Managing Nutrition in Sandy Soils to Close the Yield Gap

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Background

Sandy soil types of the Northern Mallee often underperform despite good weed management and increased inputs of nitrogen and sulphur. There is still a yield gap that can be addressed, with anecdotal evidence of unused water commonly remaining in the soil at depths of approximately 60cm at harvest. In 2014 we set in place a diagnostic procedure to attempt to identify the production limitations on a poor-performing dune at the MSF site near Loxton. Characterisation of the plant available water capacity allowed us to calculate water use efficiency which suggested that the 2014 plots were operating well below industry benchmarks. Penetration resistance was measured to be greater than the threshold predicted to impede root exploration at 20-45 cm depth, suggesting that compaction might be limiting yield. Replicated harvest test strips on and off of wheel tracks measured at three locations in 2014 showed a significant effect of the wheel track compaction at one location only. The site is alkaline sand and pre-sowing soil tests in 2014 indicated relatively low soil test values for sulphur (S) and zinc (Zn). In-season tissue tests indicated marginal status for nitrogen (N), Zn and copper (Cu) and test strips with additional N showed a positive response. The likely primary limitations to production identified were compaction and nutrition.

How was the project done?

In 2015, we chose to test some nutrition packages that might help to boost production on the sand. The treatments included a range of N, S and Zn based treatments which were designed to address whether; 1) constraints to productivity on sands could be managed by manipulating the nutrition package, 2) early application of N is the most profitable option, 3) Zn is a constraint to yield and if the source of Zn is important, and 4) S is a constraint to yield and if the source of S is important.

Key messages

- 40 kg N/ha applied upfront was the best yielding treatment for 2015, with the best protein results where the 40 Kg of N was applied as Urea.
- We found that 20 kg N/ha applied as a Zn enriched Urea product achieved a yield close to 40 kg N/ha as straight urea and we plan to test this treatment again in 2016.
- The timing and form of S application did not have any effect in 2015.

About the 2015 trials

Plots were sown at Loxton with Mace wheat on the 6th May and all plots received 10 kg P/ha as triple superphosphate with the following nutritional treatments applied with four replicates:

Control- P only
20N Urea @sow
40N Urea at sow
20N Zn enriched Urea @sow (Zn Oxide)#
20N Urea + Zn blend @sow (Zn Oxide)
20N urea + Foliar Zn @ 2-3 leaves (farmer Zn, Zn Sulfate)
20N Urea @sow + 20N Urea@GS14/22*

#This product is not commercially available in Australia
**GS14/22-early tillering, GS31-first node*

20N Urea @sow + 20N Zn enriched Urea@ GS14/22
20N Urea @sow + 20N Urea@GS31
20N Urea @sow+20S gypsum pre-sow
20N Urea @sow+20S gypsum@ GS14/22
20N Urea @sow+20S/20 N SOA+ Urea@ GS14/22
20N Urea @sow+4 S SOA@ GS14/22 (replacement S)
20N Urea @sow + 20N Urea@ GS14/22+20S gypsum@ GS14/22

Pre-sowing soil water and nutrition was measured. In-season plant assessments of emergence, biomass (first node, GS31 and anthesis, GS65) and nutritional status (GS65) along with grain yield and quality were assessed.

Results and Discussion

Sowing Soil Measurements

The profile had on average 68 mm of PAW and 28 kg/ha mineral N to one metre depth across the replicates of the nutrition trial at the time of sowing. Surface soil tests indicated that Zn and Cu levels were just above the critical value while S was low in the surface and to depth (2mg/kg throughout) (Anderson et al. 2013). Colwell phosphorus and potassium were adequate (Peverill et al. 1999).

Table 1. Pre-sowing soil test results (0-10 cm depth) **Note that critical KCl-S values are under review*

Test	Result
pH (H2O)	8.7
Organic carbon (% w/w)	0.27
***KCl extractable Sulphur (mg/kg)**	2.6
Colwell P (mg/kg)	19
Colwell K (mg/kg)	174
DTPA Zn (mg/kg)	1.03
DTPA Cu (mg/kg)	0.24

Biomass and Grain Yield and Grain Protein

There were some small differences in biomass at first node, in particular a response to the addition of N (Table 2). At anthesis the response to N was marked, while responses to Zn and S in various forms were less consistent (e.g. the second tier of biomass yields at 2.56-3.02 t/ha could be achieved using various treatments including N, S and Zn treatments). Tissue N content at anthesis indicated that all treatments where 40N was applied had a higher content than where less N was applied (Table 2). Similarly, tissue S was higher where S was applied at 20S (at the GS22 timing) and tissue Zn was slightly higher for treatments where Zn was added (data not shown).

At maturity the highest yielding treatment was for 40N upfront which yielded similarly to all other treatments receiving 40N. Interestingly 20N applied as Zn enriched urea yielded similarly to the treatments with 40N applied. The timing and form of S did not influence yield and the yield outcome of these treatments was driven by the N applied with the S. Protein levels were responsive to N addition and all treatments with 40N applied as urea had the highest category of protein (Table 2).

Table 2. *Biomass response to nutrient management package treatments. X Cells shaded light grey have more biomass or grain yield than the control (for tissue N% and protein it is greater than the lowest value),* ***X*** *Cells shaded dark grey have more biomass, grain yield or protein than the control and the light grey cells. Significant differences were determined at P=0.05.*

Treat Name	First Node dry wt (t/ha)	Anthesis dry wt (t/ha)	Anthesis Tissue N (%w/w)	Maturity Grain Yield (t/ha)	Maturity Grain Protein (%)
Control	0.82	1.62	1.03	0.96	9.54
20N Urea @sow	1.16	2.29	1.09	1.41	9.13
40N Urea at sow	1.15	**2.57**	1.24	**1.66**	**10.16**
20N Zn enriched Urea @sow	**1.21**	**2.56**	1.05	**1.53**	9.13
20N Urea + Zn blend @sow	**1.19**	2.43	1.01	1.38	9.27
20N urea + Foliar Zn @ 2-3 leaves	1.16	2.42	0.96	1.39	9.03
20N Urea @sow + 20N Urea@G14/S22	**1.23**	2.54	1.16	**1.61**	**9.93**
20N Urea @sow + 20N Zn enriched Urea@ GS14/22	1.08	2.50	1.20	**1.55**	9.60
20N Urea @sow + 20N Urea@GS31	1.11	2.38	1.19	**1.56**	**10.45**
20N Urea @sow +20S gypsum pre-sow	1.13	2.44	1.15	1.29	8.88
20N Urea @sow +20S gypsum@ GS14/22	**1.24**	**2.72**	1.04	1.35	9.43
20N Urea @sow + 20N Urea@ GS14/22 +20S gypsum@ GS14/22	**1.26**	2.47	1.20	**1.55**	**9.93**
20N Urea @sow +20S/20 N SOA+ Urea@ GS14/22	**1.18**	**3.02**	1.16	**1.59**	9.63
20N Urea @sow +4 S SOA@ GS14/22	1.04	**2.69**	1.03	1.37	9.25

References

Anderson et al. (2013) Soil sulphur – crop response calibration relationships and criteria for field crops grown in Australia. Crop and Pasture Science 64:523-530.
Peverill K.I., Sparrow L.A., Reuter D.J. (1999) Methods of soil analysis-an interpretation manual, CSIRO Publishing.

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