Nutrition Packages for Wheat on Sands

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Key Messages

- Good early nitrogen nutrition remains a key driver of yield in Mallee soils and penalties can occur with delays in applications to first node.
- Previously observed benefits of improved N use efficiency where Zn is supplied with the N were not captured in the 2017 season.
- Wheat fertilised with DAP placed with seed yielded 0.5 t/ha (20%) less than wheat with DAP placed below seed in 2017 at Loxton but had no effect at Karoonda.
- Using 50 kg DAP/ha with the seed and 35 kg Urea/ha deep was better than 50 kg DAP/ha and 35 kg Urea/ha all below the seed on sand at Loxton.

Background

Following six years of measurements at Karoonda consistently demonstrating production and profit advantages of increased N inputs on sands all applied at sowing (40 kg N/ha relative to district practice of 10 kg N/ha at experiment commencement, McBeath et al. 2015), the soil-specific response to the timing and dose of N inputs were tested across a Loxton based dune-swale system and a dune and mid-slope soil at Ouyen in 2017 to address the following questions:

- Are there soil-specific differences in the amount and timing of N that will maximize productivity on new Mallee sites?
- Do high (relative to district practice) rates of N boost productivity on any of the key soil types at other Mallee sites?
- Does all N upfront remain the best strategy for productivity and risk at other Mallee sites?

Supplying nitrogen (N) to wheat crops at 20 kg N/ha utilising products that contained zinc (Zn) produced yields equivalent to 40 kg N/ha supplied as straight Urea in two consecutive seasons (2015 and 2016) at Loxton (McBeath et al. 2017a). The 2017 cropping season was the third year of testing the potential benefits of nutrition packages containing various combinations of N and Zn for Mallee sands at Loxton and the first year for Karoonda and Ouyen. The aims of the nutrition package work were to address the following question:

- Are there Zn containing N fertiliser products that have a consistent production or N use efficiency advantage over Urea?

In 2015 we noticed that wheat plant establishment was significantly better on non-wetting sand (crest and dune) plots that received no fertiliser with the seed compared with those that received 50 kg DAP/ha. Similar effects were measured in trials established by Jack Desbiolles at Moorlands in 2015 (McBeath et al. 2016). These effects were explored in more detail for their effects on crop productivity in 2016 demonstrating a 0.5 t/ha (20%) yield penalty for placing 50 kg DAP/ha with the seed. A further interesting lead was that the toxicity effect on yield could be overcome when 50 kg/ha DAP was placed with the seed with an extra 35 kg/ha of Urea placed below the seed in 2016 (McBeath et al. 2017b).

The aims of fertiliser placement work at Karoonda and Loxton were to establish if;

- Supplying 50 kg DAP/ha with seed had a consistent yield penalty
- If wheat yield could be improved by altering the placement of sowing fertiliser

About the trials

All experiments at a site were sown on the same day (24th of May at Ouyen, 25th of May at Loxton and the 29th of May at Karoonda) into wheat stubble with Scepter wheat on 28 cm row spacing and 1.5 L/ha of trifluralin pre-sowing. The trials were established using knife points and a dual shoot system. Fertiliser placed below the seed was approximately 5cm below seeding depth (3 cm). Pre-sowing soil water and nutrition was measured. In-season plant assessments of establishment, biomass (first node, GS31 and anthesis, GS65) along with grain yield and quality were assessed.

Soil-specific Inputs and Timing of Nitrogen

For both sites, all plots received a pre-sowing application equivalent to 33 kg/ha of potassium sulfate to eliminate K and S as confounding issues and 10 kg P/ha as triple superphosphate at sowing. All plots received an in-crop foliar application of Cu and Mn.

A range of N rate and timing treatments were set up at Loxton on plots covering the dune to swale system over 100 m length (Table 1). All N was applied as Urea and sowing N treatments were applied below the seed while in-season treatments were surface applied.

Table 1. *Nitrogen rate (kg N/ha) and timing (GS22 is early tillering and GS31 is first node) treatments for the dune-swale at Loxton.*

Treatment	N applied (kg/ha)
Nil N	0
10 N at sow + 10 N GS22	20
10 N at sow + 10 N GS31	20
40 N at sow	40
20 N at Sow + 20 N GS22	40
20 N at Sow + 20 N GS31	40

At Ouyen plots were sown on dune sand and mid-slope soil types (Table 2). All N was applied as Urea and sowing N treatments were applied below the seed while in-season treatments were surface applied.

Table 2. *Nitrogen rate (kg N/ha) and timing (GS22 is early tillering and GS31 is first node) treatments for the dune and mid-slope soils at Ouyen.*

Treatment	N applied (kg/ha)
Nil N	0
20 N at sow	20
10 N at sow + 10 N GS22	20
40 N at sow	40
10N at sow + 30 N GS22	40
40 N at sow +20 N GS22	60
10N at sow + 50 N GS22	60
40N at sow +40 N GS22	80
10N at sow + 70 N GS22	80
40N at sow + 60 N GS22	100
10N at sow + 90 N GS22	100

Nutrition Package

On the back of the key responses to nutrition packages in 2015-2016 at Loxton a range of N source treatments were implemented at Loxton, Karoonda and Ouyen in 2017 (Table 3). Inputs of P, K and S were balanced across all treatments (10 kg P/ha, 9 kg S/ha, 18 kg K/ha) at sowing and Cu and Mn were applied as a foliar application in-crop.

Table 3. *Nutrition package treatments for experiments at Loxton, Karoonda and Ouyen.*

N and Zn Product	N applied (kg/ha)	Zn applied (kg/ha)
Nil	0	0
Urea	20	0
Urea	40	0
MAP	20	0
ZnMAP	20	0.4
Zn-coated Urea	20	0.4
Zn-S coated Urea	20	0.4
Urea plus foliar Zn	20	0.4

Note-The Zn-coated Urea treatment was discarded at Loxton due to a calibration issue.

Fertiliser Placement

To further explore the potential for fertiliser toxicity effects and the possible benefits associated with altered fertiliser depth, a small experiment of four treatments (Table 4) was established at Loxton and Karoonda. All plots received a pre-sowing application of 33 kg/ha of potassium sulfate to eliminate K and S as confounding issues with an in-crop foliar application of Zn, Cu and Mn.

Table 4. *Fertiliser Treatments applied in the fertiliser placement experiment at Loxton and Karoonda*

Fertiliser with seed	Fertiliser below seed
Nil	50 kg DAP/ha
50 kg DAP/ha	Nil
50 kg DAP/ha	35 kg Urea/ha
Nil	50 kg DAP/ha+35 kg Urea/ha

Results & Discussion

Soil-specific Inputs and Timing of Nitrogen

The highest yields at Loxton in the Dune Sand were produced from 40 kg N/ha and 20 kg N/ha except when half was applied at first node (Table 5). For the Loamy Sand and Mid-Slope, yields were reduced if 40 kg N/ha was split with half delayed and applied at first node or if only 20 kg N/ha was applied.

Table 5. *Grain Yield (t/ha) in response to rate and timing of N input across dune-swale soils at Loxton. Treatments in bold produced the highest yields. Treatments shaded grey are not significantly different from the highest yielding treatment.*

Treatment	N input (kg/ha)	Dune Sand	Mid-slope	Loamy Sand Swale
Nil N	0	0.31d	0.72d	1.16d
20N at sow	20	0.56abc	1.07bc	1.29cd
10 N at sow + 10 N GS22	20	0.56abc	1.04bc	1.32cd
10 N at sow + 10 N GS31	20	0.51c	0.96c	1.17d
40 N at sow	40	**0.65a**	1.18ab	**1.62a**
20 N at Sow+20N GS22	40	0.63ab	**1.27a**	1.54ab
20 N at Sow+20N GS31	40	0.54bc	1.08abc	1.42bc
LSD (P=0.05)		0.09	0.19	0.20

At Ouyen, the highest yields were produced at 60 kg N/ha but they were not significantly more than yields at 40 kg N/ha, nor 20 kg N/ha if all was supplied at sowing (Table 6). While production potential differed between soils, there was no clear difference in N requirement.

Table 6. *Grain Yield (t/ha) in response to rate and timing of N input in dune sand and mid-slope soils at Ouyen. Treatments in bold produced the highest yields. Treatments shaded grey are not significantly different from the highest yielding treatment.*

Treatment	N applied (kg/ha)	Dune Sand	Mid-slope
Nil N	**0**	0.34d	1.93d
20 N at sow	**20**	1.04abc	2.43abcd
10 N at sow + 10 N GS22	**20**	0.80c	2.43abcd
40 N at sow	**40**	1.13abc	2.90ab
10N at sow + 30 N GS22	**40**	1.11abc	2.80ab
40 N at sow +20 N GS22	**60**	**1.29a**	**3.00a**
10N at sow + 50 N GS22	**60**	0.85bc	2.10cd
40N at sow +40 N GS22	**80**	1.08abc	2.64abc
10N at sow + 70N GS22	**80**	1.00abc	2.38bcd
40N at sow + 60N GS22	**100**	1.23ab	2.36bcd
10N at sow + 90N GS22	**100**	1.00abc	2.00d
LSD (P=0.05)		0.41	0.57

Nutrition Package

Contrary to previous seasons, there was no clear response to adding 40 kg N/ha compared to 20 kg N/ha as Urea across all sites except the mid-slope soil at Ouyen (Table 7). Where there was differentiation between 20 and 40 kg N/ha as straight Urea, with the exception of ZnMAP, all other treatments containing 20 kg N/ha produced yields similar to 40 kg N/ha as straight Urea (Table 7). The 2017 growing season featured some extremely dry periods at critical growth stages (May-Jul and September for Loxton and Ouyen and June and September for Karoonda) and these conditions often diminish responses to fertiliser inputs.

Table 7. *Grain yield (t/ha) in response to nutrition package treatments for experiments at Loxton, Karoonda and Ouyen. Treatments in bold produced the highest yields. Treatments shaded grey are not significantly different from the highest yielding treatment. Treatments containing Zn supplied 0.4 kg Zn/ha.*

N and Zn Product	Loxton	Karoonda	Ouyen-sand dune	Ouyen-mid slope
0N Nil	0.43b	2.60c	0.31d	1.71c
20N Urea	0.83a	3.58a	0.88abc	2.23b
40N Urea	0.83a	**3.75a**	**1.09a**	**2.58a**
20N MAP	**0.88a**	3.25ab	0.80bc	2.56a
20N ZnMAP	0.85a	3.44ab	0.80bc	2.20b
20N Zn-coated Urea	*	3.36ab	1.01ab	2.34ab
20N Zn-S coated Urea	0.86a	3.61a	1.06a	2.46ab
20N Urea plus foliar Zn	0.75a	2.98bc	0.74c	2.29ab
LSD (P=0.05)	0.2	0.56	0.22	0.32

Fertiliser Placement

Establishment was not affected by fertiliser placement with all plant numbers close to or in excess of 90 plants/m^2 at both sites (Table 8). Placement of 50 kg DAP/ha with the seed caused a 0.2 t/ha or 30% yield penalty compared with below the seed at Loxton but not Karoonda. Despite the possibility of a toxicity effect of DAP with the seed, the best performing treatment was 50 kg DAP/ha with the seed plus 35 kg Urea/ha deep. Similarly, 50 kg DAP and 35 kg Urea/ha applied below the seed was high yielding with only a small decrease in yield observed at Loxton (0.14 t/ha) compared with a split placement.

Table 8. *Establishment and grain yield and protein response to fertiliser placement. Treatments in bold produced the highest yields. Treatments shaded grey are not significantly different from the highest yielding treatment.*

Fertiliser with seed	Fertiliser deep	Establishment (plants/m^2)	Grain yield (t/ha)	Protein (%)
		Loxton		
Nil	**50 kg DAP/ha**	97	0.84c	10.70ab
50 kg DAP/ha	**Nil**	95	0.64d	10.88a
50 kg DAP/ha	**35 kg Urea/ha**	94	**1.18a**	10.90a
Nil	**50 kg DAP/ha+35 kg Urea/ha**	94	1.04b	10.43b
LSD (P=0.05)		NSD	0.12	0.35
		Karoonda		
Nil	**50 kg DAP/ha**	94	2.33b	8.30
50 kg DAP/ha	**Nil**	89	2.36b	8.28
50 kg DAP/ha	**35 kg Urea/ha**	91	**3.02a**	8.68
Nil	**50 kg DAP/ha+35 kg Urea/ha**	89	**2.81a**	8.55
LSD (P=0.05)		NSD	0.44	NSD

Implications for commercial practice

While we have measured increased productivity per unit N input when Zn is supplied with N in the fertiliser in past seasons, this was not clearly measured in 2017. We will continue to explore the dynamics of this interaction in order to better predict the soil types and seasons it will be of most benefit.

Sands continue to show responses to increased inputs of N across a range of environments and seasons, but responsiveness is dependent on yield potential. Nitrogen inputs at first node appear less effective than at early tillering and sowing, indicating good early N nutrition on sands remains a consistent requirement for cereal productivity.

We have measured toxicity effects of supplying 50 kg DAP/ha with seed. This effect does not tend to outweigh the benefits that come from having some fertiliser with and some below the seed compared with all deep. There are several combinations of fertiliser placement that remain to be tested to ensure that we have identified the optimal configuration.

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