Managing nutrition on sandy soils – yield gains from Zn and N

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Key Messages

- The highest yield in 2016 at Loxton could be achieved with either 40 kg N/ha as urea or 20 kg N/ha as Zn-coat urea or Zn-enriched MAP.
- Compared to applying 20 kg N/ha as normal urea, using Zn-coated urea (20 kg N/ha) or Zn-enriched MAP with urea (20 kg N /ha) increased yield by over 20%.
- This is the second consecutive season that Zn coated Urea at sowing (20kg N/ha) has significantly increase yield compared to normal Urea (20 kg N /ha).
- Applying foliar Zn has not increased yield at this site in 2015 or 2016.
- Nitrogen was a key driver of wheat productivity again, with 40 kg/ha N at sowing increasing yield by over 20% compared to 20 kg/ha N at sowing, but water use efficiency remained poor on this sandy soil.
- There was also no benefit in delaying N application at Ouyen, however very high rates (60-80 kg/N ha) using higher late application rates increased yield on the midslope.
- In 2016 there was a large difference in yield between the midslope (2.90 t/ha) and the nearby sand dune (0.86 t/ha) at Ouyen which could not be closed through the addition of N, S and Zn to the sand.

Background

Sandy soil types of the Northern Mallee often underperform despite good weed management and increased inputs of nitrogen and sulfur. 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.

After several years of demonstrating the value to wheat production of increased nitrogen inputs on sands at Karoonda, it was time to explore nutrition packages at a broader set of Mallee sites.

About the trial

Loxton

On the back of the key responses to nutrition packages in 2015 where there was no response to S or delaying N application after sowing, the treatments were narrowed to all N applied at sowing with a range of Zn sources (Table 1). Plots were sown with Scepter wheat on the 27th May into wheat stubble with 28 cm row spacing with 1.5 L/ha of trifluralin pre-sowing. All plots received a pre-sowing application of 33 kg/ha of potassium sulfate to eliminate K and S as confounding issues and 10 kg P/ha at sowing as triple superphosphate, except for the treatment receiving MAP. All plots received an in-crop foliar application of Cu and Mn. 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.

Table 1. *Treatments applied at Loxton 2016*

N and Zn Product	N applied (kg/ha)	Zn applied (kg/ha)
Nil	0	0
Urea	20	0
Urea	40	0
#Zn-coated Urea	20	0.4
Zn-coated Urea	40	0.8
***Urea plus foliar Zn-sulfate**	20	0.4
Urea plus Zn enriched MAP	20	0.4
Urea plus Zn-oxide powder	20	0.4

*Foliar Zn-sulfate applied at 4-leaf #This product is not commercially available in Australia

Ouyen

Two separate trials were established in 2016 near Ouyen to investigate nitrogen timing x rate and fertiliser source to supply N, S and Zn (Table 2). Each trial was replicated on deep sand with historically low productivity and a responsive sandy midslope soil. Both trials were sown with Grenade wheat on the 16th May into canola stubble with 30.5 cm row spacing with 1.5 L/ha of trifluralin pre-sowing. All plots received 50 kg/ha of single super phosphate. The rate x timing trial also received a pre-sowing application of 33 kg/ha of potassium sulphate to eliminate K and S and foliar applications of Zn, Mn and Cu. The fertiliser source trial received a foliar application Mn and Cu only. Pre-sowing soil water and nutrition was measured. In-season plant assessments of emergence, biomass (first node, GS31 and anthesis, GS65) along with grain yield and quality were assessed.

Table 2. *Treatments applied in the two trials at Ouyen*

Trial 1: Rate x Timing				Trial 2: Fertiliser Source			
Treatment	**Seeding**	**Early Tiller**	**Late Tiller**	**Treatment**	**N**	**S**	**Zn**
	N (kg/ha)				**Nutrient (kg/ha)**		
Nil	-	-	-	**Nil**	-	-	-
20 S	20	-	-	**Urea**	20	-	-
10 S + 10 ET	10	10	-	**Zn coated urea**	20	-	0.4
10 S + 10 LT	10	-	10	**Urea + ZN Oxide**	20	-	0.4
40 S	40	-	-	**Urea + ZN Oxide + Foliar Zn**	20	-	0.4
20 S + 20 ET	20	20	-	**Urea + SOA**	20	11.9	-
20 S + 20 LT	20	-	20	**Urea + SOA + ZN Oxide**	20	11.9	0.4
30 S + 30 ET	30	30	-	**Urea + SOA + ZN Oxide + Foliar Zn**	20	11.9	0.4
30 S + 30 LT	30	-	30				
40 S + 40 ET	40	40	-				
40 S + 40 LT	40	-	40				

Results

Loxton

Sowing Soil Measurements

The profile had on average 77 mm of soil water and 34 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 S were just above the critical levels (soil test S was 4-5.3 at 0-30 cm depth) (Table 2). Colwell phosphorus and potassium were adequate.

Table 3*. Pre-sowing soil test results (0-10 cm depth)*

Test	Result
pH (H2O)	7.8
Organic carbon (% w/w)	0.36
KCl extractable Sulfur (mg/kg)	4
Colwell P (mg/kg)	18
Colwell K (mg/kg)	175
DTPA Zn (mg/kg)	0.9

Crop Measurements

Establishment was not influenced by treatment and averaged 71 plants/m^2. There was a clear early biomass response to N input when combined with Zn, with the Zn-coated urea at 20 kg N/ha the best (Table 3). Zn-coated urea at 40 kg N/ha was the highest yielding treatment at maturity, but was equivalent to 20 kg N/ha when supplied as either Zn-coated urea or Zn enriched MAP and 40 kg N/ha Urea with no Zn. Improved N supply has been shown to facilitate improved Zn uptake in cereals (Xue et al. 2014). As a result, equivalent yields could be achieved with either 40 kg N/ha as urea or 20 kg N/ha when supplied with an effective source of Zn (Zn-coat urea or Zn-enriched MAP). The absence of a further yield benefit when 40 kg N/ha was applied with Zn suggests that the Zn requirement for the achievable yield had been met. The wheat crop still suffered other limitations, in particular root disease (predominantly TakeAll) and yielded well below the potential which was in excess of 2 t/ha.

Table 3. *Wheat response to nutrient package.*

N and Zn Product	N applied (kg/ha)	Zn applied (kg/ha)	GS31 biomass (t/ha)	Grain Yield (t/ha)	Protein (%)
Nil	0	0	0.26^{c}	0.77^{d}	9.1^{a}
Urea	20	0	0.36^{bc}	1.08^{c}	8.4^{b}
Urea	40	0	0.33^{bc}	1.32^{ab}	8.5^{b}
Zn-coated Urea	20	0.4	0.50^{a}	1.30^{ab}	8.4^{b}
Zn-coated Urea	40	0.8	0.30^{bc}	1.43^{a}	8.3^{b}
Urea plus foliar Zn-sulfate	20	0.4	0.35^{bc}	1.04^{c}	8.4^{b}
Urea plus Zn enriched MAP	20	0.4	0.39^{ab}	1.36^{ab}	8.4^{b}
Urea plus Zn-oxide powder	20	0.4	0.38^{ab}	1.18^{bc}	8.3^{b}

Ouyen

There was a large difference in soil fertility between the deep sand and midslope soils for both trials. Approximately 30 kg/ha of mineral nitrogen and 16 kg/ha of sulfur was measured in the top 1 meter on the sand dune while the midslope soil had 50 kg N/ha and 140 kg S/ha in the soil profile. Soil zinc (DTPA) levels were 0.64 and 1.16 mg/kg on the dune and midslope soils respectively.

Trial 1: Rate x Timing

Both the midslope (48plants m^2) and sand (35plants m^2) had less than desirable crop establishment, primarily due to the DEDJTR seeding equipment sowing too deep across the undulating site, especially on the sand dune. It is highly likely that the variability in establishment has impacted the crop's ability to fully respond to the applied treatments.

The midslope site was highly productive with an average grain yield of 3.14 t/ha while the sand dune only yielded 0.9 t/ha. Much of the difference between treatments could be summarised by the total amount of N applied with a gain of 13 kg grain per kilogram of N applied on the midslope and 8.8 kilograms of grain per kilogram of N applied on the sand. For both soil types the first 20-40 kg N applied produced he greatest yield response and there was no significant benefit from delaying N application, however applying very high N rates (60-80 kg N/ha) using late applications to the midslope soil increased yield (Table 4). Greater and later applications of N slightly increased grain protein levels on both soil types, however all treatments still had protein levels of less than 10 percent.

Table 4. *Grain yield response to treatments at Ouyen for the Midslope and Sand soil types.*

N rate (kg/ha)	Midslope			Sand		
	Sowing	Sowing + Early Tiller	Sowing + Late Tiller	Sowing	Sowing + Early Tiller	Sowing + Late Tiller
0	2363 ± 168	na	na	402 ± 145	na	na
20	2960 ± 97	2595 ± 168	3317 ± 168	856 ± 84	707 ± 145	705 ± 145
40	3328 ± 168	3067 ± 168	3157 ± 168	833 ± 145	895 ± 145	892 ± 145
60	na	3310 ± 168	3657 ± 168	na	1081 ± 145	1153 ± 145
80	na	3458 ± 168	3707 ± 168	na	1222 ± 145	1262 ± 145

Trial 2: Fertiliser source

As with trial 1, low and variable plant establishment was observed in the fertiliser source trial with 49 and 42 plants per square meter measured for the midslope and sand sites respectively. Again there was a large overall difference in productivity between the two soil types (2.9 t/ha for the midslope and 0.86 kg/ha for the sand). However only the addition of N increased grain yield on the flat and no significant grain yield differences were observed on the sand for N, S or Zn. This is potentially a result of poor plant establishment of the site, therefore these findings should be treated with caution.

Implications for commercial practice

Increasing N fertiliser rates had a substantial effect on yields on the sandy soils once again, as expected given the above average 2016 season rainfall, however poor water use efficiency highlights the potential for much more improvement in production from sandy soils. The results highlight the potential for Zn coated Urea or Zn-enriched MAP at seeding to improve yields on some sandy soils despite foliar Zn applications having no effect. Further work will investigate the best delivery and rates of Zn at more sites. Results from the Victorian Mallee at Ouyen support recommendations from research at in South Australia that there is no benefit from delayed application of N to underperforming sandy soils.

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Links and references

Xue et al. (2014) Effects of nitrogen management on root morphology and zinc translocation from root to shoot of winter wheat in the field. Field Crops Research, 161, 38-45.