Effect of cotton residues on N_2O emissions and soil N following incorporation

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Background

- Nitrous oxide (N_2O) is a greenhouse gas 298 times more potent than carbon dioxide (CO_2) [2]
- Incorporation of crop residues known to increase N_2O and CO_2 emissions, and soil nitrogen (N) content
- Emission factors (EFs) (% of residue N lost as N_2O) vital for estimating N_2O budgets and mitigation strategy development. Current default IPCC EF = 1% [2]
- No data exists on cotton residue-induced N_2O emissions and its N contribution for subsequent crop

Project Aims

- Quantify CO_2 and N_2O fluxes, and corresponding EFs from a cotton fallow in sub-tropical Australia
- Determine cotton residue contribution to soil N available for subsequent crop

Experimental set-up at Oakey, Queensland

Materials and Methods

- Field site set up in Oakey, Queensland during 2016 cotton fallow period
- 4 treatments: control (C), C + 50mm rainfall monthly (C+I), residue retention (R), and residue retention + 50mm rainfall monthly (R+I). Residues contained 77±3.5kg N/ha
- Semi-automated greenhouse gas chamber system measured CO_2 and N_2O every 2 days
- Plant available N (NO_3^- and NH_4^+) in the topsoil (0-10cm) measured periodically
- Isotope ratio mass spectrometry (IRMS) to determine N contribution and losses from ^{15}N labelled cotton residues

Semi-automated greenhouse gas chamber

Results and Discussion

- Cumulative N_2O emissions ranged from 20.5 to 63.7g N/ha (table 1) with R+I resulting in the highest N_2O emissions followed by R, C then C+I. These values are at the lower end of other reported cotton fallow periods with residue removal and incorporation [3-5]
- The comparatively low N_2O emissions compared to other post-harvest phases reported in the literature might be due to the high C:N ratio of cotton (30:1), the low concentration of easily decomposable carbon from the residues, and the alkaline soil pH (7.8) [1]
- Emission factors for the cotton fallow period were 0.015% and 0.051% for R and R+I, respectively (table 1)
- Soil respiration (CO_2) was significantly higher in the R+I treatment following incorporation (fig. 1)
- Cotton residue incorporation resulted in immobilisation of N (consumption of inorganic N by soil microbes to assist with carbon decomposition) particularly in the NH_4^+ pool (fig. 2)
- The majority of residue N in both R and R+I treatments was recovered in the top 20cm of soil at the end of the fallow

Table 1: Cumulative CO_2 and N_2O emissions, and corresponding EFs. Different letters correspond to significant differences ($p < 0.05$).

Treatment	CO_2 emissions (kg CO_2-C ha^{-1})	N_2O emissions (g N_2O-N ha^{-1})	EF (%)
C	381.6 ± 52.6^a	24.5 ± 5.7^a	-
C+I	485.7 ± 34.8^a	20.5 ± 1.4^a	-
R	435.4 ± 40^a	35.1 ± 4.1^a	0.015
R+I	800.3 ± 36.8^b	63.7 ± 18.9^a	0.051

Figure 1: Soil N_2O (top) and CO_2 (bottom) fluxes for all four treatments over the cotton fallow period

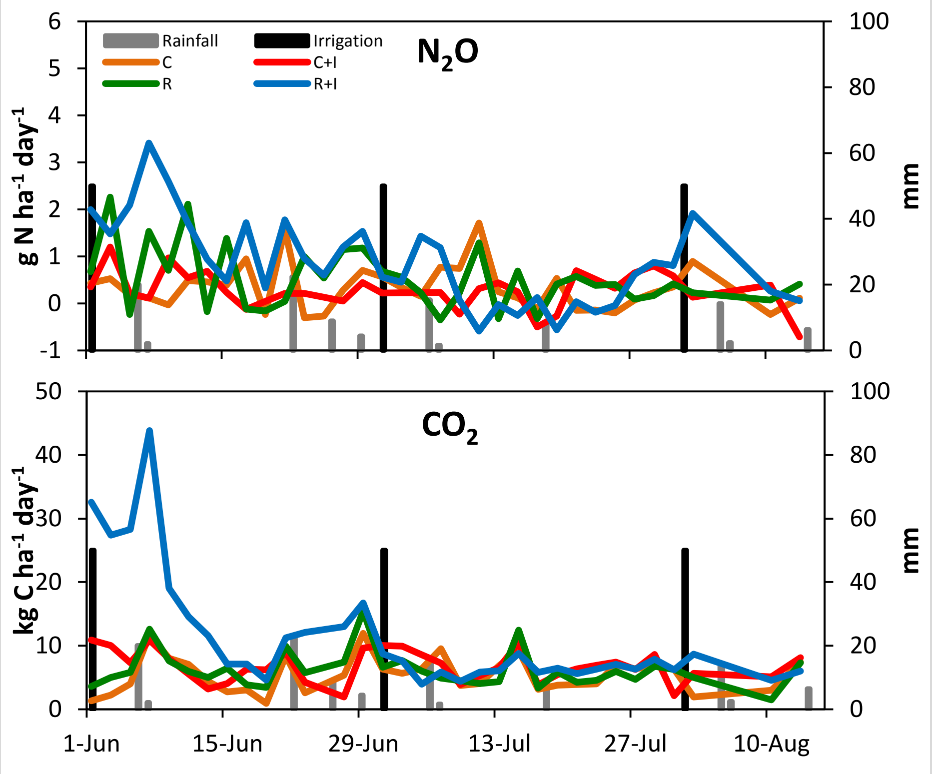
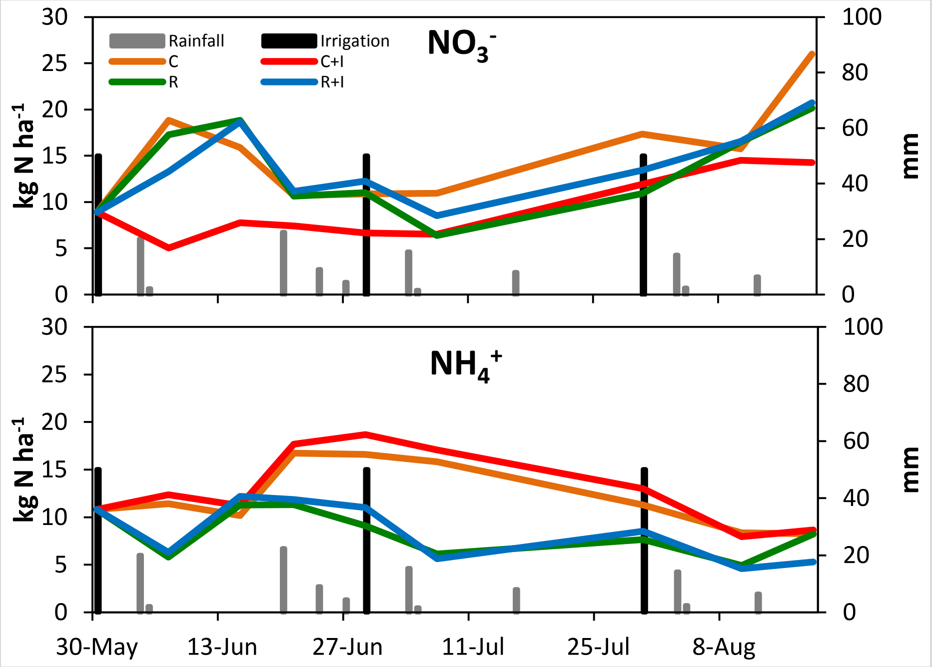


Figure 2: Plant available N, NH_4^+ (top) and NO_3^- (bottom), for all four treatments over the cotton fallow period



Conclusion

- N_2O emissions from cotton residues are minimal and the IPCC default EF of 1% needs to be re-evaluated
- Cotton residue incorporation contributed mostly to topsoil N while a very minimal amount was lost
- Cotton residue N contribution and immobilisation needs to be considered in the N fertiliser applications

References

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