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

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Key findings

- Changing the pre-plant nitrogen (N) fertiliser location from beside the non-irrigated furrow to beside the irrigated furrow increased nitrous oxide (N_2O) emissions, primarily from the fertiliser band location.
- Irrigating every single furrow instead of every second furrow did not significantly change N_2O emissions.
- Altering irrigation furrows in relation to pre-plant N fertiliser did not significantly affect mineral N in the surface soil, nor did it affect any measure of crop production.
- These results do not support changing from the current irrigation and N fertiliser placement system in use.

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 applications are often applied into the soil on the non-irrigated side of the formed plant bed usually to a depth below that of the furrow.

In this experiment, we compared this conventional practice with two alternative pre-plant N fertiliser placements in relation to the irrigated furrow, to investigate the potential impact on soil mineral N concentrations, nitrous oxide (N_2O) emissions, and cotton production.

Site details

Location	'Redbank' Moree
Co-operator	Ray Fox
Soil type	Black vertosol. The soil (0–30 cm) had 54% clay, 20% sand and 26% silt.
Rainfall and irrigation	At Moree, there was 5.2 mm of rainfall during the 38-day pre-plant period between N application and sowing, and a further 340 mm of rainfall during the cropping season. The crop was irrigated 11 times (including one pre-plant irrigation) with approximately 7.5 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 380 m long (paddock length).
Sowing date	The site was sown with Sicot 748B3F on 15 October 2015.
Harvest date	The trial was harvested with a commercial six-row picker on 8 April 2016. All cotton from each plot was baled separately and then weighed, ginned and quality-tested at a commercial gin.

Treatments

Three treatments were applied (Table 1). Pre-plant N fertiliser was applied on 8 September 2015. In-crop N applications totalling 160 kg N/ha were applied as water-run urea in irrigations 4, 6 and 8.

Table 1. Summary of trial treatments.

Treatment	Pre-Plant N (as anhydrous ammonia)	Location of pre-plant N application	Irrigation location
T1	180 kg N/ha	Non-irrigated side of the plant bed.	Water into every 2nd furrow
T2	180 kg N/ha	One side of the plant bed only.	Water into every furrow
T3	180 kg N/ha	Irrigated side of the plant bed.	Water into every 2nd furrow

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, 2, 3, 5 and 6 (irrigation 1 = pre-plant). 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.

Unfortunately, all samples from the first irrigation event were lost in transit to the laboratory.

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 nitrogen

Surface soil (0–10 cm) sampling during the season found that neither treatment nor sampling position affected the concentration of ammonium N (data not shown). There was also no significant N location treatment effect on soil nitrate at any sampling time.

There were some large differences in soil nitrate according to sampling position, with very high concentrations found in the hill positions in early December (Figure 1). During January, soil nitrate increased in both hill positions before declining to low levels in February. The increasing nitrate concentrations in the hills through the season suggest that nitrate moved upward and sideways from the pre-plant N locations and from the water-run N applications.

At the conclusion of the season, deep soil core sampling to 90 cm found a total of 31 kg N/ha across all treatments. Treatment three had more nitrate N in the 30–60 cm zone than the other two treatments, with most found in the fertilised hill and irrigated furrow (next to fertiliser band positions). In the 60–90 cm zone, nitrate concentration was higher under the fertilised furrow in all three treatments.

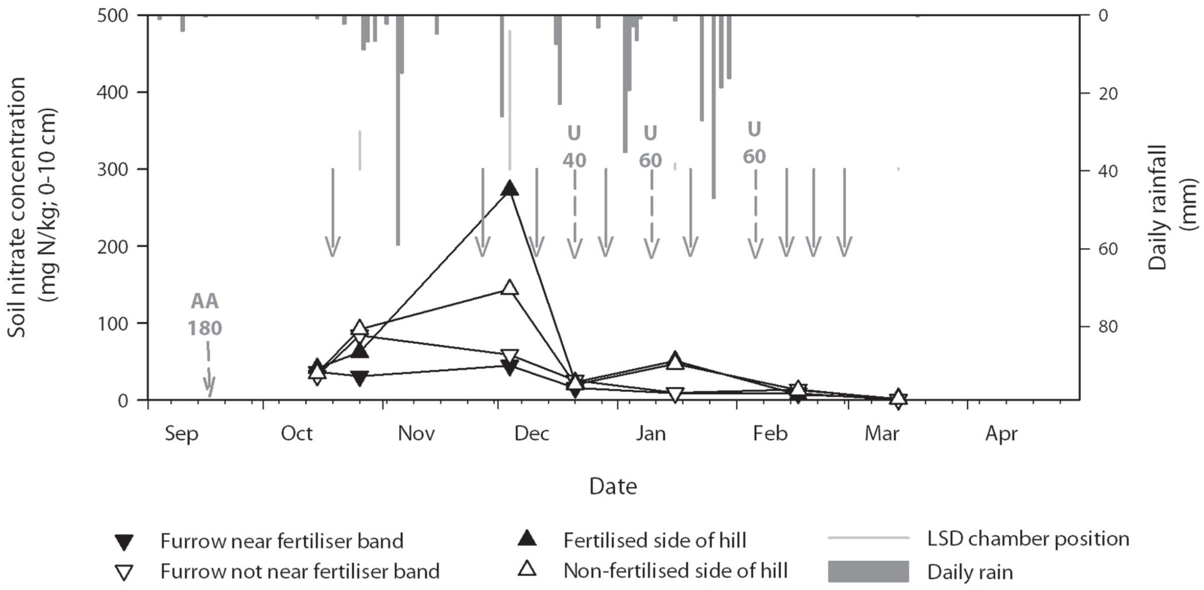

Figure 1. Surface soil (0–10 cm) mineral N at the Moree experiment as influenced by chamber location, and daily rainfall (mm, from top). AA = pre-plant anhydrous ammonia, solid arrows = irrigation with water only, dashed arrows = irrigation with water-run urea.

Nitrous oxide emissions

The N_2O emission results from irrigations 2, 3, 5 and 6 showed a variety of responses to different irrigation events and different treatments (Figure 2). There was generally little emission response to the second irrigation event in late November, despite there being large concentrations of nitrate in the soil at that time (Figure 1). Losses were greater from T3 than the other treatments, primarily due to a large flux from the fertilised side of the hill (next to the irrigated furrow). This position in T3 also had the highest N_2O losses in the following two measurement periods, and was highest when all results were combined. The third sampling event (irrigation 3) showed initially low emissions after the irrigation ceased, but then an increase after 30 mm of rainfall on day six of the week-long post-irrigation measurement campaign. There were no N location treatment differences in this campaign.

The fourth sampling event (after irrigation 5) produced very high N_2O fluxes for the first few days after the irrigation ceased, particularly in the fertilised hill position of T3. Total losses from T3 were significantly greater than T1 or T2. This irrigation event was water-only, but it closely followed irrigation 4 in which water-run urea had been applied. Emissions were lowest from the furrows not near the fertiliser band, especially in T1 and T3, even though this was the non-irrigated furrow in T3. In T2, all positions produced similar N_2O emissions.

Emissions of N_2O measured in mid-January after irrigation 6 were modest compared with the previous sampling, with most N_2O loss occurring within the first two days after the irrigation concluded. This is despite the irrigation occurring just five days after a 74 mm rainfall event at the site. As with the previous event, T3 showed the lowest emission from the non-irrigated furrow and highest from the fertilised hill position, while the highest emission from T1 was from the non-fertilised side of the hill (irrigated side).

When the results from these four sampling events were combined, N_2O losses from T3 were significantly greater than from the other two treatments, primarily because of the high emissions from the fertilised (irrigated) side of the hill.

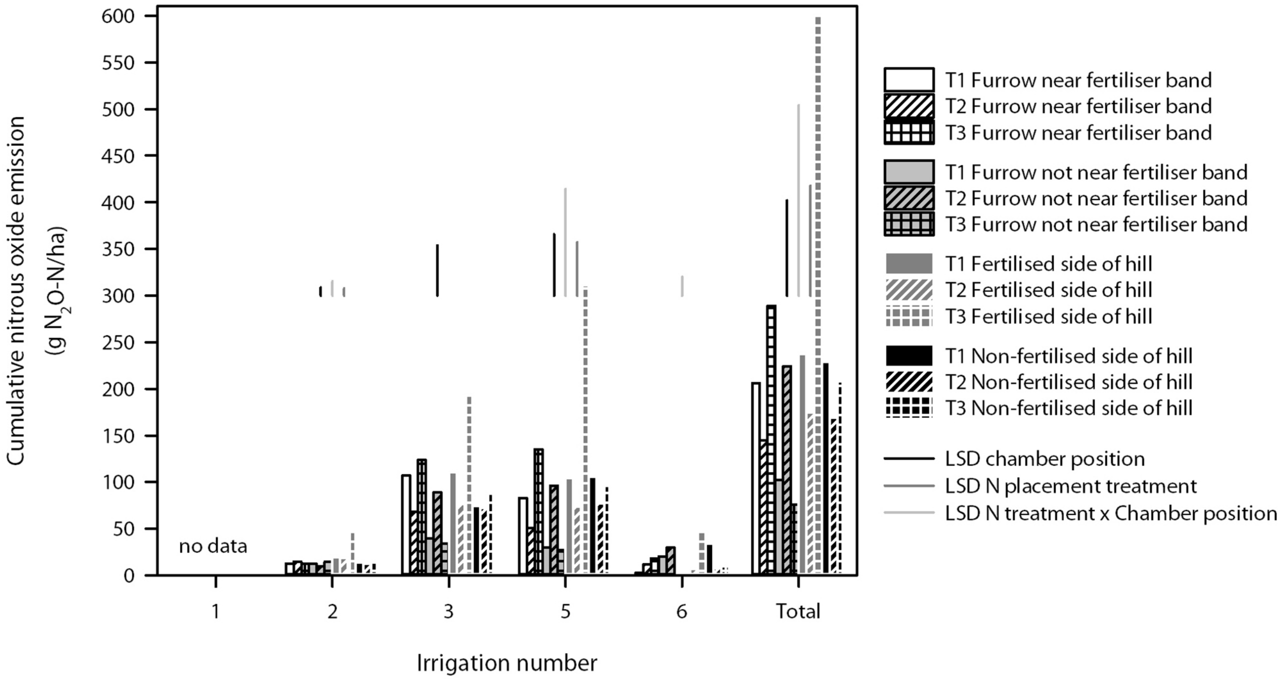

Figure 2. Cumulative nitrous oxide emissions from the Moree experiment as influenced by N location treatment and chamber location. Emissions were monitored for seven days following an irrigation event. There is no data from the first irrigation event.

Plant results

There was no impact from the N fertiliser location treatment on plant population, boll number, dry matter, dry matter N content, lint yield (either hand-picked or machine picked), lint N content or seed N content. Lint yield across the site averaged 13.2 bales/ha.

Conclusions

Even though we do not have data for the first irrigation, where N_2O losses are usually greatest, the data we do have is still instructive as to the potential impacts of changing irrigation strategy with respect to pre-plant fertiliser location. The experimental treatments examined here produced some clear indications that soil nitrate from pre-plant and water-run N applications can be highly mobile, both vertically within the soil profile and horizontally within the plant bed. The alternative system trialled in T3 appeared to increase N_2O emissions, compared with the current practice (T1), while the system with every furrow irrigated (T2) appeared to produce results no better or worse than T1.

None of the treatments trialled at Moree affected the cotton lint yield results. Changing the irrigation system to apply water into every furrow would require additional labour and materials for siphons. Altering the system so that the irrigated water is applied to the N-fertilised side of the beds appeared to increase N_2O losses. Therefore, there appears to be no environmental or agronomic benefit to changing the current irrigation setup in relation to pre-plant N placement (T1) to either of the tested alternatives (T2 or T3).

Acknowledgements

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