Nitrogen management and yield dynamics of canola

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Key findings

- Grain yield was driven by biomass production rather than harvest index.
- Timing of nitrogen had relatively little impact on yield or nitrogen response.
- Nitrogen rate had little effect on total crop water use.
- Nitrogen use efficiency and water use efficiency were improved with additional water availability (irrigated treatment).

Background

Water and nitrogen (N) availability are the most critical factors for sustaining canola productivity but often water use efficiency (WUE) and N use efficiency (NUE) are low in South Australia. Canola has a high N requirement and how best to manage N in an environment where rainfall is variable is a challenging problem. Relatively little work has been done to look at ways to improve NUE and to understand how N strategies affects canola water use. Consequently the aim of this study was to investigate how different N management strategies affect growth, yield and WUE under different water regimes.

Methodology

Field trials were undertaken at Roseworthy and Tarlee in 2013 to investigate the effect of N management on growth, yield, N and water use efficiency of canola. A medium maturity Clearfield canola cultivar (Hyola 575CL) was sown on 17th of May 2013 at Roseworthy and 4th May 2013 at Tarlee under five different N application strategies: three N rates (0, 100 and 200 kg/N ha) (as granular urea) with the N applied just after emergence or equally split at the rosette stage, green bud appearance and at first flower.

At Roseworthy 60 mm of irrigation was applied at the early rosette stage to create different amounts of soil water. Irrigation increased the soil water to a depth of 100 cm. Treatments were replicated six times at Tarlee and three times at Roseworthy. Initial and final soil moisture contents to a depth of 120 cm at Roseworthy and Tarlee were measured by sampling with a 4 cm hydraulic core and the soil water measurements were used to estimate seasonal water use in the different nitrogen treatments. Crop biomass and grain yield were measured at maturity. Agronomic efficiency of N use was calculated as the increase in yield per kg N applied. Growing season (April to October) rainfall was 287 mm at Roseworthy and 431 mm at Tarlee (Figure 1).

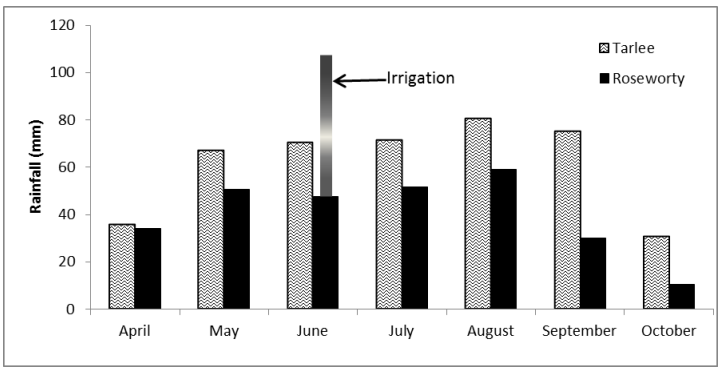

Figure 1. Growing season rainfall for Tarlee and Roseworthy, 2013.

Results

Grain yield and yield dynamics

Applying N increased the grain yield by up to 20% at Tarlee and up to 83% at Roseworthy. There was no significant difference between rate and timing of N on the yield response. In the irrigated treatment, N applications produced significantly higher yield and total dry matter compared with the control but all N treatments were similar to each other.

Under rainfed conditions at Roseworthy, only 200 kg N/ha in one application produced a significantly higher total dry matter than the control however, there was no significant difference between applying 100 or 200 kg N/ha. At Tarlee, all N treatments and the control produced statistically similar total dry matter. Responses in grain yield were affected mainly by changes in crop dry matter production because there was very little difference in the harvest index among the treatments or between the two trial sites. On average canola converted about 23-24% of its biomass into grain yield at Roseworthy and about 27% at Tarlee. Interestingly with additional water application grain yield improved by 49% with an increase of 41% in total dry matter without any considerable improvement in harvest index.

Oil content was generally higher at Tarlee than at Roseworthy. Irrespective of the site and irrigation treatment adding N decreased oil content and this effect was influenced by the timing of application (Tables 1 and 2). Generally there was no improvement in oil content when N was applied as either a split application or single application.

Water use efficiency and agronomic efficiency

The amount of N applied did not influence crop water use (Table 3). At Roseworthy the irrigated treatment used 62 mm more water than the rainfed treatment (Table 2). The average WUE of the rainfed crop was 7.4 kg/ha/mm and the WUE of the irrigated crop was 8.7 kg/ha/mm (Table 1, 2 & 3). The additional water from irrigation was used almost twice as efficiently as the seasonal (WUE = 13 kg/ha/mm) (Table 2). At Tarlee, there was about 15 mm more water used by the crops when N was applied but no difference among the N treatments was noticed (Table 3). Average WUE at Tarlee was 8.0 kg/ha/mm which was slightly higher than that measured in the rainfed treatment at Roseworthy (7.4 kg/ha/mm). Overall, WUE was not significantly affected by N rate or application timing.

At both sites 200 kg N/ha dried the profile more by maturity compare to no nitrogen treatment (Figure 2). At Tarlee water use was limited to largely 70 cm without N (Figure 2a) whereas with N water use was seen up to 110 cm. At Roseworthy, water use was limited to 70 cm in irrigated and at 50 cm in rainfed treatment for N and without N (Figure 2b and c).

Agronomic efficiency (yield increase per unit N applied) fell at the higher rate of N at Roseworthy with an improvement with additional irrigation over rainfed conditions. At Tarlee, single application of 100 kg N/ha gave higher agronomic efficiency than split application of 100 kg N/ha but it reverse in the case of 200 kg N/ha.

Summary

This study on canola under different water regimes with N showed that grain yield was mainly driven by the biomass production. It also revealed that the timing of N had little impact on yield but split application showed the improvement in oil content. Canola crops extracted water to 60-80 cm and adding N dried the profile more by maturity compare to no N but had little effect on total water use. Nitrogen use efficiency and WUE were improved by the additional water availability.

Table 1. Grain yield, total dry mater (TDM), harvest index and oil content of canola as affected by N treatments at Roseworthy and Tarlee for rainfed treatments.

	Grain yield (kg/ha)		TDM (kg/ha)		Harvest index		Oil content (%)	
N Treatments	Roseworthy	Tarlee	Roseworthy	Tarlee	Roseworthy	Tarlee	Roseworthy	Tarlee
0	1310[b]	2356[b]	5587[b]	8555	0.24[ab]	0.28[a]	44.7[a]	44.8[a]
100, single	1745[a]	2832[a]	8002[a]	10283	0.22[cd]	0.29[a]	42.5[b]	43.9[c]
100, 3 split	1736[a]	2542[a]	7473[a]	10329	0.23[bc]	0.25[a]	42.0[b]	44.4[ab]
200, single	2074[a]	2848[a]	8272[a]	10828	0.25[a]	0.26[a]	42.2[b]	44.1[bc]
200, 3 split	1866[a]	2726[a]	8812[a]	9534	0.21[d]	0.28[a]	41.9[b]	43.7[c]
LSD (P≤0.05)	448	327[#]	1995	NS	0.02	NS	0.89	0.46

**LSD = least significant difference for timing x N, # significant at P≤0.10*

Table 2. Effect of irrigation on grain yield, total dry matter (TDM), oil content, water use (WU) and water use efficiency (WUE) at Roseworthy.*

	Grain yield (kg/ha)	TDM (kg/ha)	Oil content (%)	Water use (mm)	WUE (kg/ha/mm)
Irrigated	2604	10826	42.76	299	8.73
Rainfed	1746	7629	42.67	237	7.52
LSD (P≤0.05)	193	1995	NS	54	1.39

**there was no significant interaction between N rate and timing in GY, TDM, oil content, WU and WUE for Roseworthy.*

Table 3. Agronomic efficiency (AE), water use (WU), and water use efficiency (WUE) of canola as affected N treatments at Roseworthy and Tarlee.

	Agronomic N efficiency (kg/kg)			Water use (mm)			Water use efficiency (kg/ha/mm)		
N treatment	Roseworthy		Tarlee	Roseworthy		Tarlee	Roseworthy		Tarlee
	Irrigated	Rainfed	Rainfed	Irrigated	Rainfed	Rainfed	Irrigated	Rainfed	Rainfed
0				293	235	320	5.75	5.69	7.34
100, single	9.14	4.35	4.76	301	232	337	8.59	7.6	8.4
100, 3split	11.36	4.26	1.86	294	226	331	9.57	8.01	7.7
200, 3split	5.96	3.82	2.46	294	253	338	9.72	8.51	8.44
200, single	7.00	2.78	1.85	314	240	335	10.01	7.81	8.18
LSD (P≤0.05)				42.9		11[#]	2.5		NS

**LSD = least significant difference for timing x N, # significant at P≤0.10*

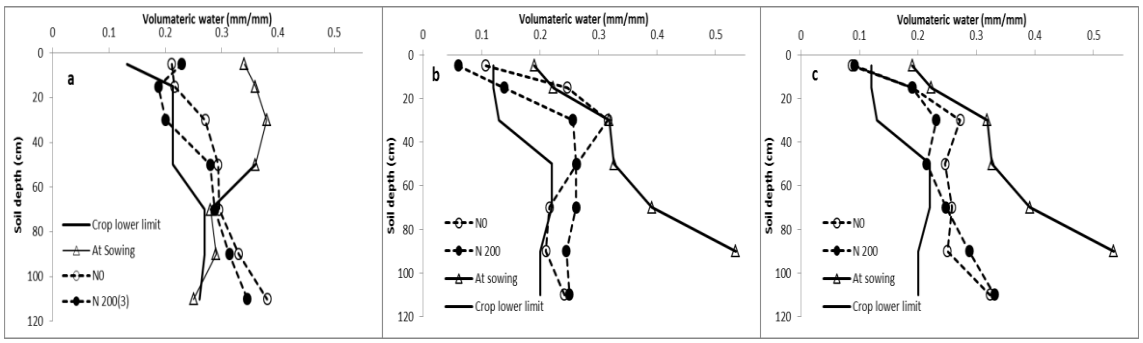

Figure 2. Water use patterns at maturity in 0-120 cm soil profile under nil N and 200 kg N/ha at (a) Tarlee dry land (b) Roseworthy dry land and (c) Roseworthy Irrigated.