Controlled traffic farming reduces nitrous oxide emissions from grain cropping

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BACKGROUND

Controlled traffic farming (CTF) is a system in which all machinery has the same or modular working and track width so that field traffic can be confined to the least possible area of permanent traffic lanes. In well-designed systems, permanent traffic lanes represent 20% or less of the cropped area. Without CTF, varying equipment operating and track widths translate into random traffic patterns which can cover more than 40% of field area each time a crop is produced. Nitrous oxide (N_2O) is the greatest contributor to agriculture's greenhouse emissions from cropping, and research suggests that it is produced largely in the topsoil (0-100 mm) under conditions of high water-filled porosity when nitrate (mainly from fertiliser-N) and carbon (usually from crop residues) are available. Compaction is often persistent meaning that all soils in non-CTF systems suffer from some degree of compaction at depths ≥100 mm. This can compromise water infiltration, increase the frequency and duration of waterlogged conditions, and therefore enhance N_2O emissions[1].

OBJECTIVES

This project aims to quantify the effect of 'fully controlling field traffic' on greenhouse gas (GHG) emissions from grain cropping systems in Australia. It seeks to demonstrate that N_2O emissions can be significantly reduced in CTF systems compared with non-CTF systems due to the significant reduction in the area affected by traffic compaction. It is also hypothesised that CTF systems can reduce methane (CH_4) emissions through the process of absorption in non-trafficked soil. The associated reduction in soil compaction and N_2O emissions in CTF systems should translate into increased fertiliser use efficiency and crop yield.

MATERIALS AND METHODS

The studies are conducted on sites representing intensive grain production under CTF systems across three contrasting soil types and agro-climatic regions located in Queensland, Victoria and Western Australia over three growing seasons, and include winter cereal and sorghum crops. At the Queensland sites, N fertiliser is either injected as anhydrous ammonia (82% N) or incorporated as urea (46% N) at planting at rates of 80-125 kg N ha^{-1} in the inter-row, which is common farm practice. Gaseous emissions are monitored from a CTF plot on which additional 'random' traffic was imposed to simulate wheel-traffic impacts in non-CTF systems. The plot has been designed to have three treatments from which gaseous emissions are measured using the static chamber technique. The treatments are: (1) Permanent traffic lanes, (2) Permanent crop bed in CTF bed, and (3) Random wheeling, which comprise 15%, 85% and 25%, respectively, of total cropped area. For each treatment, there are four chambers, which are sealed only during emission monitoring. Samples (20 ml) are collected on a weekly or fortnightly basis from headspaces at 20 minutes intervals following enclosure (from 0 to 60 minutes), and analysed using a Shimadzu GC-2014 gas chromatograph. Flux rates calculations are estimated from the linear increase in gas concentration. The chambers' arrangement and frequency of sampling aim to overcome the difficulties arising from the episodic nature (spatio-temporal variability) of GHG emissions.

RESULTS AND CONCLUSIONS

Figure 1 shows N_2O fluxes observed for the three traffic treatments at the two experimental sites in Queensland. Results showed that post-planting emissions from permanent beds (non-wheeled soil) were between 10% and 70% lower than from wheeled soil under zero-tillage depending on the crop and season. Given the relatively dry conditions recorded in 2013 and 2014, differences between traffic treatments were mainly observed following rainfall or fertiliser application. However, emissions throughout the winter and summer crop seasons were consistently lower in CTF compared with non-CTF ($P<0.05$). Rainfall events greater than about 10 mm in the presence of nitrate initiated spikes in N_2O emissions, particularly from soil subjected to random traffic or in permanent traffic lanes, but with significantly smaller effects in permanent beds. Differences in N_2O emissions were attributed to reduced infiltration rates in wheeled compared with non-wheeled soil. Overall, emissions from random traffic and permanent traffic lanes were of similar magnitude ($P>0.05$).

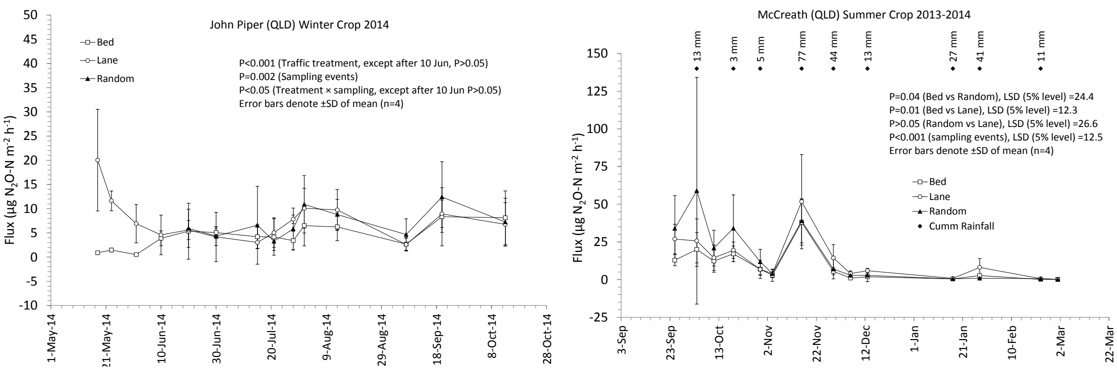

Figure 1: Nitrous oxide fluxes recorded at the two experimental sites in Queensland, Australia.

REFERENCES

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