3.26 fgh	3.42 fgh	3.28 cd
AV-Garnet	3.96 ab	3.59 ef	3.62 b
Hyola® 559TT	3.44 efg	3.24 gh	-
Hyola® 575CL	3.46 efg	3.91 bcd	-
Hyola® 600RR	3.77 bcd	3.56 ef	3.51 bc
Nuseed Diamond	3.88 bc	4.09 b	4.18 a
Nuseed GT-50	3.59 cde	3.76 cde	-
Pioneer® 44Y89 (CL)	3.54 def	3.66 def	-
Pioneer® 45Y25 (RR)	3.99 ab	4.00 bc	-
Pioneer® 45Y88 (CL)	4.25 a	4.47 a	4.19 a
Victory® V3002	3.19 gh	3.48 fg	-
Average	**3.62**	**3.70**	**3.66**
l.s.d. $_{(P = 0.05)}$	**0.30**	**0.27**	**0.24**

Numbers in the same column sharing a common letter are not significantly different.

Sowing date significantly interacted with variety to influence yield in the population by SD experiment. Several varieties namely, AV-Garnet, Hyola® 600RR, Nuseed GT-50, Pioneer® 44Y89 (CL), Hyola® 559TT and Victory® V3002, had improved yield when sown at the earlier sow date (5 April) compared to the

delayed sowing date (26 April). In contrast, the other six varieties had no difference in yield when sown at either sowing date, showing flexibility in sowing window opportunity (Figure 1).

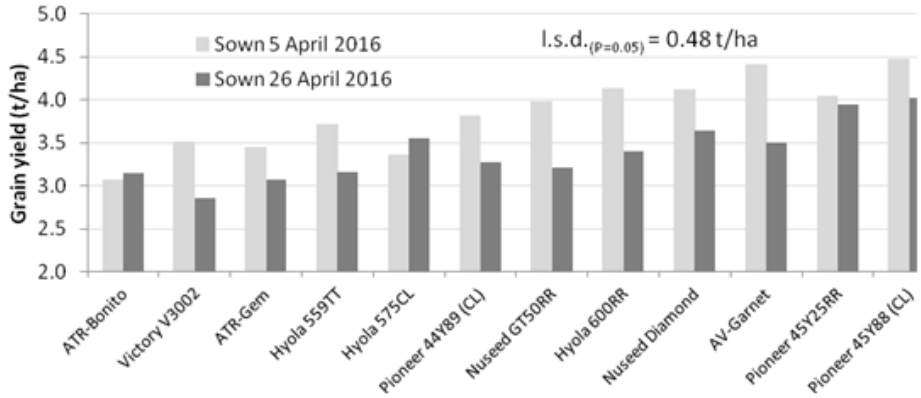

Figure 1. Grain yield (t/ha) of 12 canola varieties at two sowing dates for the 'population x sowing date' experiment at Leeton in 2016.

Application of N affected grain yield, with 150 kg N/ha at sowing and zero in-crop topdressing, resulted in a significantly lower grain yield (3.46 t/ha) compared to the three higher N rates. There was no statistical difference in yield between the application of 200 kg N/ha, 250 kg N/ha and 300 kg N/ha split with a mean varietal yield of 3.72 t/ha, 3.85 t/ha and 3.79 t/ha, respectively (Table 3).

Table 3. Grain yield, grain oil content and lodging score of four nitrogen treatments in the 'Nitrogen Management' experiment at Leeton in 2016.

Nitrogen Treatment	N Rate at sowing (kg N/ha)	N Rate at bud (kg N/ha)	Grain yield (t/ha)	Oil content (%)	Lodging score (0-9)
Very Low (VL)	150	0	3.46 b	46.91 a	1.34 a
Low (L)	150	50	3.72 a	46.73 a	1.99 b
Medium (M)	150	100	3.85 a	45.41 b	3.59 c
High (H)	150	150	3.79 a	44.39 c	4.31 d
l.s.d. (*P*=0.05)	n.a.	n.a.	0.16	0.60	0.37

Numbers in the same column sharing a common letter are not significantly different.

Grain yield was significantly affected by plant population in the population experiment, with plant populations of 35, 42 and 56 plants/m^2 superior in yield to 18 and 68 plants/m^2 (Table 4).

Table 4. Grain yield, grain oil content and lodging score of five plant density treatments in the 'population' experiment at Leeton in 2016.

Population Treatment	Density (plants/m2)	Grain yield (t/ha)	Oil content (%)	Lodging score (0-9)
Very Low	18	3.31 c	45.5	2.6 a
Low	35	3.74 ab	45.7	3.0 ab
Medium	42	3.91 a	45.8	3.3 b
High	56	3.69 ab	45.1	4.5 c
Very High	68	3.67 b	45.3	4.8 d
l.s.d. (*P*=0.05)	n.a.	0.23	n.a.	0.60

Numbers in the same column sharing a common letter are not significantly different.

Grain quality

Variety influenced canola oil content in the population by SD and N management experiments. AV-Garnet and Hyola® 559TT were in the top 5 oil yielding varieties in either experiment (data not shown). Higher oil contents were observed in the population by SD experiment when sowing was delayed from 5 April (42.4%) until 26 April (46.1%), with an improvement in oil content irrespective of variety, with a range of increased oil contents between 4.5% to 14% over 5 April sowing date.

Application of N significantly affected oil content, with decreasing oil % with increasing rates of N applied. Application of 150 kg N/ha and 200 kg N/ha resulting in oil content of 46.9% and 46.7%, respectively with no statistical difference in oil content for these applied N rates. Reduction in oil content came when 250 kg N/ha or 300 kg N/ha was applied, with reductions in oil content of 3% and 5% respectively.

Lodging

Varietal selection significantly affected lodging in each experiment, as did plant population, sow date and N management. Several varieties with reduced lodging included Pioneer® 45Y88 (CL), Hyola® 575CL and Pioneer® 45Y25 (RR) in each of the experiments (data not shown). In contrast Hyola® 559TT, Hyola® 600RR and AV-Garnet were more susceptible to increased lodging.

Increasing population significantly increased lodging risk. Lodging scores increased significantly between 23 and 44 plants/m^2 in both population and population x SD experiments, with increased lodging of between 3% and 50%, respectively. Sow date also affected lodging with higher lodging scores observed at the later sowing date of 26 April (2.62) when compared to the earlier sowing date of 5 April (1.82). The reduced lodging at the earlier sowing date may be due in part to more advanced crops having better developed root systems and sturdier stems.

Significant trends were observed in the N management experiment, between lodging and N rate with lodging scores increasing as N rates increased, at 300 kg N/ha the lodging score was 4.3, in excess of 2 times the lodging score of 150 kg N/ha. Large increases in lodging scores were also observed when N applications were increased from 200 kg N/ha to 250 kg N/ha (Table 4).

Conclusion

Varietal selection was a key driver to achieving maximum yields in 2016 irrigated canola experiments at Leeton Field Station. Of the currently released varieties Pioneer® 45Y88 (CL), Nuseed Diamond and Pioneer® 45Y25 (RR) achieved yields close to and/or in excess of 4 t/ha in each of the three experiments. In combination with variety, sowing date was an important factor in maximising yield potential. Planting early in the sowing window (5 April) saw higher grain yields for most varieties. Grain yield potential increased by 11% with increasing application of N fertiliser from 150 kg N/ha to 250 kg N/ha, with a slight reduction in grain yield with the addition an extra 50 kg N/ha over 250 kg N/ha. Plant population maximised grain yield when populations were either too high (68 plants/m^2 or too low (18 plants/m^2).

The varieties AV-Garnet and Hyola® 559TT consistently achieved the highest oil content in these experiments. Crops sown at the later sowing date of 26 April had higher oil content than when sown early, with N application rates having the potential to decrease oil content, even with split applications. Several varieties tended to lodge more than other varieties, including Hyola® 559TT, Hyola® 600RR and AV-Garnet. Sowing date, plant population and N rate all influencing lodging potential. Crop lodging increased with plant populations above 56 plants /m^2, N rates above 200 kg N/ha and for the later sowing date (i.e. 26 April).

Maximising yield potential can be achieved through varietal selection, in conjunction with the sowing date, rate of N fertiliser and targeted planting densities. Grain yields of above 4t/ha are achievable with current canola varieties when implementing agronomic management strategies around sowing date, targeted plant populations and N management. Importantly, varietal selection is also influenced by factors related to paddock history and weed management considerations.

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