Nitrous oxide emissions from wheat grown in a medium rainfall environment in SE Australia are low compared to overall nitrogen losses

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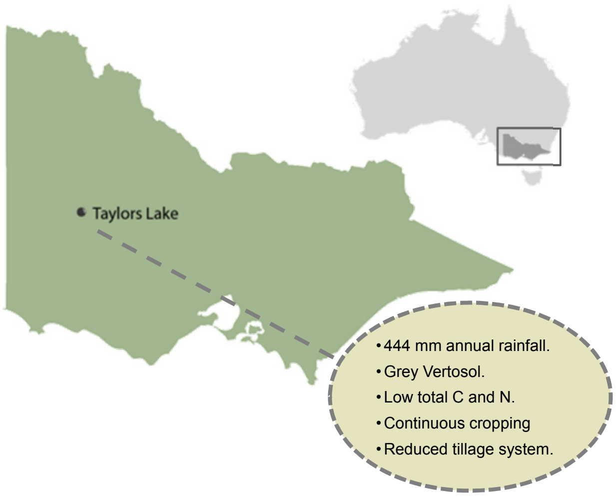
AGRICULTURE VICTORIA

Nitrous oxide is an important contributor to both global warming and ozone depletion, representing 15.5% of Australia's agricultural GHG emissions (Department of the Environment, 2015) and the loss of a valuable nutrient. This study investigated the effect of altered N fertiliser management on N_2O flux, ^{15}N fertiliser recovery and crop production for wheat grown in Western Victoria.



Methods

- A field trial was established at Taylors Lake in 2012 to test the impact of a range of fertiliser management strategies on N_2O flux and fertiliser recovery. Treatments were applied at a rate of 50 kg N/ha and included:
  - Urea at sowing; banded below the seed (50N).
  - Urea at sowing; banded below the seed with added nitrification inhibitor (50N DMPP).
  - Urea top-dressed at the end of tillering (0:50N).
  - Urea top-dressed at the end of tillering with added urease inhibitor (0:50N NBPT).
  - 0N control.
- N_2O flux was monitored regularly throughout the season, with greater intensity around fertiliser application. A subset of the 0N and 50N treatments were also monitored on a weekly basis from 15-August.
- N_2O flux was measured using a static chamber methodology and calculated according to the method of Harris, Officer et al .(2013).
- Fertiliser recovery was measured using a ^{15}N mass balance approach. Steel micro-plots (53 x 30 cm) were installed at the unfertilised end of each plot and ^{15}N enriched fertiliser applied. Grain, straw and soil samples were analysed for δ15N at harvest and recovery was calculated using the approach of Malhi, Johnston et al. (2004).

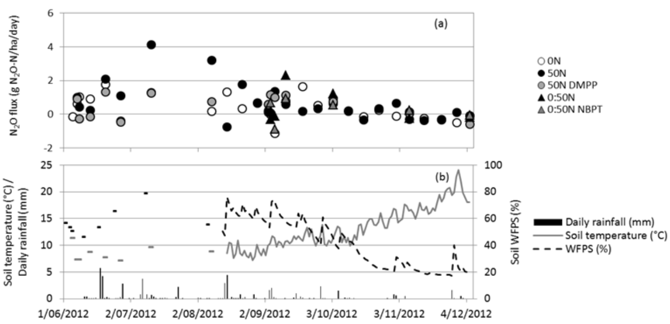


Figure 1. Daily N_2O flux for various N fertiliser management treatments, daily rainfall, soil temperature (0-5 cm) and soil WFPS (0-5 cm).

Conclusions

- Measured losses of N_2O from a medium rainfall cropping system of western Victoria were low compared to overall N requirements of the wheat crop and total fertiliser losses.
- Addition of N fertiliser, regardless of timing or the use of inhibitors had limited impact on daily N_2O flux rates or fertiliser recovery in this season.
- Movement of N to depths below 10 cm was greater where N was applied at sowing indicating that in-season application may help to avoid peak winter periods when NO_3^- movement was most likely (albeit within the likely rooting zone) and improve synchronicity of nutrient supply to crop demand.
- Given the importance of N fertiliser to maintaining crop productivity in favorable seasons it is suggested that successful mitigation of N_2O loss will require research and communication of practices that improve overall N use efficiency and reduce more than just N_2O flux.

Effect of fertiliser management on N_2O flux

- N_2O flux rates were similar in magnitude to studies from other semi-arid environments (Barton, Kiese et al. 2008) and significantly lower than those from high rainfall cropping systems of Victoria (Harris, Officer et al. 2013).
- Peak daily flux was 4.1 g N_2O-N/ha/day (for the 50N treatment) during July (Figure 1) resulting in cumulative flux rates of 0.075 kg N_2O-N/ha and 0.236 kg N_2O-N/ha for the 0N and 50N treatments respectively (over 183 days). Across the season, daily flux rates were not significantly changed due to fertiliser addition regardless of timing or the use of inhibitors..
- Daily N_2O flux was positively correlated with soil water filled pore space (0-5 and 5-10 cm) and soil nitrate (5-10 cm), but negatively correlated with soil temperature; most likely related to the increase in soil temperature later in the season when soil water content reduced significantly.

Effect of fertiliser management on ^{15}N recovery

- Recovery of applied fertiliser ranged from 78-86% with limited differences between treatments except for increased movement of fertiliser below10 cm where N was applied at sowing (Figure 2).
- Movement of fertiliser below the steel micro-plots (>20 cm) also increased where N was applied at sowing (data not shown).
- Crop uptake (straw and grain) ranged from 49-54% of applied N which was approximately 30% of above ground N uptake, boosting yields significantly from 2.8 t/ha to 3.7-4.6 t/ha
- Total loss of applied fertiliser ranged from 7-11 kg N/ha, far greater than cumulative N_2O loss and suggesting that some other loss mechanism/s were responsible.

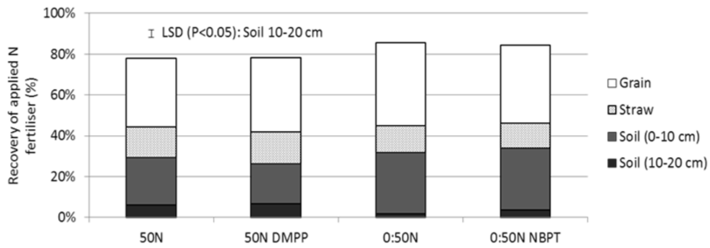
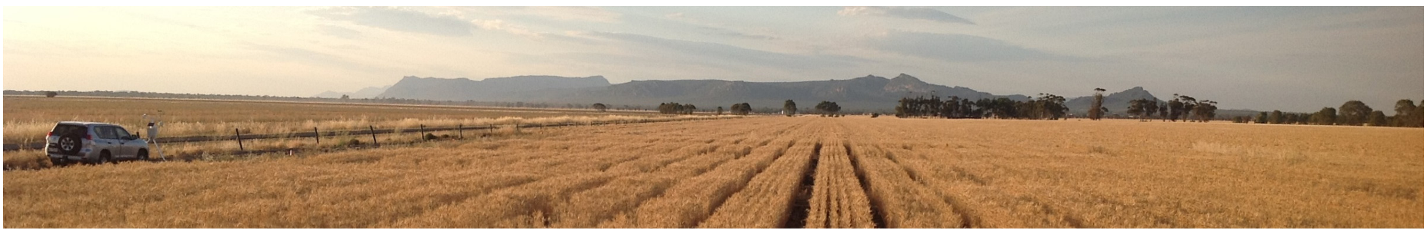


Figure 2. Recovery of applied N fertiliser in soil and above ground biomass at harvest for various fertiliser management treatments.

References

- Barton, L., R. Kiese, et al. (2008). "Nitrous oxide emissions from a cropped soil in a semi-arid climate." Global Change Biology 14(1): 177-192.
- Department of the Environment (2015), National inventory report 2013: Volume 1. Commonwealth of Australia.
- Harris, R. H., S. J. Officer, et al. (2013). "Can nitrogen fertiliser and nitrification inhibitor management influence N2O losses from high rainfall cropping systems in South Eastern Australia?" Nutrient cycling in agroecosystems 95(2): 269-285.
- Malhi, S., A. Johnston, et al. (2004). "Landscape position effects on the recovery of 15 N-labelled urea applied to wheat on two soils in Saskatchewan, Canada." Nutrient cycling in agroecosystems 68(1): 85-93.



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