Nitrous oxide emission levels in response to alternative crop rotations

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RESEARCH

Searching for answers

Location:
Minnipa Ag Centre, Airport paddock
Rainfall
Av. Annual: 324 mm
Av. GSR: 241 mm
2013 Total: 334 mm
2013 GSR: 237 mm
Paddock History
2012: Wheat
Soil Type
Calcareous red sandy loam
Soil Test
Organic C%: 0.9
Plot Size
10 m x 3 m x 3 reps

Location:
Wanilla - David Giddings
Rainfall
Av. Annual: 550 mm
Av. GSR: 400 mm
2013 Total: 600 mm
2013 GSR: 480 mm
Paddock History
2012: Wheat
Soil Type
Duplex sand over loam
Soil Test
Organic C%: 1.2
Plot Size
10 m x 3 m x 3 reps
Yield Limiting Factors
November hailstorm
Environmental impacts
Soil Health
Soil structure: Stable
Compaction risk: Nil no livestock
Ground cover or plants/m^2: standard crop establishment and management practice no grazing
Perennial or annual plants: Annual
Water Use
Runoff potential: Low
Resource Efficiency
Energy/fuel use: Standard
Greenhouse gas emissions (CO_2, N_2O): Cropping
Social/Practice
Time (hrs): No extra
Clash with other farming operations: Standard practice
Economic
Infrastructure/operating inputs: Canola rotation has higher input costs
Cost of adoption risk: Low

Key message

- **Preliminary results showed the level of nitrous oxide emissions did not increase over the 2013 winter as a result of near capacity soil water contents coupled with increased nitrate nitrogen levels resulting from seeding and in-crop nitrogen applications on the canola compared with a pulse crop and legume pasture.**

Why do the trial?

Direct greenhouse gas emissions from agriculture currently accounts for approximately 15 per cent of Australia's total, of which nitrous oxide (N_2O) from agricultural soils contributes about 17% of total emissions from agriculture. A review by Grace (unpublished data) suggested Eyre Peninsula had low nitrous oxide emission potential. However the increasingly common wheat-canola rotation in the 400-500 mm rainfall zone of the lower EP, with 200-300 units of synthetic nitrogen (N), largely top dressed onto the canola phase, plus a further 100-150 units of N applied during the wheat phase may lead to higher emissions than previously estimated.

This project will measure N_2O at two sites, in key biophysical areas of the region, quantifying the relative amount of gas emitted from the use of synthetic N fertilizer while assessing the opportunity to provide alternative cost effective N sources (pulse and pasture legume N), which local farmers may adopt.

How was it done?

Rotation trials were sown at Minnipa Agricultural Centre on 30 April 2013 and at Wanilla on 17 May 2013. The treatments were replicated 3 times (Table 1).

Greenhouse gas measurements were taken at Minnipa and Wanilla on 2 and 17 May (post seeding), 24 and 26 June (post N application), 31 July and 1 August (post N application) respectively. Further sampling on the 30 August and 2 September, 1 and 5 October, and 9 November and 25 October at Minnipa and Wanilla respectively awaits analysis.

Measurements collected included;

- Gas samples from individual collection chambers were taken at 0, 20, 40 and 60 minutes from commencement and sent to the University of Melbourne for N_2O and carbon dioxide ($CO_{2)}$ concentration analysis.
- soil water content (mm 0-10 cm, 10-30 cm),
- biomass (live crop and crop residues),
- soil temperature (5 cm) and
- NH_4 and NO_3 chemical analysis (0-10 cm, 10-30 cm).

Crop establishment counts were completed on 14 June (Minnipa) and 31 May 2013 (Wanilla). Pea and canola plots were harvested for grain yield at Minnipa on 8 October and at Wanilla on 27 November 2013. Pasture plots were mown on the October and November dates to simulate grazing.

What happened?

Annual rainfall at Minnipa totalled 334 mm, with 237 mm falling during the growing season (April to October). Wanilla received 600 mm over 2013, of which 480 mm fell over the growing season. Soil type is a calcareous sandy loam at Minnipa, pH $CaCl_2$ 8.1, with 70 kg N/ha and soil organic carbon content 0.9% (0-10 cm) and an acidic gravelly sand over clay pH $CaCl_2$ 5.5, with 73 kg N/ha and soil organic carbon content 1.2% (0-10 cm) at Wanilla in April 2013

Table 1 Crops, seeding rates and fertiliser applications applied at [1]Minnipa and [2]Wanilla in 2013

Crop Type	Variety	Seeding rates	Fertiliser rates	In crop nitrogen fertiliser (kg N/ha)		
		kg/ha	kg/ha (N + P)	June	July	August
Canola	[1]Stingray	3	23 N + 10 P	23	23	
	[2]Hyola 575CL	4	54 N + 16 P	46	46	30
[1]Ann. medic	Angel	10	10 P			
[2]Sub-clover	Dalkeith	16	8 N + 16 P			
[1]Field pea	Twilight	80	10 P			
[2]Lupin	Mandelup	80	8 N + 16 P			

Table 2 Crop biomass (tDM/ha), volumetric soil water (mm 0–30 cm), soil temperature (°C, 5 cm), nitrate and ammonium nitrogen (mg/kg 0–30 cm) and nitrous oxide emissions (g/ha/day) on the 24 June and 31 July at Minnipa

Crop Type	Date	Biomass	Soil water	Soil temp.	NH_4 NO_3	N_2O emissions
		(tDM/ha)	(mm)	(°C, 5 cm)	(mg/kg)	(g/ha/day)
Canola	24 June	0.2	59	13.3	68	1.6
Ann. medic	24 June	0.1	63	13.2	29	1.1
Field pea	24 June	0.3	59	12.8	28	2.6
Canola	31 July	1.6	51	14.4	36	6.3
Ann. medic	31 July	1.0	53	17.5	9	2.1
Field pea	31 July	1.5	55	17	20	5.1

Table 3 Crop biomass (tDM/ha) volumetric soil water (mm 0–30 cm) soil temperature (°C, 5 cm) nitrate and ammonium nitrogen (mg/kg 0–30 cm) and nitrous oxide emissions (g/ha/day) on 26 June and 1 August at Wanilla

Crop Type	Date	Biomass	Soil water	Soil temp.	NH_4 NO_3	N_2O emissions
		(tDM/ha)	(mm)	(°C, 5 cm)	(mg/kg)	(g/ha/day)
Canola	26 June	0.2	52	13.9	68	3.6
Sub-clover	26 June	0.1	60	15.1	20	1.8
Lupins	26 June	0.2	55	14.8	24	3.4
Canola	1 August	1.1	84	12.3	75	5.2
Sub-clover	1 August	1.1	86	13.4	29	4.4
Lupins	1 August	1.1	85	12.6	38	6.0

Table 4 Plant establishment (plants/m²) and crop grain (t/ha) and total biomass yields (tDM/ha) at Minnipa and Wanilla

Location	Crop Type	Establishment	Biomass	Grain yield
		(plants/m²)	(tDM/ha)	(t/ha)
Minnipa	Canola	62	4.0	0.6
	Ann. medic	129	2.8	
	Field pea	49	6.0	1.4
Wanilla	Canola	72	9.1	1.2*
	Sub-clover	94	6.5	
	Lupins	46	12.5	1.5*

**Grain yields were reduced at Wanilla as a result of a hailstorm.*

Nitrous oxide emission levels appeared more closely correlated with biomass production (regression analysis of 0.9 and $0.87r^2$) than with soil nitrogen content (-0.17 and $0.43r^2$) at Minnipa and Wanilla respectively. There was no difference in soil water content between treatments, however there was a trend towards lower soil temperatures under the canola. More nitrous oxide emission data taken over a longer time period is required before a statistical analysis can be undertaken, and more rigorous conclusions can be drawn.

What does this mean?

This work seeks to test the hypothesis that high levels of soil N created by high inputs of synthetic N in combination with waterlogged conditions will lead to higher N_2O emissions in the EP environment. The two sites represent the high and low rainfall zones of the region, and so the alternative cropping rotations effect on gas emissions can be assessed under these conditions.

The preliminary results show the level of nitrous oxide emissions did not increase as a result of higher soil nitrate nitrogen concentrations resulting from seeding and in-crop nitrogen applications to canola crops. The Wanilla site reached a 30% volumetric soil water content in August in conjunction with higher comparative measured levels of nitrate in the canola treatment compared to the legumes, but this did not translate into higher nitrous oxide emissions. The two sites had similar measured levels of nitrous oxide emissions over the winter growing season even though the Wanilla site had increased nitrate levels and similar or higher soil water contents. Any perceived increase in emission levels was seemingly associated with increased biomass.

Measurements will continue in response to any major summer rain events and the 2014 seeding and in-crop nitrogen applications to assess any response from increased levels of residual N resulting from the legumes.

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