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Sulphur and nitrogen boost canola yield and grain quality

Grain yields obtained from canola in the Western Cape are often variable and generally low, and need to be increased to compete financially with wheat and barley. Nitrogen (N) and sulphur (S) are key nutrients that affect yield and quality in canola, while timing of application and N and S sources may also be important because requirements differ for various growth stages, and sources differ in plant availability and mobility in soil.

Field trials to determine the N and S requirements of canola were conducted in three locations during the winter growing seasons of 2012 to 2014. In Altona and Langgewens in the so-called Swartland production area, almost 80% of the annual rainfall occurs in winter from April to September, but annual precipitation decreases from 645mm (long-term average) at Altona to 473mm (long-term average) at Langgewens. At Roodebloem, located in the Southern Cape, about 65% of the annual precipitation of 563mm (long-term average) occurs in winter.

At all localities, S-content was low. Compared to Roodebloem, the percentage carbon (C) and N at Altona and Langgewens was low, suggesting a much lower N and S mineralisation potential. Boron (B) also showed low values at all localities, but was applied as a foliar spray to prevent deficiencies.

Yield and quality of canola

Grain yield increased significantly on all localities due to increasing N application rates, but responses differed between localities and also due to S application rates (*Table 1*).

In case no N was applied, S had an effect at Altona and Roodebloem, but not at Langgewens. At the Swartland localities of Altona and Langgewens, which exhibited lower C and N soil contents before planting compared to Roodebloem, grain yields were significantly increased due to S applications for all N treatments from 40 to 160kg N/ha, but no yield differences were recorded when S application was increased from 30 to 60kg S/ha.

Although grain yields at the higher rainfall locality, Altona, were unexpectedly lower than at Langgewens, the highest yields were obtained where 120 to 160kg N and 30 to 60kg S/ha were applied. At the lower rainfall locality, Langgewens, N rates of above 80kg/ha and S rates of more than 30kg/ha had no effect on grain yield.

At Roodebloem, which showed higher C and N soil contents before planting, no grain yield increases were obtained with N application rates of more than 80kg N/ha, and at high N rates S applications also had no significant effect on grain yield.

Use of agronomic efficiency (AE) of N, which showed the increase in grain yield per kilogram of N fertiliser applied, decreased at all localities, with an increase in N application rate. Although grain yield was not significantly increased with increases in N application rates from 80 to 120kg/ha, values for AE of N at rates of 120kg N/ha were still higher than 4,5 at all localities.

Applications of N fertiliser at this rate will therefore still improve profit margins of canola, if the cost of 1kg of N fertiliser does not exceed 4,5 times the price of 1kg of canola grain.

Table 1: Effect of increasing N (applied as LAN split between planting, 30 and 60 days after planting) and S (applied as gypsum at planting) application rates on canola grain yield (2012 to 2014) with AE use of N in (-).

Nitrogen	Sulphur	Grain yield kg/ha		
(kg/ha)	(kg/ha)		Langgewens	Roodebloem
0	0	1 194e	1 553f	1 243f
	30	1 257de	1 599ef	1 561e
	60	1 315d	1 607ef	1 578e
	Mean	**1 255C**	**1 586C**	**1 461C**
40	0	1 351d	1 735de	1 662e
	30	1 477c	1 934c	1 700de
	60	1 593bc	1 922c	1 849cd
	Mean	**1 474B (5,47)**	**1 864B (6,95)**	**1 737B (6,90)**
80	0	1 516c	1 974b	1 899bc
	30	1 698b	2 156a	1 948abc
	60	1 742b	2 194a	1 959abc
	Mean	**1 652A (4,96)**	**2 108A (6,52)**	**1 935A (5,92)**
120	0	1 668b	1 949bc	2 074a
	30	1 907a	2 196a	2 068a
	60	1 894a	2 232a	2 053ab
	Mean	**1 823A (4,73)**	**2 126A (4,51)**	**2 065A (5,03)**
160	0	1 554c	1 891cd	1 987abc
	30	1 975a	2 163a	2 008abc
	60	1 881a	2 145a	2 016ab
	Mean	**1 803A (3,42)**	**2 066A (3)**	**2 003A (3,38)**

Means in the same row for each one treatment with at least a common letter are not significantly different, LSD 0,05.

Although the oil content in the canola grain tends to decrease and the protein tends to increase with increasing N application rates at all localities, responses in oil content were affected by S application rates (*Table 2*). At Altona, oil content showed significant increases with the application of 60kg S/ha at all N application rates, except the highest rate of 160kg N/ha.

At Roodebloem, the increase in oil content due to the application of 60kg S/ha was also recorded where no N was applied. Grain protein content did not demonstrate any significant response to S application on any of the localities tested.

Table 2: Effect of N and S applications on oil and protein content (0% moisture) of canola. Mean 2012 to 2014.

Nitrogen (kg/ha)	Sulphur (kg/ha)	Altona		Langgewens		Roodebloem	
		% Oil	% Prot	% Oil	% Prot	% Oil	% Prot
0	0	38,7^{f}	18,2^{c}	37,6^{b}	21,7^{a}	38,8^{c}	18,6^{a}
	30	41,3^{def}	19,3^{bc}	38,9^{ab}	21,6^{a}	40,8^{c}	19,0^{a}
	60	46,6^{a}	19,2^{bc}	40,9^{a}	21,7^{a}	44,2^{a}	18,4^{a}
	Mean	**42,2^{A}**	**18,9^{B}**	**39,1^{A}**	**21,6^{A}**	**41,3^{A}**	**18,7^{A}**
40	0	40,0^{f}	19,3^{bc}	38,9^{abc}	21,8^{a}	40,8^{c}	19,0^{a}
	30	39,9^{f}	19,2^{c}	38,8^{abc}	22,0^{a}	39,6^{c}	18,5^{a}
	60	45,4^{ab}	18,7^{c}	39,7^{ab}	21,3^{a}	44,0^{a}	18,6^{a}
	Mean	**41,8^{A}**	**19,1^{B}**	**39,1^{A}**	**21,7^{A}**	**41,5^{A}**	**18,7^{A}**
80	0	40,1^{def}	19,2^{c}	37,0^{c}	21,6^{a}	41,0^{bc}	19,3^{a}
	30	39,6^{f}	19,5^{abc}	38,5^{abc}	22,4^{a}	39,9^{c}	19,4^{a}
	60	44,0^{abc}	19,3^{bc}	37,2^{c}	21,6^{a}	43,9^{ab}	19,7^{a}
	Mean	**41,2^{A}**	**19,3^{B}**	**37,5^{A}**	**21,9^{A}**	**41,6^{A}**	**19,5^{A}**
120	0	40,0^{f}	19,8^{abc}	37,4^{bc}	22,6^{a}	39,8^{c}	20,5^{a}
	30	39,4^{f}	20,4^{abc}	38,0^{bc}	23,0^{a}	39,6^{c}	19,9^{a}
	60	42,8^{bcd}	20,8^{abc}	37,1^{c}	22,8^{a}	40,0^{c}	19,8^{a}
	Mean	**40,7^{A}**	**20,3^{AB}**	**37,5^{A}**	**22,8^{A}**	**39,8^{A}**	**20,1^{A}**
160	0	40,6^{def}	21,2^{abc}	37,6^{bc}	22,8^{a}	39,6^{c}	20,7^{a}
	30	39,9^{f}	21,8a	38,3^{bc}	22,9^{a}	38,6^{c}	19,6^{a}
	60	41,2^{def}	21,8a	36,7^{c}	22,8^{a}	40,3^{c}	20,6^{a}
	Mean	**40,5^{A}**	**21,6^{A}**	**37,5^{A}**	**22,8^{A}**	**39,5^{A}**	**20,3^{A}**

Means in the same row for each one treatment with at least a common letter are not significantly different, LSD 0,05.

Split S applications

Splitting (10kg S × 3 or 20kg S × 3) the S application between planting, 30 and 60 days after planting had no effect on grain yield at Altona (*Table 3*). At Langgewens, splitting of the 60kg S application into three applications of 20kg S/ha resulted in significant lower yields where 80kg N was applied, but not so if 160kg of N was applied.

At Roodebloem, 60kg S/ha at planting resulted in significantly higher grain yields compared to 30kg S when applied in combination with 80 or 160kg N/ha. Splitting of the S application had no effect on grain yield where 80kg N was applied. However, in combination with a 160kg N application, three applications (planting, 30 and 60 days after planting) of 10kg S/ha instead of 30kg at planting, resulted in significantly higher grain yields for the period 2012 to 2014.

"Grain protein content did not demonstrate any significant response to S application on any of the localities tested.

As shown for grain yield, top dressing with gypsum as a source of S did not have a major effect on oil or protein content of canola grain for the period 2012 to 2014 at the three localities tested.

These generally poor results obtained with split applications of S are in contrast to literature, which showed that top dressing (splitting) with S during the growing season can be implemented with good results. These results may be due to the use of gypsum as source of fertiliser in this study. Gypsum is known to have a low solubility and may therefore need to become plant available in future.

Table 3: Effect of S applications (applied at planting or split between planting, 30 and 60 days after planting) on grain yield of canola grown with different N rates (split between planting, 30 and 60 days after planting. Mean 2012 to 2014.

Nitrogen kg/ha	Sulphur kg/ha	Grain Yield (kg/ha)		
		Altona	Langgewens	Roodebloem
0	0	1 666^{c}	1 755^{e}	1 338^{f}
	30	1 632^{c}	1 713^{e}	1 353^{f}
	60	1 744^{bc}	1 719^{e}	1 303^{f}
	10×3	1 683^{c}	1 725^{e}	1 373^{f}
	20×3	1 655^{c}	1 728^{e}	1 363^{f}
	Mean	1 676^{B}	1 728^{B}	1 346^{B}
80	0	1 800^{b}	1 904^{d}	1 553^{e}
	30	2 053^{a}	2 110^{abc}	1 743^{cd}
	60	2 121^{a}	2 209^{a}	1 888^{ab}
	10×3	2 144^{a}	2 202^{a}	1 848^{abc}
	20×3	2 127^{a}	2 069^{bc}	1 813^{bcd}
	Mean	2 049^{A}	2 098^{A}	1 769^{A}
160	0	1 827^{b}	1 994^{cd}	1 535^{e}
	30	2 024^{a}	2 128^{ab}	1 730^{d}
	60	2 030^{a}	2 073^{bc}	1 848^{abc}
	10×3	2 090^{a}	2 180^{ab}	1 873^{ab}
	20×3	2 028^{a}	2 060^{bc}	1 955^{a}
	Mean	2 000^{A}	2 087^{A}	1 788^{A}

Means in the same row for each one treatment with at least a common letter are not significantly different, LSD 0,05.

Grain yield and quality

In a study where limestone ammonium nitrate (LAN) (28% N) as N and gypsum as a source of S were compared to urea-S (40% N and 5,5% S), grain yield showed significant increases with increases in N and S application rates at all localities, but sources of N and S did not have any effect on grain yield or quality (*Table 4*).

Producers can for this reason use the most cost-effective or most convenient source of N and S. It must however be borne in mind that urea-S (U-S) contains only 5,5% S. On soil with low S contents, or under conditions where little N fertiliser is required, this low percentage S may result in suboptimal S applications.

Table 4: Effect of different rates of LAN plus gypsum and urea-S (U-S) as N and S sources on grain yield, oil and protein content (0% moisture) of canola (2012 to 2014).

Treatments	Altona			Langgewens			Roodebloem		
N source kg/ha	Yield kg/ha	% Oil	% Prot	Yield kg/ha	% Oil	% Prot	Yield kg/ha	% Oil	% Prot
0	1 235^{c}	39,5^{a}	21,7^{b}	1 246^{c}	36,8^{ab}	24,4^{a}	1 149^{c}	36,5^{a}	20,9^{a}
60 LAN	1 658^{b}	36,3^{b}	23,0^{ab}	1 619^{b}	35,3^{b}	24,2^{a}	1 304^{b}	36,3^{a}	20,2^{a}
60 U-S	1 713^{b}	37,6^{b}	22,7^{ab}	1 658^{b}	37,9^{a}	24,2^{a}	1 332^{b}	36,7^{a}	20,1^{a}
120 LAN	1 813^{a}	36,8^{b}	23,4^{a}	1 772^{a}	35,1^{b}	24,5^{a}	1 509^{a}	35,6^{a}	21,2^{a}
120 U-S	1 787^{a}	37,1^{b}	22,6^{ab}	1 839^{a}	36,2^{ab}	23,5^{a}	1 591^{a}	35,7^{a}	20,0^{a}

Means in the same row for each one treatment with at least a common letter are not significantly different, LSD 0,05.

Conclusions

This research clearly illustrates the need to apply S to canola in the Western Cape production region with the aim of higher yields and even high oil contents in the grain. Optimum rates for both N and S depend on soil and climatic conditions, but despite very low S contents in the soil (as indicated by soil analysis at planting), very little support for S applications of more than 30kg/ha was found.

Responses to S applications were higher in soil with low organic C contents, and for this reason are of greater importance in the Swartland production area compared to the Southern Cape.

Splitting S applications to apply a certain amount of S as top dressing did not improve grain yield in this study where gypsum was used as S source, but comparing gypsum to urea-S did not demonstrate any yield or quality penalty due to the use of gypsum. Canola producers can therefore use the most cost-effective source of S. Gypsum also contains a certain amount of calcium and should also beneficial on soil with poor structure and salinity problems.

Optimum N application rates in this study varied between 80kg N/ha in the lower-rainfall areas of the Swartland and on soil in the Southern Cape, which indicates high N and C contents at planting. However, in the higher-rainfall areas of the Swartland, which generally als o show low C and N contents at planting, optimum rates varied between 120 and 160kg N/ha. Highest yields and oil content were only obtained if sufficient amounts of S were also applied.

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