Strategies to reduce nitrous oxide emissions from nitrogen fertiliser applied to dryland sorghum. Part 1. Effects on crop production and gross margins

Graeme Schwenke and Bruce Haigh
NSW DPI, Tamworth

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Key findings

Fertiliser nitrogen (N) rates should be tailored to suit paddock history and soil mineral N levels at sowing.

Sorghum yields without N fertiliser, although high in a favourable season, were still well below those achieved using additional N fertiliser.

At Tamworth, in-season rainfall ideally suited a split-N application strategy resulting in the highest yields.

At Breeza, drier conditions meant that neither split N application nor slow-release N products boosted grain yields above those reached using urea all applied at sowing.

Gross margins for most alternative N strategies were greater than that achieved when no N was applied.

Introduction

Grain sorghum is a profitable, major summer crop in northwest NSW, and is often grown on medium–heavy clay vertosols (cracking clay soils). Nitrogen (N) fertiliser is typically applied either before, or at, sowing. Where intense rainfall occurs on these slowly permeable soils before the crop has reached the stage of rapid N uptake, waterlogging can result in substantial loss of soil nitrate N to the atmosphere through denitrification. The gases emitted include nitrous oxide (N_2O), a greenhouse-warming gas, and di-nitrogen (N_2). Most of the N lost during denitrification occurs as N_2, which does not affect global warming but can constitute a significant loss of applied N from the paddock.

The trials described here are the final year of a three-year project focused on investigating options for reducing nitrous oxide emissions from dryland summer grain cropping in northern NSW. The aim in 2014–15 was to optimise both N rate and fertiliser N release to benefit both crop production and reduce N_2O emissions. At the Tamworth site, optimum N fertiliser rates varied depending on the previous crop (sorghum or soybean), which affected the amount of starting soil mineral N (Figure 1). An additional 120 kg N/ha post-sorghum and 40 kg N/ha post-soybean was applied to achieve optimal yield, based on residual soil mineral N levels measured in these two prior cropping histories before sowing. Nitrogen fertiliser was then applied, either all at sowing or split 33:67 between applications at sowing and at booting, about 45 days after sowing. At the Breeza site, there was no difference in previous crop history, so treatments instead focused on comparing alternative slow-release fertilisers, fertiliser blends, and split application strategies.

This paper reports the agronomic and economic results of these two trials, while another paper reports the gaseous emissions results.

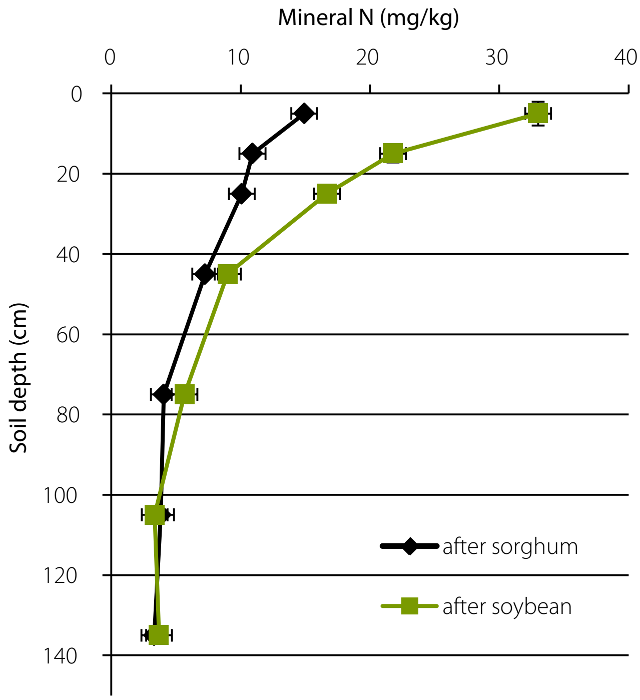

Figure 1. *Concentration of mineral N (ammonium + nitrate) in the soil profile at sowing, as influenced by the previous summer crops (sorghum or soybean) – Tamworth 2014–15*

Site details

2014–15

Location: **Tamworth**

Co-operator: **NSW Department of Primary Industries (Tamworth Agricultural Institute)**

Agronomy: **MR Bazley sown on 75 cm rows on 28 November 2014, harvested on 6 March 2015**

In-crop rain: **422 mm**

Location: **Breeza**

Co-operator: **NSW Department of Primary Industries (Liverpool Plains Field Station)**

Agronomy: **MR Bazley sown on 100 cm rows on 11 November 2014, harvested on 20 March 2015**

In-crop rain: **264 mm**

Treatments

Table 1. *Treatment details of the Tamworth and Breeza trials in 2014–15*

Tamworth		Breeza		
Name	Pre-crop, fertiliser	No.	N side-banded at sowing	N topdressed at booting
sorg_0_N	After sorghum, no N applied	1	0	0
sorg_+N	After sorghum, 120 kg N/ha urea side-banded at sowing	2	90 kg N/ha urea	0
soy_0_N	After soybean, no N applied.	3	90 kg N/ha Entec*	0
soy_+N	After soybean, 40 kg N/ha urea side-banded at sowing	4	90 kg N/ha polymer-urea**	0
sorg_split	After sorghum, 40 kg N/ha urea side banded at sowing + 80 kg N/ha topdressed as urea at booting.	5	30 kg N/ha urea + 60 kg N/ha Entec	0
		6	30 kg N/ha urea + 60 kg N/ha polymer-urea	0
		7	30 kg N/ha urea + 30 kg N/ha Entec + 30 kg N/ha polymer-urea	0
		8	30 kg N/ha urea	60 kg N/ha urea
		9	30 kg N/ha Entec	60 kg N/ha urea
		10	30 kg N/ha polymer-urea	60 kg N/ha urea
		11	30 kg N/ha urea	60 kg N/ha NV-urea***
		12	30 kg N/ha Entec	60 kg N/ha NV-urea
		13	30 kg N/ha polymer-urea	60 kg N/ha NV-urea

*Entec® is urea coated with the nitrification inhibitor 3,4-dimethylpyrazole phosphate (DMPP) [Incitec Pivot Fertilisers Ltd]

**Polymer-coated urea delays conversion of urea for up to 2 months

***NV®-urea is urea coated with the urease inhibitor N-(n-butyl) thiophosphoric triamide (NBPT). [Incitec Pivot Fertilisers Ltd]

Results – Tamworth

- Biomass cuts at plant anthesis showed no treatment effect on dry matter (Figure 2–left) but the N concentration of the biomass was significantly less in the nil-N fertilised plots after a previous sorghum crop.

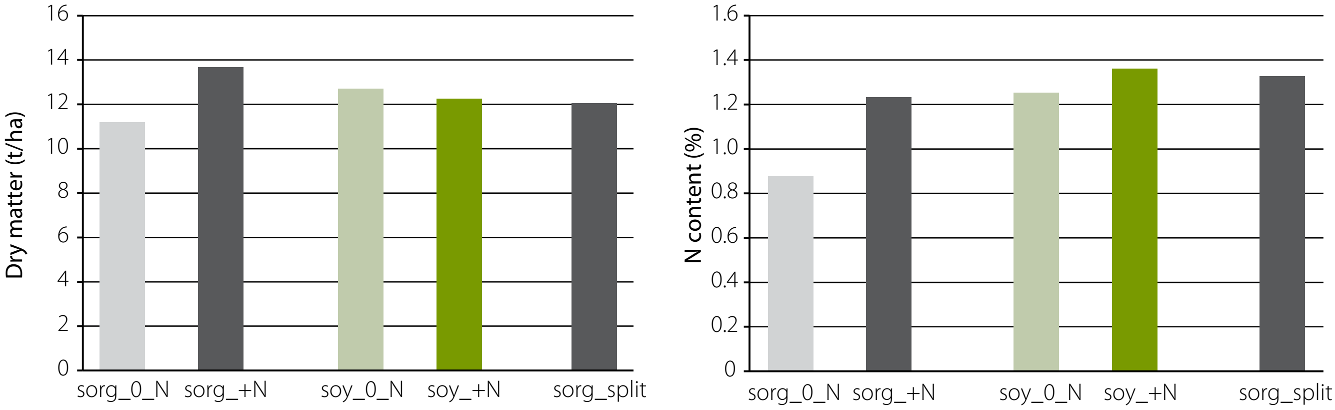

Figure 2. *Plant biomass (left) and biomass N concentration (right) at flowering – Tamworth 2014–15*

- Biomass at harvest also showed no significant treatment effects (data not shown).
- N application treatment and previous crop significantly affected the number of mature grain heads per hectare (Figure 3) with the non-fertilised post-sorghum treatment having much fewer heads than any of the other treatments.

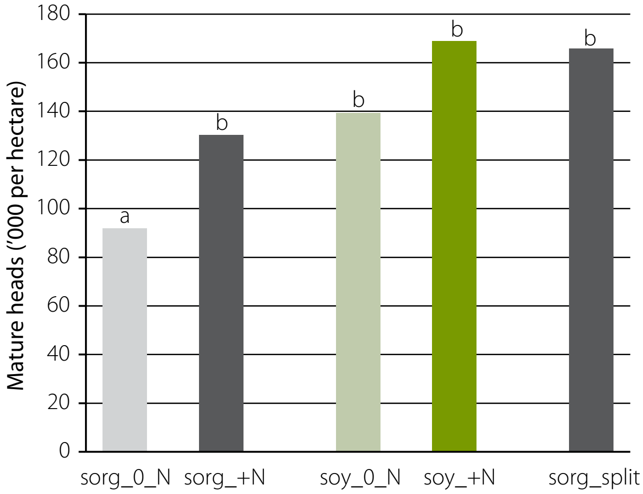

Figure 3. *Number of mature grain heads at harvest – Tamworth 2014–15*

- Average grain yield across the trial was 9.5 t/ha and mean protein was 6.8%. Grain yield (Figure 4–left) and protein (Figure 4–right) results were strongly affected by previous crop and N application treatment. There were clear and highly significant differences in grain yield according to both previous crop and N application treatment.
- When no fertiliser N was applied, sorghum grown after soybean yielded more than sorghum grown after sorghum.
- When N fertiliser was applied at the calculated rate for optimum production, the yields after the two different previous crops were not different, meaning our N budgeting had achieved an optimum yield for both initial N scenarios.
- However, when the same rate of N fertiliser was used on sorghum after sorghum, but was applied as a split instead of all at sowing, the yield was significantly greater again.
- Grain protein results showed different treatment trends than the yields, with most treatments having similar proteins levels except the post-soybean nil-N (lowest) and the post-sorghum +N treatments (highest). These results reflected the differing levels of N supply available, with the post-soybean treatment showing the effects of limited N supply through reduced protein, and the post-sorghum+N showing an excess of available N going into the grain protein rather than further increasing yield.

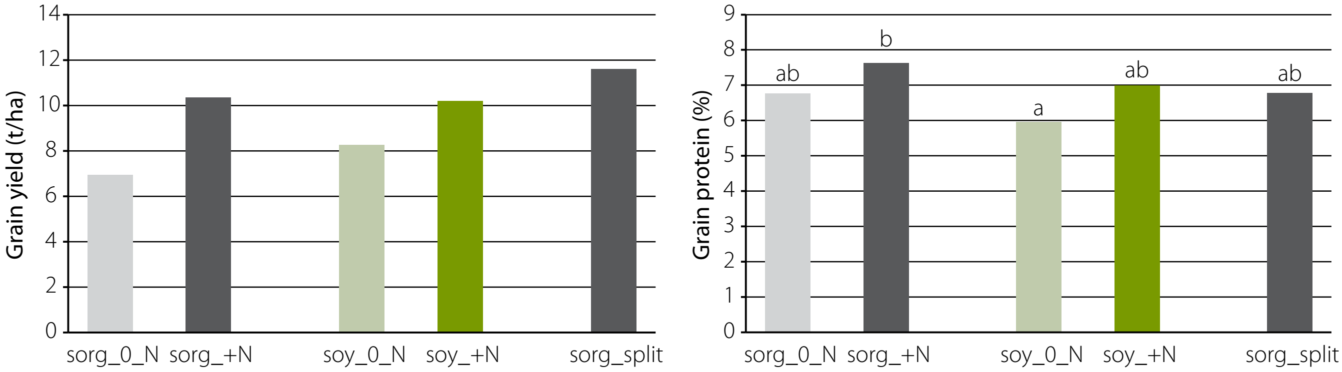

Figure 4. *Sorghum grain yield (left) and grain protein (right) – Tamworth 2014–15*

- The gross margin results for these treatments (Figure 5) closely reflected the grain yield results since sorghum grain quality does not affect pricing (unless weather damage occurs). All treatments had essentially the same variable input costs, except for the split N application, which had an additional cost for the topdressing operation, though this was small in relation to the total gross margins.
- The previous crop influenced gross margins with post-soybean making $1763/ha compared with post-sorghum at $1441/ha. The N budgeted after each previous crop led to similar returns with the post-soybean+N making $2185/ha and the post-sorghum+N making $2112/ha. Again, this indicates our budgeting based on soil N supply and prior crop history was accurate for the season.
- Adding the N as a split application increased returns above an at sowing application by an extra $320/ha.

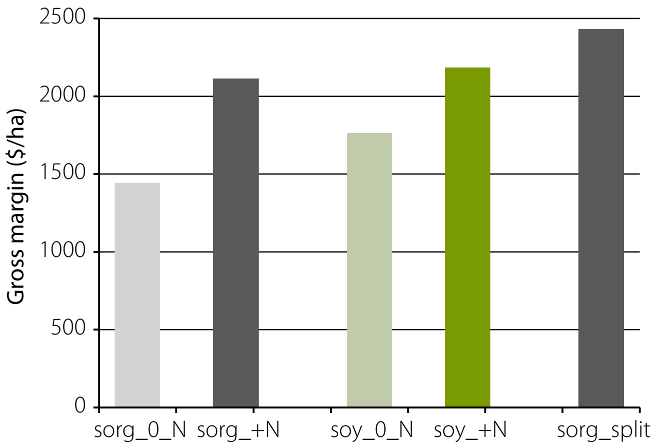

Figure 5. *Gross margins for sorghum nitrogen treatments – Tamworth 2014–15*

Results – Breeza

- No significant treatment differences were apparent in biomass at flowering or at harvest (data not shown), but N treatments did affect the N concentration of aboveground biomass at flowering (Figure 6). The N concentration of all applied N treatments was well above that of the nil N control (T1), with the next lowest being the mixed urea/Entec treatment (T5) which was not significantly different from a range of other N treatments (T3, 7, 9, 10, 11 and 13). The highest N concentrations were seen in the 100% urea (T2), 100% polymer (T4), urea/polymer mix (T6), urea+urea topdress (T8) and the Entec+NV topdress treatments (T12).
- There were no treatment effects on the number of plants or the number of grain heads at flowering (data not shown).

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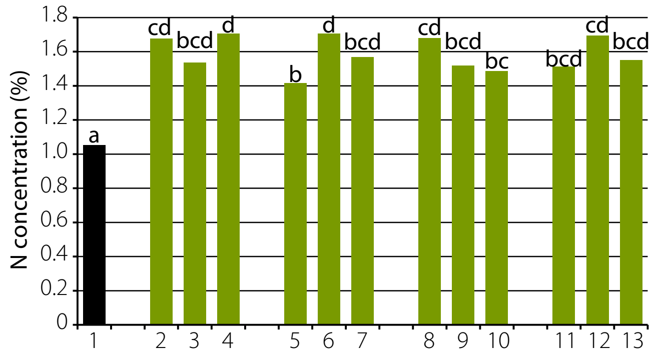

Figure 6. *Nitrogen concentration (%) in N application treatments at flowering – Breeza 2014–15*

- N treatment affected both grain yield (Figure 7–left) and grain protein (Figure 7–right).
- The nil N control (T1) had the lowest grain yield at 5.3 t/ha, whereas most other treatment yields were around 7 t/ha. Only two treatments yielded below the optimum: the 33% urea/67% polymer mixture (T6), and the 33% Entec at sowing + 67% urea top dress (T9).
- Treatment differences on grain protein were similar to those seen with the biomass N content at flowering (Figure 6).
- The nil N control (T1) had lower grain protein than any other treatment. The highest protein was found in the 100% polymer-coated urea treatment (T4), which was statistically similar to several other treatments, including the 100% urea treatment (T2).

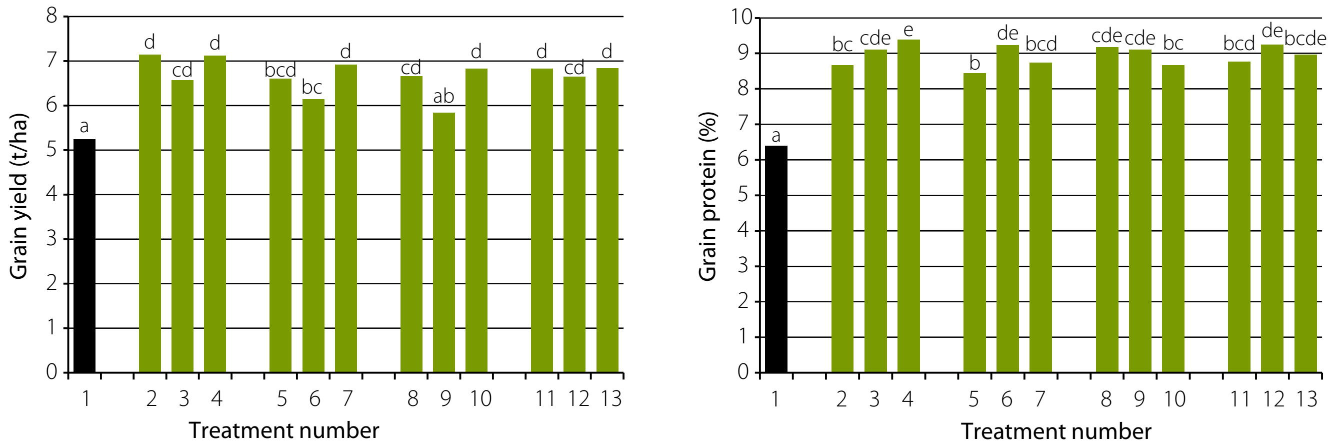

Figure 7. *Grain yield and protein associated with various nitrogen treatments – Breeza 2014–15*

- Gross margin analysis (Figure 8) did not include polymer-coated urea as this is currently not a commercially available product and thus could not be costed.
- Compared with the nil N treatment (T1), which returned $1050/ha, the highest grossing treatment was the urea all applied at sowing (T2), which made an extra $362/ha.
- Most other treatments returned about $1250/ha, except the 33% Entec at sowing/67% urea at booting treatment (T9) which yielded and grossed no better than the control (T1). Using NV-urea for topdressing (instead of urea) increased gross margins by $35/ha for urea (T11) and $194/ha for Entec (T12), although the latter difference was again mainly due to the poor grain yield of T9.

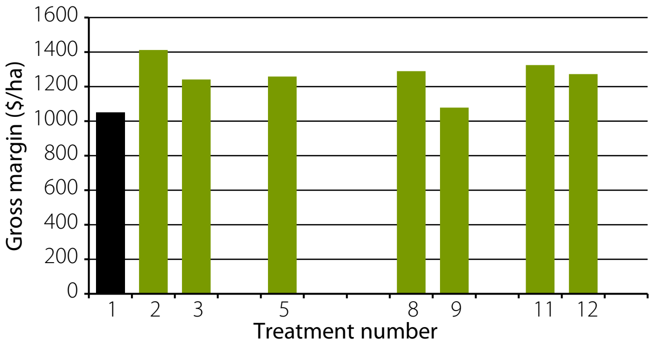

Figure 8. *Gross margins for trial treatments (not polymer treatments) – Breeza 2014–15*

Summary

The Tamworth trial results demonstrate the importance of knowing starting soil mineral N levels, either through soil testing or through calculations based on previous crop information. In what was a very good sorghum growing season, yields without N fertiliser were still high, but the N-budget calculated additional application of N fertiliser substantially lifted yield and gross margins well above the nil-N strategy. The split-N strategy provided the best yield and profit outcome, thanks to good in-crop rainfall conditions at the Tamworth site in 2014–15.

At Breeza, the nil-N fertilised grain yield was also good, but adding N fertiliser again substantially increased yields and profit margins. All but two of the alternative product/application strategies examined provided equivalent grain yield to the typical urea side-banded at sowing treatment, so their additional costs (for product or for additional fertiliser spreading) make them less profitable than the current industry practice. Two of the treatments aimed at slower N release resulted in sub-optimal yields, which is a warning that further research is needed to better align N release with N uptake into sorghum grain.

Acknowledgements

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