Sulfur Nutrition in Canola- Gypsum vs. Sulfate of Ammonia and Application timing

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Take home message

- S deficiency with significant yield and oil penalties have been previously identified in canola of up to 40%
- Trials over 4 sites in 2010 showed no yield or oil response to addition of S
- S removal rates may not be as high as previously suggested
- Nutrient budgeting and more strategic use of S fertilisers may result in significant cost savings

Background

Through Grain Orana Alliances' (GOA) consultation with the local industry it was identified that there was some question over the effect of application timing of sulphur (S) nutrition and the source this S had on subsequent yields and oils in the region's canola crops. With a recent run of dry season and the little opportunity to top-dress in crop till often quite late, it was also questioned, how late is too late?

There have also been numerous concerns raised over the central regions apparent inability to achieve acceptable oil levels (~42%). Previous trial work has shown good response in oil % to improved S nutrition.

Further to this, recent work undertaken in South Australia by Melbourne University and IPL indicate that gypsum was not as an effective source of S nutrition as sulphate of ammonia (SOA) (Laycock, 2010). Gypsum being a popular choice for S supply to canola in the GOA region mainly for its cost effectiveness. SOA- crystalline or granular is the other main source of S for canola with the product popular due to it N content and handling ability in machinery. Other S products such as starter 15 or single super are much less common but still used by some.

Application timings and methods in the GOA region can vary from broadcast pre planting up to late stage top dressing depending upon the many influences.

The current understanding of S nutrition in the local region is that S deficiencies can be common and that S fertiliser was essential to maintain yield and oil in most situations with maybe the possible exception of the heavier soils. The heavier soils, it has been suggested, contain inherently enough S for canola's requirement.

The current recommendation suggests soils that have tested to be low on S to apply 40kg S per Ha. On soils where higher levels of S are either confirmed by testing or estimated that 20kg/ha of S be applied (Good, Glendinning, 1998). The latest publication “Canola best practice and management guide” states “All paddocks sown to canola should receive 20kg/ha of sulphur in the form of available sulphate” (GRDC 2009)

This recommendation is based on S deficiency in canola being identified widely in 1991 and 1992. Trial work around this time identified in some cases large responses to S and hypothesised by the then NSW Department of Agriculture that it was also part of the problem leading to sporadic crop failure in the past (ACIL Consulting, 1998). However not all sites or soil types responded to the S treatments.

Hocking et al (1996) also showed that S deficiency could be rectified even quite late in the crop. Up to 100% of oil could be recovered in S deficient canola with S fertilisation as late as flowering and 85% of the yield. Provided S was applied by stem elongation 100% of yield and oil was recovered.

In the winter of 2010 GOA implemented 4 trials to

- Validate the current S recommendation in timings
- Assess gypsum and SOA as suitable S fertiliser sources
- Assess if under-fertilisation was contributing to our low oil %
- Assess the need for additional S fertiliser on our heavier or naturally higher S soils

GOA Trials in 2010

Methods

Sites and treatments

Four sites were selected in winter 2010 across the GOA region. 3 sites were identified through recent KCL_{40} soil tests as low- moderate in S. The fourth site was deemed adequate in S by way of KCl_{40} soil test and a heavy soil type. All four sites were managed up until sowing by the grower through weed control or grazing. The four sites are characterised below.

Location	Soil type	KCl_{40} Shallow(0-10cm)	KCl_{40} Deep	Total Calc. S/ha#
Nyngan	Red Loam	0.6 (0-10cm)	0.2 (10-60cm)	1.4kg
Narromine	Grey Clay	2.4 (0-10cm)	6.5 (10-100cm)	85kg
Curban	Red Loam	4.9 (0-10cm)	4 (10-70cm)	39kg
Wellington	Red Loam	6.5 (0cm- 30cm)	NA	23kg

calculated S total = (KCl_{40} * bulk density * depth) + (KCl_{40}* bulk density * depth) BD = 1.2 shallow, 1.4 deep

Table 1 Site details for GOA canola trials, 2010

All four sites were sown with Pioneer variety 45Y83, this represented a mid season maturity hybrid variety which would hopefully not disadvantage any one site location by way of environment.

Basal fertiliser treatment was 100kg/Ha of MAP fertiliser- banded at sowing and N was broadcast as urea in each site to level that was considered luxury (~3 t/ha yield potential) on the basis soil test and/or agronomist recommendation. Basal N was adjusted in each treatment to reflect N applied as SOA in treatments.

The trial format was a RCB small plot design of three replicates. Plots were 1.8m by 10m and between each treatment plot a buffer plot of canola was sown. These buffer plots received no S fertiliser but the same basal fertiliser treatment. This avoided any edge effects the treatments may have had.

Treatments are detailed below in table 2.

S Fertiliser				Adj to basal N rate kg/ha
Timing	**Type**	**Rate kg/ha**	**placement**	
Pre-sowing Broadcast	Gypsum	203	broadcast	+55
	SOA	62.5	broadcast	+27
	SOA	125	broadcast	Nil
At Sowing Banded	SOA	62.5	banded	+27
	SOA	125	banded	Nil
4-5 Leaf stage	Gypsum	203	broadcast	+55
	SOA	62.5	broadcast	+27
	SOA	125	broadcast	Nil
Early Bolting	Gypsum	203	broadcast	+55
	SOA	62.5	broadcast	+27
	SOA	125	broadcast	Nil
During flowering- 10-29% flowering	SOA	125	broadcast	Nil
Split- 50% pre sow- 50% early bolting	SOA	125	Banded/broadcast	Nil
UTC	Nil	-	-	+55

Table 2 Details of timing, fertiliser type, rate and placement used in field trials

Post sowing treatments were applied as close to programmed timings as forecast rainfall would allow. All post sowing treatments received rain within three days of application. These treatments were broadcast by hand.

Plots were desiccated with Reglone and harvested by small plot header. Grain samples were tested by NIR for oil %, moisture and protein.

Statistical analysis

Data was analysed by ANOVA and means separated by least significant difference at 95% confidence

Results

Analysis of the data by ANOVA across all trial sites or as individual trial sites have show there is no significant difference at a 95% confidence level in either yield or oil%.

All sites performed well by district averages and consideration of the season. Sites means are represented below in table 3.

Site	Site av. Yield t/ha	Site av. Oil%	S removal kg @ 10kg S/t
Nyngan	2.5	40.8	25
Narromine	2.2	40.9	22
Curban	2.8	43.7	28
Wellington	2.2	43.9	22

Table 3 Site mean grain yield and oil % for 2010 trials

Further analysis of the source of S, gypsum or SOA, does not show any significant differences. Analysis of the timing of application of the S fertiliser be it pre- sowing, 4-5lf or early bolting, also showed no significant differences in resultant yields.

Discussion

It has been shown that S responses are influenced by N availability. If sufficient N is not available S deficiencies will be exacerbated (Good et al, 1993). In these particular trials sufficient N was applied and therefore should only increased potential S responses.

Sufficient rain was received on all trial sites and the season's mild finish was such that yield and hence S responses should not have been limited by moisture availability. Sufficient rain was also received post fertiliser applications to facilitate dissolution and incorporation of fertiliser into the root zone.

Good et al (1995) showed that significant yield responses were experienced in canola to the addition of S. However the most significant response, up to 40%, was following pasture. In the same work when the canola followed cereals the response dropped to 11%. In sites that were described as non responsive, canola following pasture responded by 11% and following cereals only 3% (Good et al 1995).

A Trial at Wellington NSW in 1993 also showed a significant response to S however the site was following a 5 year pasture ley (Good et al 1993).

It seems the magnitude of response may be correlated with cropping history. All four trials undertaken by GOA this year were sown into cereal stubbles. This, as shown by previous work, may have limited the S response.

As can indicated in table 1 the soil status of S of the various sites was variable. The suggested S removal rates quoted in the literature are variable but commonly quoted around 10kg/t of grain (ACIL, 1998). Taking this figure and calculating the S removal of the above crops, all sites with the exception of the Narromine site, would have been able to satisfy this removal demand but only ignoring any uptake inefficiencies and S left in the tops. This would indicate that sufficient S should not have been available in at least three of the four sites yet responses were still not seen.

Therefore possible explanations of the non response maybe;

- S requirement of canola may not be as high as thought, as is grain removal
- S is being supplied or accessed in ways not acknowledged or understood

Sampling of seed samples from the Nil S, Low rate SOA and the high rate SOA and nutrient analysis showed no large variations in seed S content between treatments (non replicated). The tests indicated the S concentration of the seed was in the range of 0.45% - 0.54% or 4.5kg to 5.4 kg per ton of seed. Although un-replicated, these figures are much lower than commonly suggested levels.

Janzen and Bettany (1984) showed in pot experiments that varying rates of S and N did not equate to much change in seed S levels with a range of 0.25-0.33%. Hocking et al (1996) showed S concentration in seed varied between 0.24-0.46% to varied rates of S fertilisation.

Therefore if we may accept that S removal in grain is lower than commonly accepted. Therefore S requirements of the trial yields could have been satisfied even considering an arbitrary figure of only 50% efficiency, except the Nyngan site. Nyngan with extremely low soil S still did not show any differences in seed S % or yield.

Pinkerton et al. (1993) also identified a critical seed S level of 0.36% to separate S deficient seed form those with adequate S. The seed from these trials were all above this critical level indicating even the nil treatments did not suffer S deficiencies.

Although specific varietal data is not available it has been discussed that there are differences in uptake efficiency of S between varieties. Therefore the figure of 50% above has no sound basis the author is aware of.

It has commonly been accepted that zero tillage farming reduces the mineralisation of organic matter and hence release of sulphur (GRDC, 2009).However in systems of stubble retention this organic matter mineralisation is postponed or delayed. This is in contrast to the farming systems of the 90’s where even in the direct drill systems of the day most stubbles were either burnt or grazed heavily while other paddocks were cultivated. The first two options resulted in either movement or loss of S from the soil/paddock, the latter probably sees the mineralisation brought forward compared to that of today’s stubble retention systems.

Has the evolution of our systems and retention of stubbles seen an increase or a retention of the S contained in stubble? Has in-crop mineralisation of S been under estimated? Were the differences in responses to S following pasture or cereal in the early nineties a function of cropping systems and stubble load than starting N?

The common soil testing depth for canola is ~60cm. Sulfur is a mobile nutrient and there is some possibility that additional S is contained at depth. It has been shown that seedling or vegetative canola will not commonly show S deficiency symptoms. It is latter stages at flowering that symptoms and damage occurs (Hocking et. al 1996).

Is it possible that although the soils tests for the sites showed low to moderate S, further S was contained deeper and to a level adequate to satisfy crop requirements. As the crop reached critical stages of flowering onwards the root systems were able to access the deeper stored S and recover fully.

Summary

Sulfur applied as either gypsum or sulphate of ammonia applied to soils over a number of timings over four sites in 2010 failed to show a response in yield or oil %. Seed samples tested also indicate that S was not deficient in even the nil treatments.

Sulfur deficiency has been identified in canola previously with trials demonstrating large responses of up to 40% have been achieved by remediation. This trial work lead to a blanket recommendation to apply S fertiliser to all canola crops. This was probably based on the premise that most canola was sown as the first crop in the rotation where yield responses were greatest. However this may not be as common today in continuous or more intensive cropping programs. The original data suggested that S response where not as common or to the same magnitude following cereals.

The very favourable condition of 2010 and the run of poor seasons would assumedly increased mineralisation and accumulation of S. This may have reduced the likelihood of S responses in these four trials. Despite this, current recommendations, knowledge and soil testing would suggest that three of the four sites should have responded.

The farming system has also evolved with greater stubble retention that may change the dynamics of S cycling. And since the original recommendation were made, soil testing has adopted the KCl_{40} test which is suggested to better estimate the S in the organic pool which previous soil tests may have not accounted for well. However the results from soil tests on these sites would still have suggested a highly responsive site at Nyngan however this was not realised.

It could be suggested more informed, planned and strategic use of S fertilisers in canola may be best. However our understanding on this matter may not seem so clear and a number of questions may require addressing:

- Has the change to our farming systems changed the S cycle?
- Are our current estimates of S removal and requirements for canola accurate?
- Is the KCl40 soil test our best option and how deep should we sample?
- Is a blanket approach to S nutrition in canola still appropriate with tight cropping margins?

It must be said that these results are of four trials in an exceptional year. Our understanding and prediction of responsiveness to S may now being challenged and may require further investigation. Deficiency can be severe and S nutrition in canola should not be, on the basis of this work, discounted or ignored.

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References

ACIL Consulting (1998) Sulfur test KCl40 and the growth of the Australian canola industry. Edited and design Arawang Communication Group, Canberra.

Good, A.J. , Pinkerton, A. , Hocking, P. , Blair, g. , Sykes, J (1993) Nitrogen and sulphur affect canola seed yield and oil percentage. Retrieved- www.regional.org.au/asa/1993/poster/grain-legumes-oilseed/1993pgs342-pos 7th Feb. 2011.

Good, A.J and Glendinning, John S (1998) Canola Needs Sulphur. Better Crops International, Vol 12, No 2, November 1998. Retrived from http://anz.ipni.net/ipniweb/regions/anz/regionalPortalANZ.nsf/4d69fbe2e4abc746852574ce005c0150/d6dd95ec92bd94de852576ff0082d61c/$FILE/BC%20sulfur%20and%20canola.pdf

Janzen, H.H. and Bettany, J.R. (1984). Sulfur nutrition of rapeseed. Influence of fertiliser nitrogen and sulphur rates. Journal of the soil Science Society of America **48**, 100-7

Hocking, P.J. , Pinkerton, A. , Good, A. (1996) Recovery of field grown canola from sulphur deficiency. Australian Journal of Experimental Agriculture, **36**, p79-85

Laycock, J (2010) In the Know, Incitec Pivot Limited

GRDC, Editors- McCaffery, Don. Potter, Trent. Marcroft, Steve. And Pritchard, Felicity(2009). -Canola Best Practice Management Guide for South-Eastern Australia- Coretext

Pinkerton, A., Hocking, P. J., Good, A., Sykes, J., Lefroy, R. D. B.,and Blair, G. J. (1993~)A. preliminary assessment of plant analysis for diagnosing sulfur deficiency in canola.In 'Proceedings of the 9th Australian Research Assembly on Brassicas'. Wagga Wagga, NSW. (Eds N. Wratten and R. J. Mailer.) pp. 21-8.

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