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GREENHOUSE GAS EMISSIONS FROM ORGANIC CROP MANAGEMENT

Interim Research Report E2008-20

BACKGROUND

Organic potato production systems are characterized by extended rotations involving legume green manures often combined with organic amendments like manure or compost. In these soils, the reliance on legume nitrogen from biological nitrogen fixation and relatively high quantities of stable organic matter from compost may regulate the availability of soil nitrogen and carbon needed for release of greenhouse gases (GHG), specifically nitrous oxide (N_2O), carbon dioxide (CO_2), and methane (CH_4).

Few studies have examined the impact of organic rotations on N_2O emissions and greenhouse gas budgets, compared to conventional production systems. Researchers are interested in the relationship between nitrogen (N) supply and crop demand, and how N_2O emissions differ with N source: inorganic fertilizer, compost or legume green manure.

Two research teams (AAFC - Bouctouche, NSAC) in Atlantic Canada are attempting to answer these research questions by examining the effect of organic soil and crop management on soil carbon and nitrogen dynamics and N_2O emissions.

RESEARCH OBJECTIVES

The specific study objectives are to examine N_2O emissions as affected by:

NSAC site:

- Crop (red clover, timothy or potato)
- Timing of forage tillage (spring/fall)
- Potato fertility regime (preceding forage crop with or without inorganic fertilizer)

AAFC Bouctouche site:

Compost compared with inorganic N fertilizer:

- Applied in preceding 4 years (2002-2005)
- Also applied at potato planting

Greenhouse gas sampling chambers in the NSAC Brookside field, 2007

WHAT WAS DONE

At NSAC (Brookside), forage plots of either timothy or red clover established in 2004 received one of three different management treatments:

(i) Maintained as mowed forage
(ii) Fall plowed followed by potato
(iii) Spring plowed followed by potato

Subplots received N fertilizer (ammonium nitrate) at either 0 or recommended rates applied in spring. For potatoes, the rates were 90 kg N ha^{-1} following clover and 140 kg N ha^{-1} following timothy, and for forages 0 for clover and 0 or 140 kg N ha^{-1} (split application) applied to timothy, respectively. Fertilizer was broadcast on forages, and banded in the hill at potato planting. Soil type ranged from clay to clay-loam.

At AAFC Bouctouche, plots were established in 2002 that were amended with inorganic fertilizer (135 kg N ha^{-1} yr^{-1}) or compost (2 rates: 135 or 405 kg N ha^{-1} yr^{-1}) each year until 2005. In 2006, these plots were split and half continued to receive amendments while the other half did not receive fertilizer. All treatments were broadcast and incorporated at potato planting.

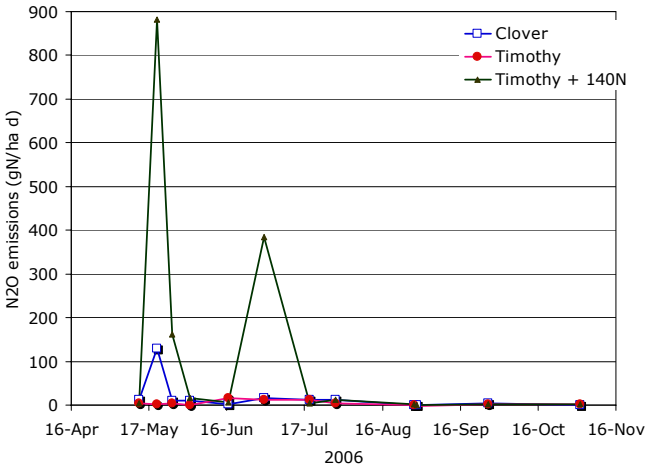

Figure 1. Daily N_2O emissions (g N ha^{-1} d^{-1}) from forage crops as influenced by management

At both sites, trials were planted in mid to late-May with the potato cultivar Goldrush. Due to space limitations, forage and potato yield data is not reported here. N_2O flux measurements were made weekly to bi-weekly until potato hilling and then monthly thereafter. In potato plots, gas sampling chambers were established in both hill and furrow locations. Samples were collected by removing 20 ml of gas from the headspace of the chamber and analyzing for N_2O with a gas chromatograph.

Preliminary Results

At AAFC Bouctouche, cumulative growing season emissions were low (~ 1.0 kg N ha^{-1}) for all treatments except where compost was applied at planting. Large events (> 20 g N_20-N ha^{-1} d^{-1}) occurred more frequently following rainfall and where compost was applied at planting.

At NSAC, large amounts of N_2O were emitted from the forage and potato plots during a relatively wet growing season with cumulative emissions ranging from 1 to 80 kg N ha^{-1} over the monitoring period. There were no significant effects of previous crop, time of tillage or fertilization on N_2O emissions from potatoes. Figure 1 demonstrates the increased daily N_2O emissions from timothy fertilized with conventional fertilizer when compared with clover or unfertilized timothy. Cumulative N_2O emissions from forage crops were significantly increased as a result of the application of inorganic fertilizer (Table 1).

Table 1. Cumulative N_2O emissions from potato and forages as influenced by crop type, N fertilization and previous crop

Treatment Means	N_2O emissions* (kg N ha^{-1})	
Fertilized	14.3	A
Non-fertilized	4.0	B
Potato (prev. clover)	4.9	
Potato (prev. timothy)	8.1	
Clover	3.9	
Timothy	14.5	

*Means flowed by different letters are different at $p < 0.05$

The Bottom Line

Two studies in Atlantic Canada are examining the effect of (a) crop (red clover, timothy or potato), timing of tillage, and potato fertility regime, and (b) long term application of compost vs. inorganic N fertilizer, on crop productivity, N uptake and N_2O emissions.

Interim results indicate the organic system, relying on organic N sources and forages for biological N_2 fixation, emitted less nitrous oxide while maintaining acceptable yields of forage and potato crops compared with conventionally fertilized fields.

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