Does pre-plant N fertiliser location affect soil mineral N and nitrous oxide emissions from irrigated cotton at Gunnedah?

Graeme Schwenke and Annabelle McPherson
NSW DPI, Tamworth

Key findings

- Changing the pre-plant N fertiliser from the non-irrigated side of the plant bed to the irrigated side of the plant bed did not affect soil mineral nitrogen (N), plant growth or cotton lint yield.
- The pattern of nitrous oxide (N_2O) emissions after the first irrigation event differed according to N fertiliser placement treatment, but the total amount of N_2O released was the same.
- Pre-plant N fertiliser placement did affect N_2O emitted after the second irrigation (with water-run N), with more lost from the irrigated, non-fertilised side of the hill.
- The cumulative N_2O losses summed over all the measurement events showed no treatment differences resulting from pre-plant N fertiliser location, indicating that there is no agronomic or environmental benefit to changing N fertiliser location.

Introduction

In a typical cotton furrow irrigation system, water is applied to every second furrow. During the irrigation event, water 'subs' sideways through the plant bed from the irrigated furrow and eventually into the non-irrigated furrow. Pre-plant N fertiliser is applied down into one or both sides of the formed plant bed, usually to a depth below that of the furrows.

In this experiment, we compared this conventional practice with an alternative pre-plant N fertiliser placement in relation to the irrigated furrow, to investigate the potential impact on soil mineral N concentrations and consequent N_2O emissions.

Site details

Location	'Ruvigne' Gunnedah
Co-operator	Rod Smith
Soil type	Black vertosol. The soil (0–30 cm) was 65% clay, 9% sand and 26% silt.
Rainfall and irrigation	At Gunnedah, there was no rainfall during the 15-day pre-plant period between N application and sowing, but there was 405 mm of rainfall during the cropping season. The crop was irrigated eight times with approximately 7 ML/ha applied in total.
Trial design	Randomised complete block design with three replications of three treatments. Each plot was eight rows (× 1 m) wide and 560 m long (paddock length).
Sowing date	The site was sown with Sicot 75RRF on 10 September 2015.
Harvest date	The trial was harvested with a commercial six-row picker on 23 February 2016. All cotton from each plot was baled separately, then weighed, ginned and quality-tested at a commercial gin.

Treatments

Three treatments were applied, however, only two of the treatments are discussed in this paper as the third treatment concerned N fertiliser timing, not N placement, and is discussed in a separate paper.

Treatment 1 (T1): a pre-plant application of 100 kg N/ha as anhydrous ammonia was injected into the non-irrigated side of the plant bed.

Treatment 2 (T2): a pre-plant application of 100 kg N/ha anhydrous ammonia was injected into the irrigated side of the plant bed.

The pre-plant N fertiliser was applied on 16 September 2015. Both treatments had in-crop N applications of 30 kg N/ha applied as water-run urea in the second and third irrigations.

Measurements

Soil moisture and mineral nitrogen measurements

Soil moisture content was measured at each gas sampling occasion using a hand-held theta-probe calibrated using volumetric soil moisture measurements at each site. Soil mineral N (ammonium and nitrate) was measured in surface soil (0–10 cm) samples collected near each N_2O chamber location at approximately monthly intervals during the experiment. After harvest, mineral N was also measured in soil cores taken to 90 cm depth (0–30, 30–60, 60–90 cm) at each chamber location. At each sampling time, soil was extracted with 1M KCl and analysed colorimetrically using a flow injection analyser.

Nitrous oxide measurements

Nitrous oxide emissions were measured during five separate seven-day campaigns with samples collected 1, 2, 4, and 7 days after irrigations 1–5, including the pre-plant irrigation (irrigation 1). Measurements done in the previous year showed negligible N_2O emissions from late-season irrigations, so these were not monitored.

Each plot had four chambers for gas emissions measurement (15 cm diameter, 15 cm headspace, pushed 10 cm into the soil); two were placed in the furrows and two on the plant beds. The concentrations of N_2O in air sampled at 0 minutes and 60 minutes after sealing the chamber with a gas-tight lid were determined using a laboratory gas chromatograph. Hourly emission rates were calculated from the increase in N_2O concentration with time over the duration of chamber closure, then extrapolated to a daily flux result. Cumulative losses within each of the six sampling events were determined by linear extrapolation between sampling days. Days outside the sampling events were not included in the cumulative totals.

Plant measurements

Treatment effects on cotton crop production were evaluated by 3 × 1 m length biomass cuts per plot at peak biomass, 3 × 1 m length hand-picked lint samples at harvest, and machine harvesting by commercial cotton picker in the middle six rows of each plot over the entire plot length. Nitrogen concentration in dried and finely-ground plant and seed samples was measured by combustion analyser.

Results

Soil mineral N

Surface soil nitrate concentration was not different between the two treatments at any sampling time (data not shown). However, sampling location showed a much greater nitrate concentration in the side of the plant bed (hill) above the N fertiliser bands, regardless of its proximity to the irrigated furrow (Figure 1). The non-fertilised side of the hill tended to be higher in nitrate than either of the two furrows, indicating that some nitrated moved sideways within the plant bed. Concentrations declined between October and November as the crop established, but then increased again by the December sampling, most likely because this occurred shortly after the first water-run N application. Additional water-run N maintained the nitrate concentration in the non-fertilised side of the hill, but the concentration in the fertilised side of the hill continued to decline with time until February, when all locations tested low for the remainder of the season.

There were no significant effects from either N treatment or sample location on the mineral N at any depth to 90 cm when sampled soon after harvest (data not shown). There was an average of 34 kg N/ha remaining in the soil to 90 cm depth, with approximately half in the top 0–30 cm.

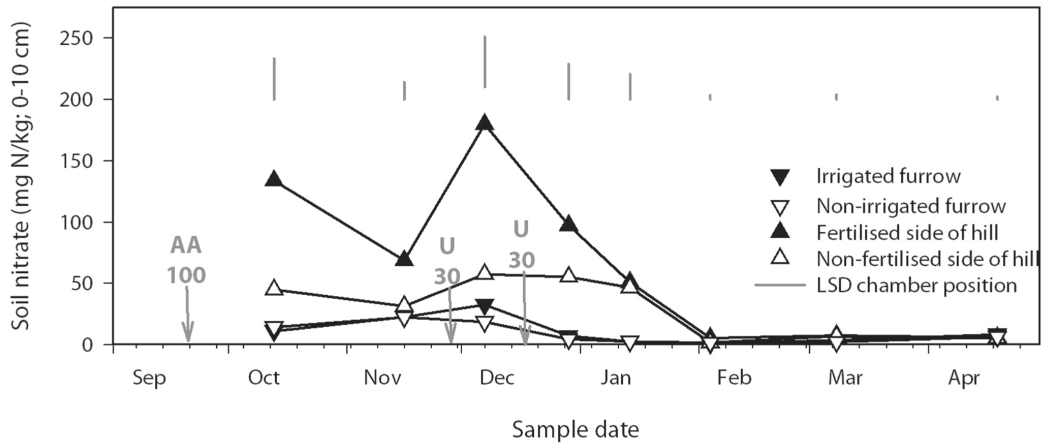

Figure 1. Surface soil (0–10 cm) nitrate concentration with time in the four sampling (chamber) locations in each plot. Results for T1 and T2 were not significantly different so are combined in this graph.

Nitrous oxide emissions

The chamber measurements showed a strong influence of location within the plot on N_2O emitted (Figure 2). The highest emissions occurred following the first irrigation event, especially from chambers located on the fertiliser band. Fluxes from the other positions were much lower and not significantly different. While there was no significant treatment difference on cumulative N_2O loss in the week following the first irrigation (Figure 3), there were differences in patterns of N_2O release (Figure 2), which were probably related to differences in the water content of the soil in the fertilised hill positions. In the fertilised hill side position of T1, fluxes on day one were high and increased on day two, and then declined. In the fertilised hill side position of T2, fluxes on day one were minimal, then increased to very high on day two and declined substantially by day four. The fluxes from the fertiliser band location had not reached the baseline emission level after seven days post-irrigation.

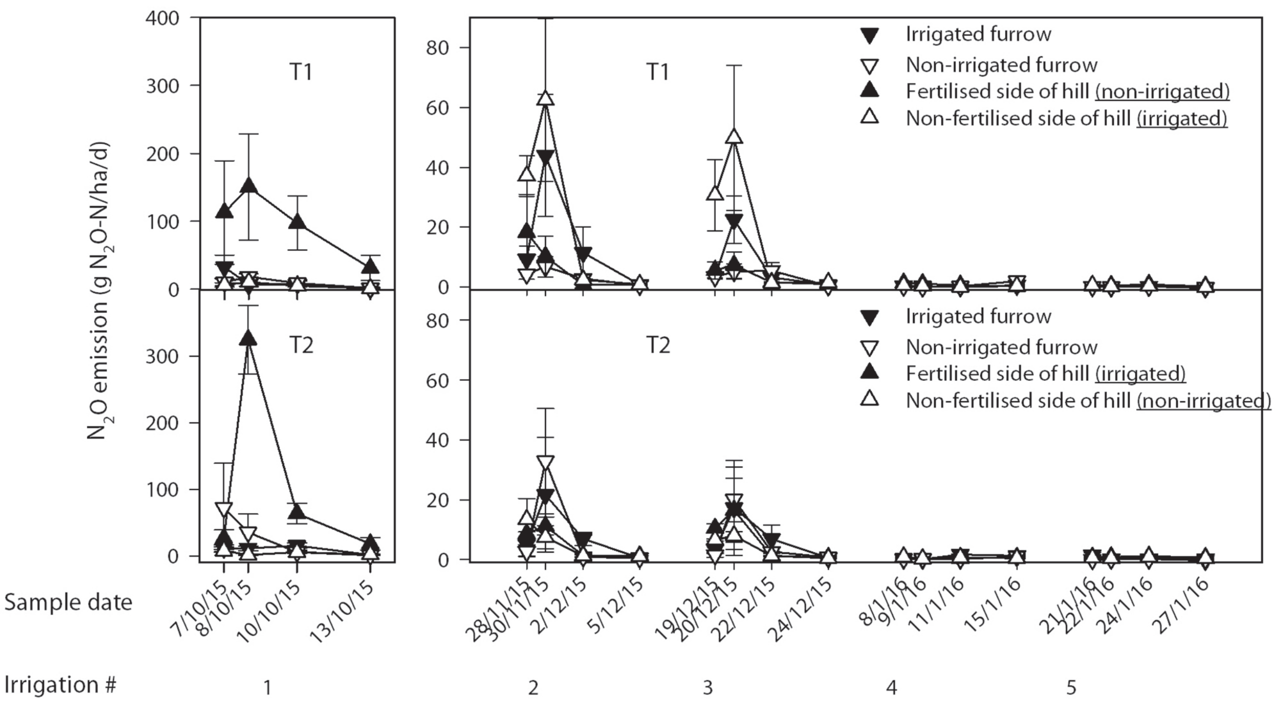

Figure 2. Daily nitrous oxide emissions from the Gunnedah experiment as influenced by N location treatment and chamber position.

Moderate N_2O emissions occurred in response to the water-run urea applied in irrigations two and three. Irrigation two was the only event when there was a significant treatment effect on N_2O loss, with more N_2O released from T1 than T2. The highest fluxes in T1 were found in

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the non-fertilised hill position (next to the irrigated furrow). By contrast, fluxes in T2 were not affected by chamber position. There were negligible N_2O emissions in response to irrigations four and five. Cumulative emissions across the five sampling occasions showed no significant difference between the treatments, but the fertilised band position was clearly the greatest overall source of N_2O emitted.

Plant results

There were no N location treatment effects on plant population, boll number, dry matter, plant N content, lint yield, lint quality or seed N content. Yield averaged 14.2 bales/ha across both treatments.

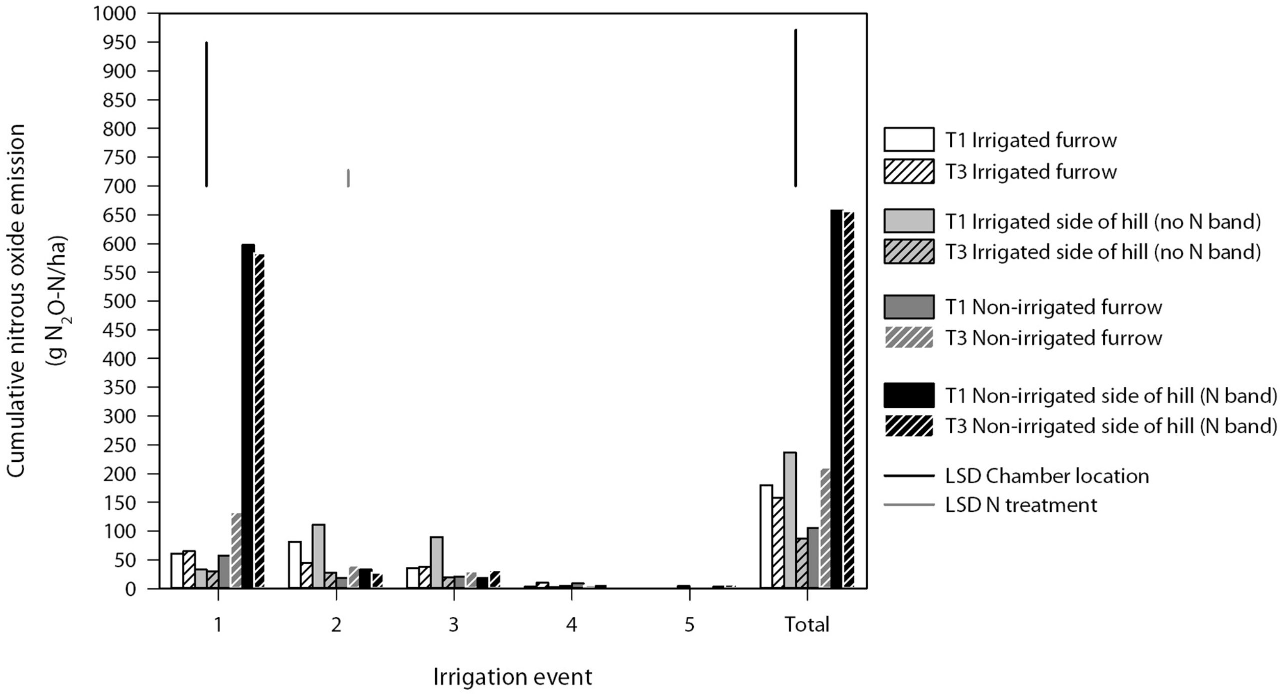

Figure 3. Cumulative N_2O emissions from the Gunnedah experiment as influenced by N location treatment and chamber position.

Conclusions

The soil mineral N results indicated that the majority of the pre-plant N fertiliser remained in the hill-side position where it was applied, with not much lateral movement evident. Irrigating the furrows beside the fertiliser band rather than those on the other side of the hill from the fertiliser band increased the initial intensity of N_2O released after the first irrigation. However, there was no net difference in N_2O emitted in total from that sampling campaign of emissions, nor across all the sampling events combined. Following the water-run urea applications, N_2O emissions were greater from the non-fertilised hill of T1 (next to the irrigation water) than in T2 (next to non-irrigated furrow), but were similar elsewhere. Overall, there was no net difference in total N_2O emitted between the two treatments when losses for the five key irrigation measurement periods were combined, and no effects on any agronomic parameters.

Therefore, there were no environmental or agronomic benefits to be gained by varying the location of the N fertiliser band in relation to the irrigated furrow.

Acknowledgements

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