TAKE HOME MESSAGES

1. The application of nitrogen increased grain yield by 0.5t/ha, but there was no benefit from additional sulphur. At this site, money was better spent on nitrogen than on sulphur.

2. Grain protein was very low (7-10% protein) which is becoming an issue on sandy country despite adequate nutrition.

3. The timing of nitrogen and sulphur applications made no difference to crop yield or quality. Consequently, growers could reduce production and financial risk by delaying some applications and adjusting rates to the seasons.

NITROGEN AND SULPHUR TIMING IN THE MALLEE

Simon Craig (Agronomise, BCG consultant)

BACKGROUND

Fertiliser management decisions can be complicated. Contrary to expectations, the more you know, the more complex the whole thing seems to become. It is well known that nitrogen (N) responses are influenced by rainfall, soil moisture, yield potential, mineralisation, leaching and soil type. One of the less documented influences on N decision making is a grower's perception of risk. Having a full soil moisture profile at sowing certainly removes some uncertainty in the season however, when there is the potential for above average yields, growers can be tempted to invest heavily in fertiliser inputs to meet those yields.

Last season, parts of the northern Mallee were fortunate to receive above average summer rainfall (in excess of 150mm in some places), setting growers in these regions up for an average to above average season. Optimism was somewhat dampened by a 'super' El Nino which was predicted to develop in August or September, casting uncertainty in growers' minds. Consequently, management of crop inputs such as N and sulphur (S) presented some challenges. Were there sufficient nutrients in the soil? Had the N and S in the soil leached? Would applying N too early be detrimental to yield potential?

In 2014, as part of the GRDC stubble initiative, BCG conducted a trial investigating the impact that N and S management in deep sands and how they influenced stubble height and composition. Although the initial aim of this project was to investigate the interaction between stubble and N and S inputs, the production data generated had relevance to nutrient management on sandy soils as it compared N and S timing this season.

AIM

To determine the best nitrogen and sulphur strategy for wheat grown on sandy soils in the Mallee with a full profile of moisture and a forecast El Niño.

TRIAL DETAILS

Location:	Kooloonong
Soil type:	Sandy loam without sub-soil constraints
GSR (Apr-Oct):	129mm
Crop type:	Grenade CL Plus wheat
Starting soil N:	54kg N/ha (0-100cm)
Sowing date:	25 April
Seeding equipment:	Knife points, press wheels, 30cm row spacing
Target plant density:	150 plants/m^2
Harvest date:	17 November
Trial average yield:	3.0t/ha

TRIAL INPUTS

Fertiliser:	refer to Table 1	
Herbicides:	Pre-sowing	Goal @ 75ml/ha + Lontrel Advanced @ 100ml/ha + Triflur X @ 1.5L/ha + Avadex Xtra @ 2L/ha + Glyphosate 450g/L @ 2L/ha + Hasten @ 0.5% v/v.
	In-crop	On-duty @ 40g/ha + Lontrel Advanced @ 150ml/ha + Hasten @ 0.5% v/v (4-5 leaf); Velocity @ 670ml/ha + MCPA LVE 600 @ 350ml/ha (GS30).

Pests and diseases were controlled to best management practice.

METHOD

A field trial was sown into a chickpea stubble on a red sandy rise using a complete randomised block trial design with four replicates. Soil analysis (100cm) was taken prior to sowing and showed that there was 54kgN in the profile. Unfortunately, the S levels were not included in the analysis. Assessments included regular NDVI readings (data not presented), crop biomass (N treatments only), head counts, and grain yield and quality parameters.

The trial was designed so that each of the treatments (with the exception of the controls) received the same 'total' amount of N and S (ie. the fertiliser treatments were balanced). Urea (46N) was used for each of the N treatments and GranAm (20N:24S) was used in the S treatments. This was to assess the impact of the timing of N and S applications on production and risk. All fertiliser applications, other than starter phosphorus Single Super (0N:8.8P:11S) for N treatments and MAP (10N:21.7P:1S) for S treatments, were broadcast using a hand-held spreader.

The trial was harvested using a Wintersteiger plot harvester. All data was analysed using one-way ANOVA (Genstat 8th Edition). To quantify the response to specific nutrients, the N-treatments were analysed separately from the S-treatments. The 'Control' treatment (to which no N or S had been applied) was subsequently used to compare both analyses against.

Table 1. Treatments used in this trial.

Treatment	Timing	Total nitrogen (kg N/ha)	Total Sulphur (kg S/ha)
Control (no N or S)	nil	0	0
Control (no N)	sowing	0	11
All N up-front	sowing	76	11
All N in-crop	4-5 leaf	76	11
Split N	sowing	38	11
	4-5 leaf	38	
Multiple N	sowing	19	11
	4-5 leaf	19	
	1st node (GS31)	19	
	Flag leaf emergence (GS37)	19	
Control (no S)	sowing	38	0
	4-5 leaf	38	
All S up-front	sowing	38	11
	4-5 leaf	38	
All S in-crop	4-5 leaf	76	11
Split S	sowing	5	5.75
	4-5 leaf	71	5.75
Multiple S	sowing	32	3
	4-5 leaf	33	3
	1st node (GS31)	2.5	3
	flag leaf emergence (GS37)	2.5	3

Above average summer rainfall, combined with an early break in April (17mm), meant the site had received 162mm (from five events) before sowing and the soil profile was full. During the season, sufficient rainfall fell after each fertiliser application (Table 2). Spring rainfall, however, was well below average, with only 19.5mm falling in four events between August and October. The total growing season rainfall was 155mm and the annual 289mm.

Table 2: Cumulative rainfall total 10 days after each treatment was applied.

Date	Growth stage	Rainfall 10 days after application
25 April	sowing	29mm
6 June	4-5 leaf	8mm
8 July	1st node (GS31)	14mm
20 July	flag leaf emergence (GS37)	10mm

The site experienced several frost events in July and August, but no crop effect was observed and yield was not affected.

RESULTS AND INTERPRETATION

This trial had all the ingredients to be very interesting – a full profile of moisture at sowing, high yield potential (for the Mallee), and a forecast very dry spring. As is often the case, however, results were not as expected.

Research from previous trials has shown that up-front N treatments can promote too much early growth and that, if moisture runs out as a result of a dry spring, the crop will 'hay off'. Considering last season's conditions, differences between treatments were expected to be substantial. The delayed N treatments should have helped control the crop canopy, subsequently conserving the valuable stored soil moisture for spring. But in season 2014 this was not the case.

For much of the season, only minor visual differences were observed between any of the treatments and each, in its own right, seemed to have above average biomass and vigor. This could be attributed to the moist, warm and humid conditions in autumn which promoted rapid crop growth and, potentially, higher than expected mineralisation. The soil N measured prior to sowing showed only 54kg N/ha to one metre. It is plausible to assume that further mineralisation occurred, or that it was not identified in the analysis, which provided adequate nutrition to dampen any response. There was no apparent visual response to the addition of S, nor to its timing.

Canopy 'greenness', measured by Normalised Difference Vegetative Index (NDVI), showed that little separated the treatments until September, when those plots without N began to reduce biomass. To better quantify these differences, biomass at flowering (8 September) found higher biomass in all up-front treatments than in the remainder (Figure 1).

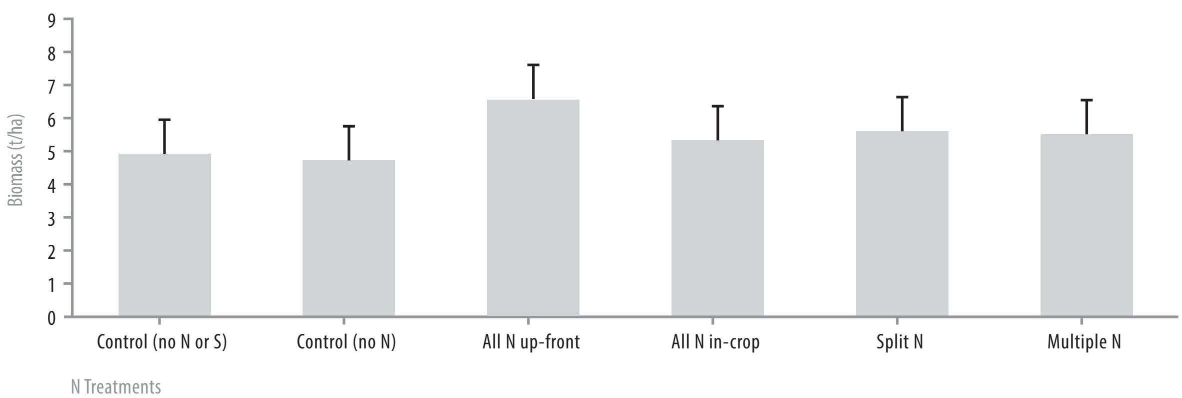

Figure 1. Biomass measured at flowering of the different N treatments.

At flowering, higher biomass was observed where N was applied at sowing (Figure 1). However, differences between the rest of the N-treatments were not as pronounced, nor significantly different, from the Control. Biomass was not physically measured in the S treatments as NDVI showed little, if any, difference from the N treatments. Where the treatments did vary, was in the number of heads (Table 3). Treatments that received some N at sowing had more heads per metre square that those that did not. The split N and upfront N had the most heads compared with the controls. Upfront applications of N will promote tillering, which in turn, convert to heads.

Grain yield differences were observed only between the N-treatments and the control (no N), following a similar trend to the previous assessments (Table 3). There was no significant yield difference between the different N timing treatments. This would suggest that rate was more important than timing in 2014.

Table 3. Grain production and quality data for N-treatments.

Treatment	Heads (m^2)	Yield (t/ha)	Protein (%)	Grade
Control (no N or S)	389^{ab}	3.26ab	8.2a	ASW
Control (no N)	351^{a}	3.10^{a}	7.9^{a}	ASW
All N up-front	492^{de}	3.61^{c}	10.1^{c}	ASW
All N in-crop	438^{bc}	3.44^{bc}	9.0^{b}	ASW
Split N	523^{e}	3.66^{c}	9.6^{bc}	ASW
Multiple N	449^{cd}	3.43^{bc}	9.4^{b}	ASW
Sig. diff.	**P<0.001**	**P=0.003**	**P<0.001**	
LSD (P=0.05)	**52**	**0.25 t/ha**	**0.6%**	
CV%	**7.8%**	**4.8 %**	**4.7%**	

Note: Letters following a treatment result indicate whether there were significant differences between treatments - same letter not significantly different, different letter significantly different.

Similarly to the N only treatments, where N had been applied upfront in conjunction with S, there were more heads. The split S treatment had the highest number of heads (Table 4) but there was no significant difference in grain yield. This would suggest that S was not limiting at this site and the application was of no benefit to the crop.

Table 4. Grain production and quality data for S-treatments.

Treatment	Heads (m^2)	Yield (t/ha)	Protein (%)	Grade
Control (no N or S)	389^{ab}	3.26	8.1^{a}	ASW
Control (no S)	351^{a}	3.79	9.6^{d}	ASW
All S up-front	492^{de}	3.53	8.6^{c}	ASW
All S in-crop	438^{bc}	3.58	9.1^{c}	ASW
Split S	523^{e}	3.62	9.3^{cd}	ASW
Multiple S	449^{cd}	3.66	9.6^{d}	ASW
Sig. diff.	**P<0.001**	**NS**	**P<0.001**	**NS**
LSD (P=0.05)	**16**		**0.5%**	
CV%	**7.8%**	**5.7 %**	**3.3%**	

In terms of grain quality, given the season and amount of N applied to the crop, the trial produced surprisingly low protein. The highest protein level was achieved by the Upfront N treatment (10.1%) while the lowest was in the Control (nil N) treatment (7.9%). While the addition of N helped increase protein by 1-1.5%, the results raise questions about a crop's ability to convert N into protein from depth on sand. With what was thought to be adequate N to satisfy yield, potentially there would have been a further response to the N if more had been applied. If the rate had been increased, protein levels may have increased, but this may not have been economical. The soft finish (cooler) may also influence protein and grain size.

Neither test weights nor screenings were influenced by each of the treatments. The additional N and S had no bearing on the final grade of the grain; all grain was classified as ASW and yield was the profit driver.

COMMERCIAL PRACTICE

This trial highlighted the need for growers to adjust their nutrition plans according to the season. Though an upfront N strategy was successful in this trial, splitting fertiliser applications is a good option to reduce both financial and production risk. This trial also showed that responses to S are not widespread and that N has the greatest influence on yield.

ON-FARM PROFITABILITY

Keeping input costs to a minimum in years with significant production risks is one strategy to mitigate losses. Ensuring that the crop has enough N and S in the soil to grow 1-1.5t/ha cereal or 0.5t/ha canola allows later applications to top-up if yields look likely to exceed those levels. The key to N management is to take the emotion out of it and make sound business decisions with all the available data: nitrogen balances (applied-removal), soil or tissues tests and Yield Prophet® are excellent tools to assist with those difficult N management decisions.

All inputs should have a measurable return on investment. In the case of this trial, though the addition of N was more expensive, it provided a return on investment which did not occur with the S application (Table 5).

Table 5. Economics for calculating return on investment (ROI).

Treatment	Yield (t/ha)	Cost ($/ha)	Increase in yield (t/ha)	Additional income ($/ha)	ROI
Control (no N or S)	3.26	-			
Addition of S	3.10	27	0*	0	0
Addition of N	3.79	80	0.53	130.45	+1.63

*is assumed to be 0 as it is not significantly different from the control.

Note: S product is assumed to be SOA ($600/t), N product urea ($500/t) and wheat ASW grade ($246.15/t).

ACKNOWLEDGEMENTS

This trial was GRDC-funded through the 'Maintaining profitable farming systems with retained stubble in Victoria and Tasmania' project (BWD00024).

KEY WORDS

wheat, nutrition, Mallee, sand, nitrogen, sulphur, timing