Nitrous oxide emission levels in response to alternative crop rotations

Brian Dzoma[1] and Roy Latta[2]

[1]SARDI, Minnipa Agricultural Centre, [2]Dodgshun Medlin, Swan Hill, Victoria

Searching for answers

Location:
Minnipa Ag Centre,
Airport paddock
Rainfall
Av. Annual: 325 mm
Av. GSR: 241 mm
2014 Total: 407 mm
2014 GSR: 290 mm
Paddock History
2013: Wheat (Mace)
2012: Wheat (Kord)
Soil Type
Calcareous red sandy loam
Plot Size
10m x 3m x 3 reps

Location:
Wanilla: David Giddings
Rainfall
Av. Annual: 550 mm
Av. GSR: 400 mm
2014 Total: 437 mm
2014 GSR: 368 mm
Paddock History
2013: Canola
2012: Wheat
Soil Type
Duplex sand over loam
Plot Size
10m x 3m x 3 reps

Key messages

- **Work conducted in low and medium rainfall environments indicate that N_2O emissions are low from an overall national perspective.**
- **Results showed that there was no clear response of N_2O emissions to nitrogen applied at sowing and post sowing.**
- **High pre-sowing soil mineral nitrogen raises the possibility of higher N_2O losses over the fallow period following significant rainfall.**

Why do the trial?

Agricultural soils are the main source of emission of the greenhouse gas (GHG) nitrous oxide (N_2O) to the atmosphere. N_2O is a potent GHG which lasts in the atmosphere for 114 years and has a global warming potential of approximately 300 times greater than that of carbon dioxide over a 100 year timescale. Agriculture accounts for 16% of Australia's greenhouse gas emissions but produces 80% of Australia's N_2O emissions.

This project seeks to measure and quantify N_2O emissions from wheat grown in rotation with canola, pulses and legume pastures at two sites in low and medium/high rainfall farming systems of the Eyre Peninsula, while assessing best management practices that local farmers can adopt to reduce the risk of N_2O losses and ultimately improve the paddock's crop productivity and gross margin.

How was it done?

During the first year of the trial, the plots were sown to canola, legume pasture (annual medic/ sub clover) and pulses (lupins/peas) and the data was presented in the Eyre Peninsula Farming Systems (EPFS) Summary 2013, p75. In 2014 (Table 1), both trial sites were sown to Mace wheat; [1]Minnipa Agricultural Centre (MAC) on 12 May 2014 and [2]Beaumont (near Wanilla) on 11 May 2014.

All treatments were replicated 3 times. Diammonium phosphate fertilizer (DAP) was applied at sowing; 50 kg/ha at MAC and 80 kg/ha at Beaumont. 21 units of nitrogen (N) were applied on the canola-wheat high input plots at MAC at growth stage 31 (15 July) and 56 units of N were applied at Beaumont on the canola-wheat high input treatment (28 units at sowing and 28 units at growth stage 31on 18 July).

N_2O gas sampling was done 5 times at MAC (11 and 14 April; 14 May; 14 and 18 July). At Beaumont sampling was done 5 times; on 30 April, 2 and 13 May, 10 and 21 July). Associated measurements collected at the time of gas sampling included:

- 0-10 cm and 10–30 cm soil water content (mm)
- Live crop biomass and stubble biomass (t/ha)
- Soil temperature (5 cm)
- 0–10 cm and 10–30 cm soil samples for mineral nitrogen (NH_4 and NO_3) analysis.

MAC trial was harvested on 5 November 2014 and Beaumont, on 25 November 2014.

Table 1 Trial treatments and rotation crops

	Year 1 crop	Year 2 crop	Treatment
1	canola-high input	wheat	Recommended yield potential rate of N
2	canola-low input	wheat	Recommended rate of N, nothing post seeding
3	[1]annual medic, [2]sub clover	wheat	Recommended rate of N, nothing post seeding
4	[1]field peas, [2]lupins	wheat	Recommended rate of N, nothing post seeding

What happened?

2013 N_2O fluxes ranged from 0–38.9g N_2O-N/ha/day (MAC) and 1.1–129.9 g N_2O-N/ha/day (Beaumont). However the N_2O fluxes for 2014 at both sites were much lower, ranging from 0.3–11.1 g N_2O-N/ha/day at Beaumont and 0–4.7 g N_2O-N/ha/day at MAC. The highest N_2O fluxes occurred on the canola-wheat high input treatments. Mean N_2O emissions were significantly higher on the canola-wheat high input treatment at Beaumont, but no significant differences in mean emissions were observed at MAC on all treatments (Table 2).

N_2O emissions at MAC peaked on a sampling done on 11 April, at 4.7 g N_2O-N/ha/day (Figure 1) and dropped to levels below 1.5 g N_2O-N/ha/day 3 days later. N_2O fluxes were relatively low after sowing (0–1.1 g N_2O-N/ha/day, and there was no indication of an increase in emission as a result of in crop N applied at GS31 (15 July 2014). The drop in soil temperature (23.4°C – 10.3°C) may have been part of the lower N_2O fluxes post sowing, coupled with low mineral nitrogen (8–12 mg/kg (NO_3 + NH_4) compared to 26–41 mg/kg on 14 April 2014.

Emission levels at Beaumont peaked at 11.1 g N_2O-N/ha/day pre-sowing following a rainfall event (30 mm on 29 April) and were higher post sowing (0.3 – 7.3 g N_2O-N/ha/day) as compared to MAC. There was an indication of an emission response (Figure 2) from the canola-wheat high input treatment, to the in-crop N applied at sowing (11 May) and GS31 (15 July).

In 2014, the wheat following lupins grain yield (2.93 t/ha) at Beaumont was significantly higher than the other treatment yields, and at MAC annual medic had the highest grain yield (2.91 t/ha), however it was not significantly higher than the other treatment yields (Table 2). The canola-wheat treatment had the highest grain protein (%) at both sites. There were no significant differences in grain protein and screenings at MAC.

A gross margin analysis for the 2014 wheat crop (not including 2013 rotation) was carried out using guidelines from the Farm Gross Margin and Enterprise Planning Guide, Rural Solutions, SA (2014). Wheat following annual medic had the highest gross margin ($477/ha) at MAC, while wheat following sub-clover had the lowest gross margin at Beaumont (Table 3).

The total variable costs were highest in the canola-wheat high input treatment at both sites due to urea inputs and freight costs, and this reduced the gross margin by 47% for the canola-wheat high input crop at Beaumont.

What does this mean?

The National Nitrous Oxide Research Program has found that N_2O emissions can range from 0.03 to 1 kg N_2O-N/ha/day depending on environment and soil type, and work conducted in low and medium rainfall environments indicate that N_2O emissions are low from an overall national perspective.

Table 2 Average N_2O emissions from 5 samplings at MAC and Beaumont in 2014

MAC		Beaumont	
Treatment	**Mean N_2O fluxes (gN_2O-N/ha/day)**	**Treatment**	**Mean N_2O fluxes (gN_2O-N/ha/day)**
ex canola H	1.34 a	ex canola H	5.71 a
ex canola L	0.71 a	ex canola L	2.97 b
ex medic	0.78 a	ex sub clover	2.14 b
ex peas	0.50 a	ex lupins	2.52 b
LSD (P=0.05)	*0.85*		*1.62*

Means followed by the same letter are not significantly different

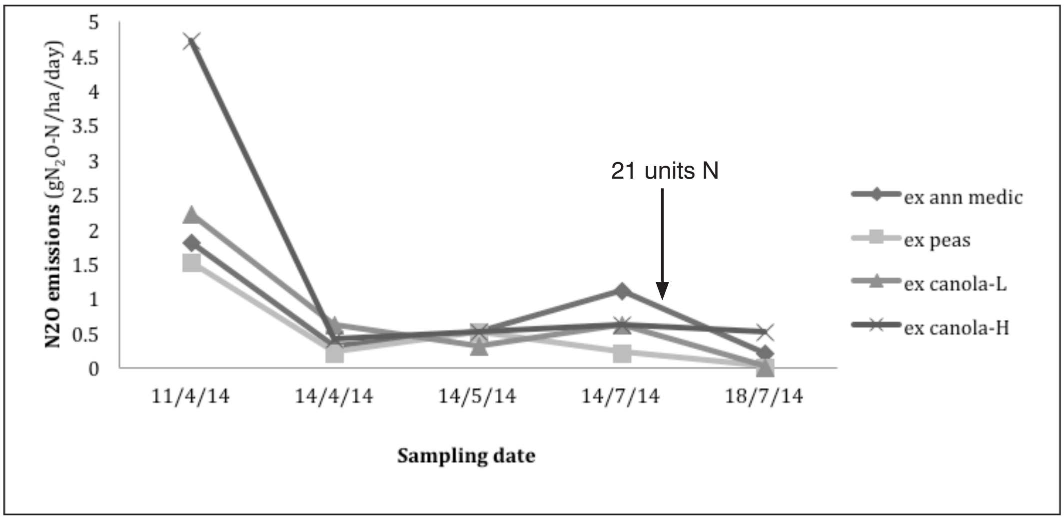

Figure 1 MAC N_2O fluxes in 2014

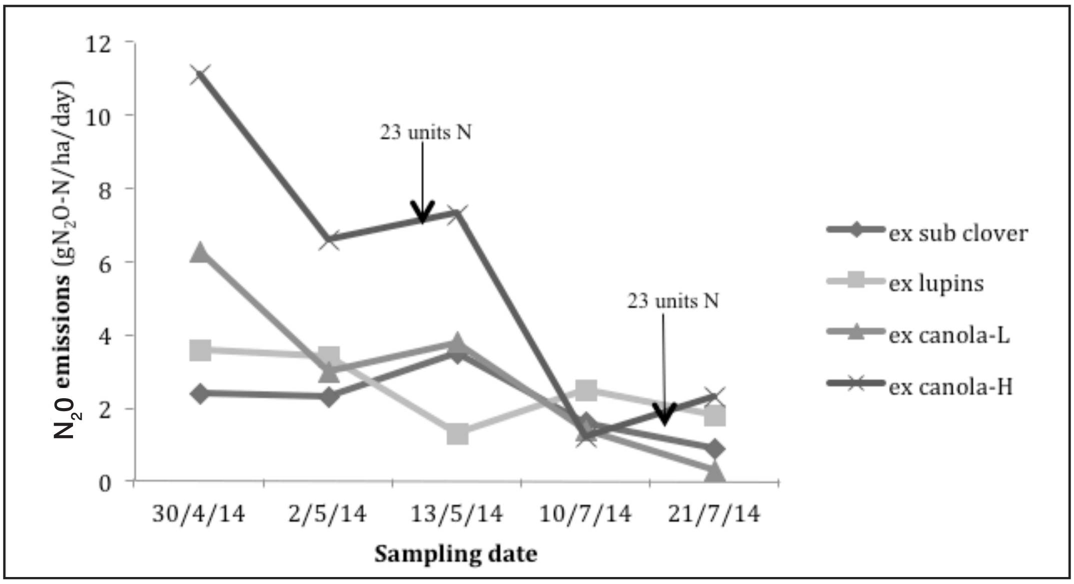

Figure 2 Beaumont N_2O fluxes in 2014

Table 3 Crop productivity and gross margins for Mace wheat at MAC and Beaumont in 2014

Location	2013 crop	2014 Crop productivity				Gross margin analysis		
		Yield (t/ha)	Protein (%)	Screenings (%)	Grain N uptake (kg/ha)	Gross income ($/ha)	Total variable costs ($/ha)	Gross margin ($/ha)
MAC	medic	2.9	9.7	1.6	49.4	717	239	477
	canola L	2.6	9.6	0.7	44.5	648	234	414
	field peas	2.7	9.7	0.9	44.9	655	234	421
	canola H	2.8	10.3	1.1	50.3	682	266	416
LSD (P=0.05)		*0.34*	*0.68*	*0.79*	*8.08*			
CV		6.1	3.5	37.3	8.6			
Beaumont	sub clover	2.3	9.3	6.2	37.8	564	233	331
	canola L	2.4	9.3	6.2	38.4	576	234	342
	lupins	2.9	9.7	4.4	49.6	721	245	476
	canola H	2.7	10.3	5.6	48.6	657	310	346
LSD (P=0.05)		*0.42*	*0.35*	*2.01*	*8.08*			
CV		8.2	1.8	17.9	9.30			

2014 All treatments sown to wheat (Mace)

Results presented so far indicate that N_2O emissions were low at both sites on the Eyre Peninsula as compared to high rainfall (>650 mm) farming systems of South West Victoria with emissions up to 588 g N_2O-N/ha/day (Harris et al., 2014).

Results also showed that there was no clear response of N_2O emissions to higher soil mineral N and moisture. The water-filled pore space (WFPS) percentage ranged from 33–42% for MAC and 20–75% for Beaumont, indicating that most of the N_2O losses occurred through nitrification and not denitrification which is driven by oxygen limiting waterlogged conditions. 2013 peak N_2O fluxes of 129 and 39 g N_2O-N/ha/day for Beaumont and MAC respectively suggest that high pre-seeding soil N (levels > 75 mg/kg NH_4 + NO_3) can have a great influence on N_2O losses over the fallow period following a significant rainfall event.

There was a weak correlation between N_2O emission and the key factors that drive emissions i.e. WFPS, mineral N, and soil temperature (low r^2 values for both sites ranging from 0.01–0.48 after a linear regression analysis), hence more work needs to be done to better understand the key drivers of N_2O emissions on the Eyre Peninsula.

Acknowledgements

Minnipa Agricultural Centre and David Giddings for the use of their land. Terry Blacker and Ian Richter for their technical support. This project is supported by funding from the Australian Government Department of Agriculture - Action on the Ground program.

SARDI
SOUTH AUSTRALIAN RESEARCH AND DEVELOPMENT INSTITUTE
EPARF EYRE PENINSULA Agricultural Research Foundation
Australian Government
BCG shared solutions
Government of South Australia
Eyre Peninsula Natural Resources Management Board