NITROUS OXIDE EMISSIONS IN GRAIN PRODUCTION SYSTEMS.

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Australian Government
Department of Agriculture

BCG shared solutions

Take Home Messages

- *N2O losses appear to be minimal from dryland low to medium rainfall farming systems; peak emissions of only 4.0 gN2O-N/ha/day were measured following rainfall.*
- *N2O emissions from legume stubble over summer and with synthetic fertiliser applied in-crop were low.*
- *An increase in soil water was the major driver of N2O emissions.*

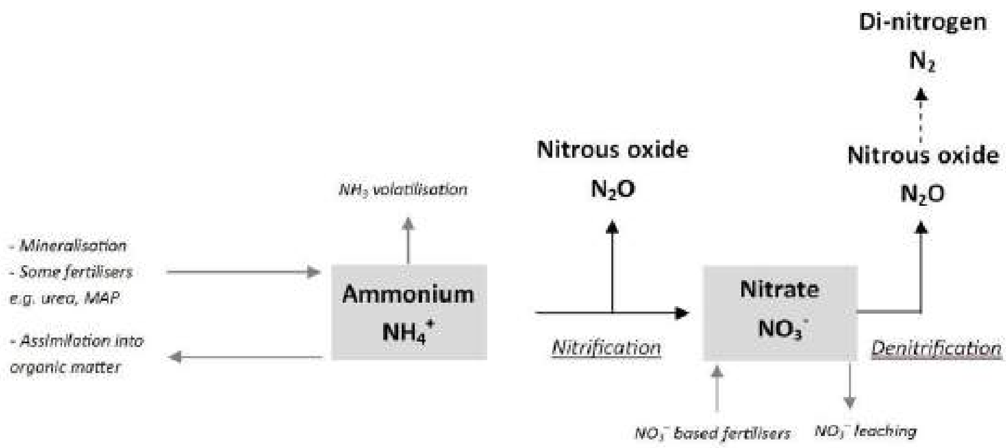
BACKGROUND

Nitrous oxide (N2O) is a greenhouse gas which has worldwide agricultural, environmental and societal implications. Part of the reason for this is that it has a global warming potential (GWP) 298 times that of carbon dioxide. GWP is a measure of how much heat a greenhouse gas can trap in the atmosphere by comparison with carbon dioxide (Trenkel 2010).

As dryland farmers, growers in the Wimmera and Mallee have a twofold concern in this context: the imperative to conserve as much nitrogen as possible in their system, and to limit their contribution to the emission of any gas with high GWP.

N2O is mainly produced by two chemical processes: nitrification and de nitrification. The presence of favourable levels of nitrogen, soil carbon, soil temperature and moisture influences these processes (Figure 1).

Figure 1: Two key processes (nitrification and denitrification) contributing to N2O generation in agricultural soils. (Source DEDJTR).



Previous work in low and medium rainfall environments has generally shown that N2O losses tend to be small when compared with the amount of nitrogen required to grow a crop. The focus of this work was to understand the level of N2O emissions from different dryland farming systems and to investigate options to improve nitrogen efficiency with the aim of ensuring that grain productivity was maximised relative to N2O emissions. Scenarios which were tested include: emissions from different stubble types over summer (pulses v. cereals) and the use of inhibitor treated fertilisers such as:

- Nitrification inhibitors (ENTEC urea) which delay the conversion of ammonium to nitrate (Figure 1)
- Urease inhibitors (Green urea) which delay the hydrolysis of urea into ammonium
- Polymer coated and controlled release fertilisers which slowly release N, potentially over longer periods.

The theory behind each of these products is that if they can slow the release or conversion of nitrogen through the soil, then it may be possible to avoid some of the N2O emissions associated with nitrification and denitrification. This has been a collaborative project between a number of farming systems groups including: BCG, CWFS, EPARF, MSF, SFS, UNFS.

AIM

To measure N20 emitted by vetch, field peas and wheat stubble over summer and to determine whether top-dressed inhibitor-treated and slow release urea products influence N2O emissions.

TRIAL DETAILS

Table 1. Details and inputs of N2O flux demonstration trials at Condobolin, Mildura, Jamestown and Horsham

Location	Condobolin (NSW)	Mildura (Vic)	Jamestown (SA)	Horsham (Vic)
Farming Group	CWFS	MSF	UNFS	BCG
Year	2014	2014	2013	2013
Soil type	Clay loam	Sand	Three zones – Sandy loam,	Clay
Rainfall over N_2O monitoring period	26 Feb – 9mm 1-2 March – 60mm	14 Feb – 16mm 15 Feb – 49mm 20 Feb – 2.2mm	17 July – 20mm (evening after top-dressing)	13 Aug – 4mm (morning before sampling) 14 Aug – 3mm 16-23 Aug – 19 mm
Crop types	Field pea stubble	Wheat, Field pea and Vetch stubble	Barley	Wheat
Sowing date	-	-	27 May	9 May
Sowing fertiliser	-	-	DAP @ 60kg/ha	MAP @ 55kg/ha
In-crop fertiliser treatments	-	-	GS30 (17 July) sandy loam – 85kg/ha urea sandy clay loam – 55kg/ha urea clay loam – 40kg/ha urea	GS 31 (14 Aug) 46 kgN/ha for all products including: granular urea, Green urea, ENTEC, polymer coated slow release urea
N_2O meaurement dates	26 Feb 3 March 10 March	13 Feb 15 Feb 21 Feb	16 July 18 July 24 July	13 Aug 15 Aug 23 Aug

METHOD

Demonstration scale measurements of N2O emissions were collected following fertiliser application or rainfall. These were measured from sealed PVC static chambers of approximately 30cm diameter, positioned on farm in small plots or in large paddocks. N2O was drawn from airtight chambers via medical syringes into evacuated vials. N2O flux measurements were collected at intervals of 0, 30 and 60 minutes one day prior to, one day after, and approximately seven days following a rain event.

Ambient and soil temperatures were also measured and soil (0-10cm) was collected to enable testing for moisture and nitrogen at each sampling. Samples were analysed by the Queensland University of Technology.

Four different demonstrations to measure N2O emissions were established as follows:

(i) Field pea stubble at Condobolin, February March 2014

(ii) Wheat, field pea and vetch stubble at Mildura, February 2014

(iii) Barley on three soil zones at Jamestown (sandy loam, sandy clay loam and clay loam), top dressed with urea at rates of 85, 55 and 40kg urea/ha)

(iv) Wheat at Horsham to which different nitrogen fertiliser products were applied: granular urea, Green urea (urease inhibitor), ENTEC (nitrification inhibitor) and polymer coated slow release urea.

RESULTS AND INTERPRETATION

Condobolin (central-west NSW)

N2O data collected from field pea stubble (2t/ha of biomass) prior to, and following, 69mm of February/ early March rainfall indicated an immediate rise in N2O emissions following rainfall; eight days later they had fallen to near zero levels (Figure 2). The peak in emissions ranged from 2.3 to 4.0gN2O-N/ha/day, demonstrating the level of variability across the site.

Figure 2. N2O flux from field pea stubble at Condobolin prior to and following 26 February, 9mm and 1-2 March, 60mm.

Jamestown (mid-north South Australia)

Nitrogen was applied at rates of 85, 55 and 40kg urea/ ha to three soil zones, sandy loam, sandy clay loam and clay loam (Figure 4). N2O flux was measured the day before and the day after 20mm of rain, and then again seven days later. Emissions quickly increased after rainfall where 55 and 40kg/ha of urea had been applied. When measured seven days later, this increase had subsided. The effects of rain on the 85kg /ha of urea were inconsistent with these findings. These were lower, with peak emissions being highest at the final sampling. Measured peak emissions from this demonstration, ranging from 2.0 to 3.0gN2O-N/ ha/day, were similar to other emissions measured.

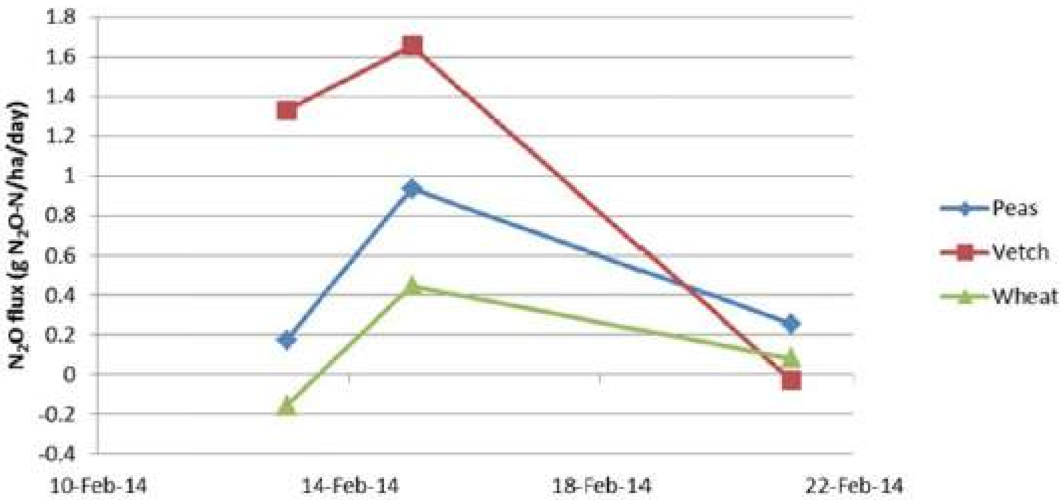


Figure 3. N2O flux from various crop stubble at Mildura prior to and following 65mm of rainfall from 14-15 February, and 2.2 mm on the 20 February (BOM, Mildura Airport).

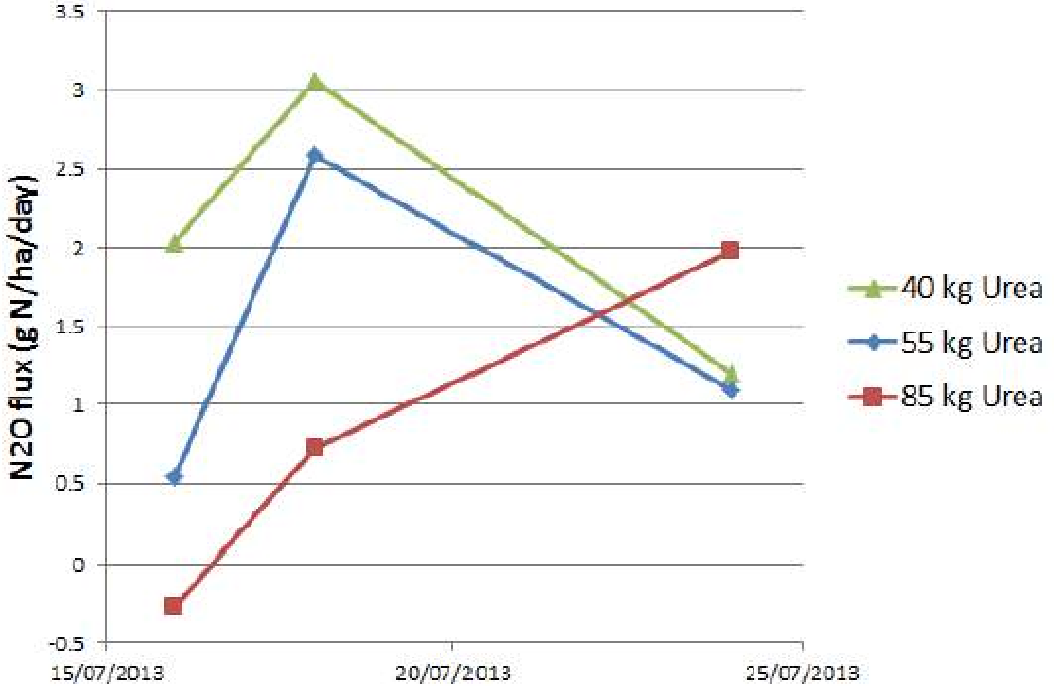


Figure 4. N2O flux following various top-dressed rates of urea prior to, immediately following and one week after fertiliser application and rainfall occurring on July 17 at Jamestown.

Horsham (Wimmera - Victoria)

N2O flux from the application of 46kgN/ha as polymer coated urea, ENTEC urea, Green urea and granular untreated urea were compared with a control to which no urea had been applied (Figure 5). Limited rain prior to the first and second measurement (after 4mm and then 3mm, respectively) meant that peak emissions for the majority of treatments did not occur until the final sampling, when an additional 19mm had fallen intermittently during the previous week. Peak emissions were very small, but the highest was from the granular urea, 1gN2O-N/ha/day. However, given that the control (nil treatment) had the second highest emissions, there was no indication of increased emissions from adding nitrogen fertiliser at this time of the year to this soil. A potential explanation for this may be that in this situation, soil moisture levels (possibly also soil carbon and temperature) may have been insufficient to generate larger N2O losses and at the level observed they may not have been limited by N supply.

It was observed that the polymer coated urea was still visible on the soil surface at the third sampling, following 21mm or rainfall. This product was designed to be used at sowing and the fact that it could still be seen long after it had been applied highlights that fertiliser products should be used at the appropriate time in their appropriate environment.

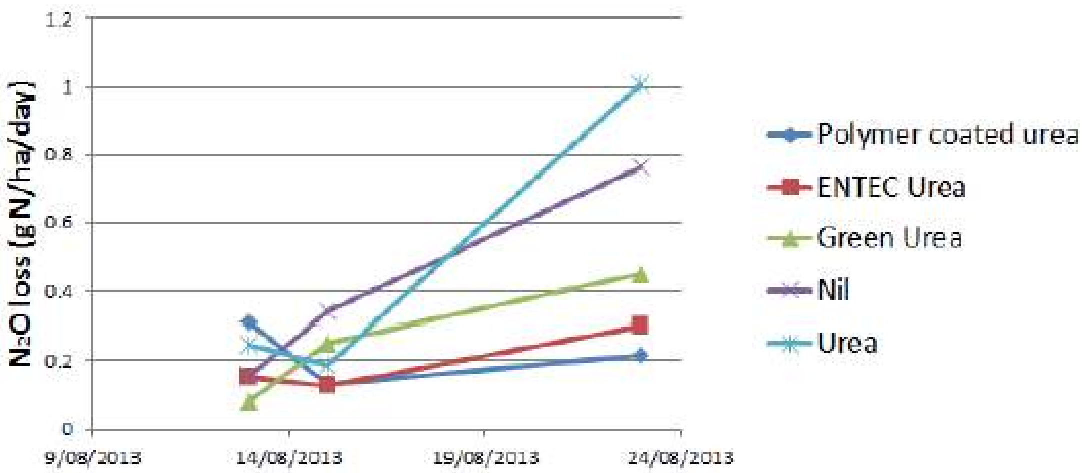


Figure 5. N2O flux, nil control and inhibitor treated and slow release urea prior to, immediately following and one week after fertiliser application and rainfall.

COMMERCIAL PRACTICE

Nitrous oxide emissions measured after rain from various stubble in summer, or from top-dressed urea products in-season, were low. Emissions generally increased following rainfall, most likely due to higher soil moisture levels stimulating the soil microbes responsible for nitrification and potentially also de nitrification.

Differences in N2O emissions from various nitrogen sources were difficult to measure because of the low emission levels produced. The highest peak emission measured was 4.0gN2O-N/ha/day from the field pea stubble in February following 69mm at Condobolin. If emissions reached a maximum of 4.0gN2O-N/ha/day for 365 days, annual emissions would equate to 1.5kgN2O-N/ha/year, however the likelihood of this occurring is low for low rainfall cropping. Previous studies, such as those summarised by Barton et el. 2014, indicate that emissions from various systems can range between 0.3 to 16.8 kgN2O-N/ha/year, making results from this study comparatively low.

While N2O loss appears to be a low risk in low rainfall environments, higher potential losses may come from other processes such as ammonia volatilisation following urea fertiliser application without follow up rainfall and nitrate leaching in sandy soils. In higher rainfall environments, where soils are wetter for longer, more denitrification is likely to occur, resulting in higher N2O emissions. However, under severe waterlogging, denitrification may produce not N2O, but di-nitrogen (N2) which is not a greenhouse gas (see Figure 1).

Overall, any loss of nitrogen from the system is a limitation to production and profitability. Practices that avoid over application and minimise nitrogen losses and unnecessary emissions should be adopted.

Tools available to assist with nitrogen application decision-making include soil testing, modelling programs such as Yield Prophet®, seasonal weather outlooks, N rich strips to indicate potential responses in-season and precision agriculture technologies. Before investing in inhibitor-treated fertiliser products, growers should be clear about how they work, what are the potential gains and the probable impact of their use on the bottom line.

ON-FARM PROFITABILITY

If we assume a theoretical paddock where maximum emissions of 4.0 gN2O-N/ha/day (1.5kgN2O-N/ha/year) occurred, then the nitrogen loss would be only $1.62/ha/year, assuming $500/tonne of urea.

Greenhouse gas emissions are reported in carbon dioxide equivalents (CO2-e) and this emission level is the equivalent of 702kg of CO2-e. At a carbon price of $23/ha, the value of N2O emitted would be $16/ha/year. However, as mentioned above, the likelihood is that emissions for low rainfall cropping systems are far lower than the 1.5kgN2O-N/ha/year, which means that the cost of emissions loss would be less.

REFERENCES

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ACKNOWLEDGMENTS

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