International Nitrogen Initiative

7th International Nitrogen Initiative Conference (INI 2016)
4–8 DECEMBER 2016
MELBOURNE CRICKET GROUND | VICTORIA | AUSTRALIA

THE UNIVERSITY OF MELBOURNE

Dual effects of nitrification inhibitors on N_2O emission from agriculture

Shu Kee Lam[1], Helen Suter[1], Rohan Davies[2], Mei Bai[1], Jianlei Sun[1], Arvin R Mosier[1], Deli Chen[1]

[1] Faculty of Veterinary and Agricultural Sciences, The University of Melbourne, Australia
[2] BASF Australia Ltd., Australia

Background

- N_2O: a greenhouse gas approximately 300 times more potent than CO_2
- Global agriculture contributes around 60% of total anthropogenic N_2O emission (Ciais *et al.* 2013).
- Nitrification inhibitors are recommended by the IPCC as a potential mitigation option for agricultural N_2O emission.
- Nitrification inhibitors: $NH_4^+ \not\rightarrow NO_3^-$

THE UNIVERSITY OF MELBOURNE

Dual effects of nitrification inhibitors

- Nitrification inhibitors decrease N_2O emission by 31–48% across diverse agricultural ecosystems.
- However the inhibitors prolong the retention of NH_4^+ in soil, and increase NH_3 emission by 20–40% (meta analyses by Akiyama *et al.,* 2010; Qiao *et al.,* 2015)
- NH_3 deposition:
  - a major threat to environmental quality and ecosystem biodiversity (Erisman *et al.* 2008)
  - indirectly contributes to N_2O emission (van der Gon & Bleeker 2005)

Knowledge gap

- Previous meta-analyses
  - included studies focussed on either N_2O or NH_3
  - expressed the effect as % change, not absolute difference in nitrogen

- No review on studies that **simultaneously measure N_2O and NH_3 emissions** in the field under the treatment of nitrification inhibitors

Methodology

- Literature search: Web of Science, Scopus, CAB Abstracts, Academic Search complete and Google Scholar

- IPCC emission factor EF_4 (indirect N_2O emission from NH_3 volatilization and deposition):
  - Default: 1%
  - Upper range: 5%

Agricultural system	Inhibitor	Effect of nitrification inhibitor (NI): Direct N_2O emission %	Direct N_2O emission Amount (kg N ha^{-1}) (I)	NH_3 volatilization %	NH_3 volatilization Amount (kg N ha^{-1}) (II)	Overall NI effect on N_2O emission (kg N ha^{-1}) (I + II × EF_4): EF_4 = 1%	EF_4 = 5%
Cropping	N-serve	–49.9	–0.57	+64.9	+12.75	–0.44	+0.07
Cropping	N-serve	–19.2	–0.27	+37.5	+15.80	–0.11	+0.52
Cropping	DCD	–20.4	–0.79	–3.7	–0.40	–0.79	–0.81
Cropping	DCD	–52.3	–1.36	+3.1	+0.35	–1.35	–1.34
Cropping; pasture	DCD	–46.5	–0.52	+6.1	+2.20	–0.50	–0.41
Cropping; pasture	DCD	–28.7	–0.48	+5.4	+0.15	–0.48	–0.47
Pasture	DCD	–56.8	–1.24	–0.8	–0.97	–1.25	–1.29
Pasture	PD	–10.6	–0.23	+4.0	+4.87	–0.18	+0.01
Pasture	DCD	–30.1	–0.38	+7.7	+2.55	–0.36	–0.26
Pasture	DCD	–42.1	–2.93	+35.5	+18.65	–2.74	–2.00
Pasture	DCD	–40.5	–2.15	+13.3	+13.87	–2.01	–1.46
Pasture	DCD	–37.1	–4.47	+43.4	+12.60	–4.34	–3.84
Pasture	DCD	–46.8	–4.33	+18.2	+8.00	–4.25	–3.93
Pasture	DCD	–38.6	–4.40	+9.1	+2.00	–4.38	–4.30
Pasture	DCD	–20.0	–0.30	+17.2	+8.60	–0.21	+0.13
Pasture	DMPP	–7.9	–0.18	+13.9	+1.80	–0.16	–0.09
Pasture	DMPP	–8.8	–0.39	–51.7	–0.15	–0.39	–0.40
Pasture	DMPP	–29.1	–4.51	+42.0	+3.16	–4.48	–4.35

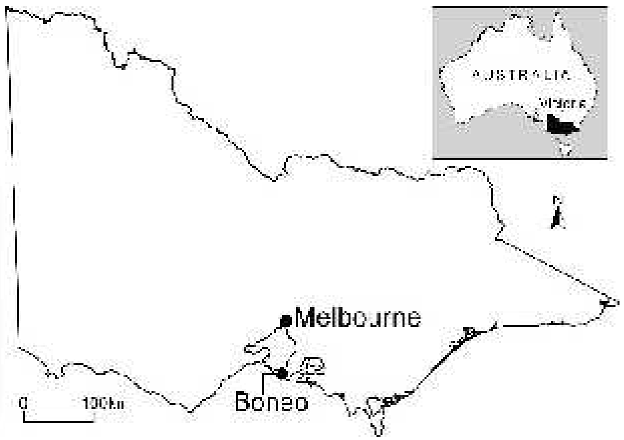
Lam et al. 2016, *Global Change Biology*

Knowledge gap

- No study on vegetable production systems (intensive N input)
- Chamber techniques for N_2O (closed) and NH_3 (open) emissions were widely used

Case study—vegetable farm

- The National Agricultural Nitrous Oxide Research Program (NANORP) in Australia
- Vegetable production system
  - Boneo, Victoria
  - Chicken manure with and without 3,4-dimethylpyrazole phosphate (DMPP)
  - 255 kg N ha^{-1} as manure; 39 kg N ha^{-1} Nitrophoska® x 5

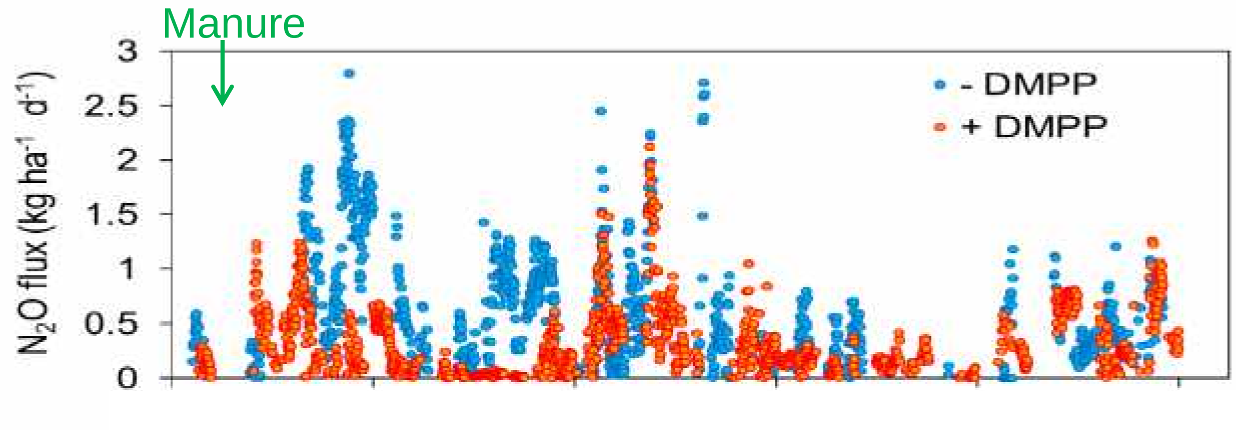


Micrometeorological methods

NH_3 and N_2O measurements

- open-path Fourier transform infrared (FTIR) spectroscopy
- paddock-scale (4 ha); continuous; non-intrusive

DMPP effect on NH_3 and N_2O emission

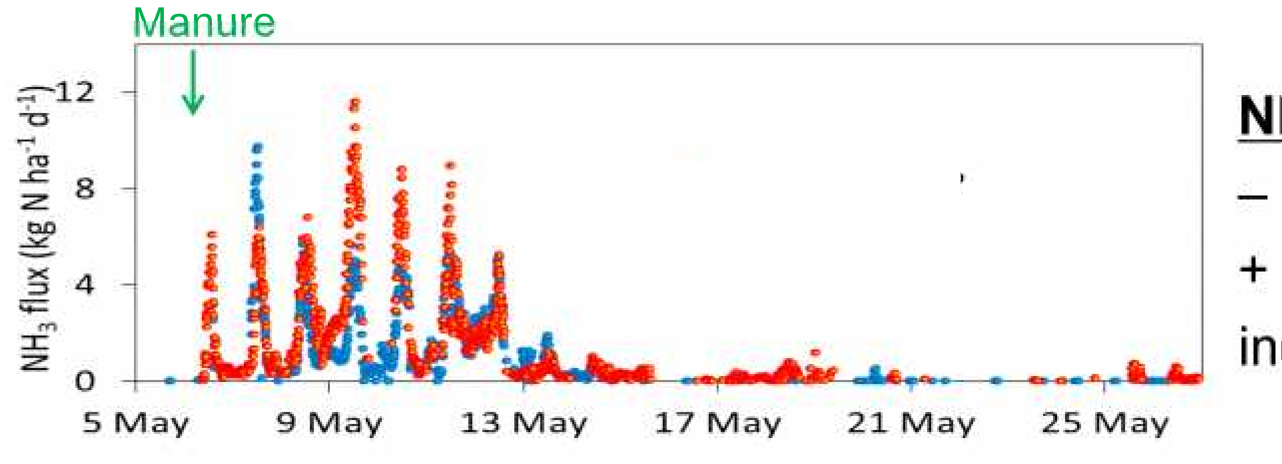


N_2O

– DMPP: 5.7 kg N ha^{-1}

+ DMPP: 3.6 kg N ha^{-1}

decreased by 37%



NH_3

– DMPP: 12.4 kg N ha^{-1}

+ DMPP: 17.2 kg N ha^{-1}

increased by 39%

Summary

- Nitrification inhibitors effectively decrease N_2O emission.
- This beneficial effect can be weakened or even reversed by the increase in indirect N_2O emission from deposited NH_3.
- The inclusion of indirect N_2O emission is critical for evaluating the effectiveness of nitrification inhibitors in mitigating greenhouse gas emissions from agriculture.

Recommendations

- Appropriate NH_3 mitigation measures should be taken where nitrification inhibitors are used:
  - double inhibitor (combining nitrification and urease inhibitors)
  - NH_4^+ based N input: substances with a high affinity for binding onto NH_4^+ ions e.g., zeolite and lignite
  - where practical, manure/fertilizers should be incorporated into soil

Acknowledgements

THE UNIVERSITY OF MELBOURNE

Funding bodies

Australian Government Department of Agriculture

Incitec Pivot Fertilisers

Landholder

Lamattina, Australia

Field and laboratory assistance

Trevor Coates, Sima Mazaherinia, Eric Ireland, Rifaath Hussain, Muhammad Shakir

Australian Government
Department of Agriculture

N_2O Network

piccc
Primary Industries Climate Challenges Centre

Incitec Pivot Fertilisers