Can organic crop production be a N_2O mitigation strategy?

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Introduction:

Nitrous oxide (N_2O) is now the third most important greenhouse gas (GHG) due to its effect on global climate change. N_2O has 300x the global warming effect of CO_2.[3]

N_2O is naturally produced by the soil microbial community from two main processes; nitrification and denitrification.[3,4]

Factors determining N_2O release are soil available carbon, moisture, temperature and oxygen as well as texture and structure of the soil which has been seen to differ with different soil management practices.[2,3,4]

Agriculture is the major contributor of N_2O emissions to the atmosphere due to nitrogen (N) additions to the soil, primarily from the use of synthetic N sources applied before the crop can utilize large amounts of N.[2,3]

Many studies have been conducted on soil N_2O emissions from conventional fertilizer applications. The IPCC estimates that approximately 1% of applied fertilizer is lost as N_2O.[3] However this emissions factor contains few studies from organic cropping systems.

Perennial legumes (i.e. alfalfa) are used in organic systems to provide N and other nutrients to the soil for subsequent cash crops[5]. However, the amount of N_2O emitted from organic systems is not well understood.

Organic agriculture is one of the fastest growing sectors in agriculture with 695,000 acres of land under organic production with an estimated retail sales of $2 billion in Canada[1].

Organic wheat is Canada's major organic export which under organic rotations follows the plow down of alfalfa[1].

Accurate determination of N_2O from differing N fertilizer sources and different soil management practices can help aid in the development and evaluation of GHG inventories and mitigation strategies.

Objective:

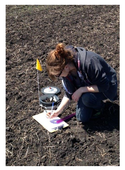
- To determine N_2O emissions from perennial alfalfa with emphasis on the plow down phase.
- To determine N20 emissions from organic wheat following alfalfa in an organic perennial rotation as well as conventional wheat and soybean in a grain-only rotation.

Methodology:

- Study site at the University of Manitoba's Glenlea Long-Term Organic Crop Rotation Study near Winnipeg, MB.
- Vented static chamber method.
- Soil and agronomic measures were also obtained using WET sensor.
- Gas chromatography for gas analysis for N_2O.

Table 1: Crop type and corresponding nitrogen (N) source.

Crop	N Source
Conventional Wheat	Urea (46-0-0) (101 kg/ha-N 2014 & 2015)
Conventional Soybean	Biological nitrogen fixation
Organic Wheat	2013 & 2014 fall plow down alfalfa
Organic Alfalfa	Biological nitrogen fixation & composted cattle manure (2014 only)



Results & Discussion: 2014-2015 Crop Year Daily Flux Data

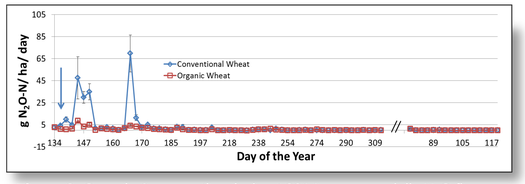


Figure 2: Organic & conventional wheat 2014 crop year daily N_2O flux. Error bars indicate standard error**. Blue solid arrow indicates date of fertilizer application.**

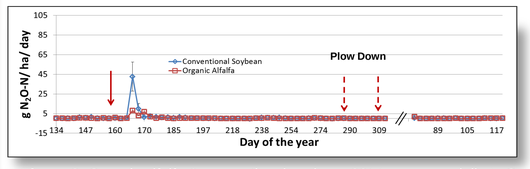


Figure 3: Organic alfalfa & conventional soybean 2014 crop year daily N_2O flux. Error bars indicate standard error. **Red solid red arrow indicates date of compost application & dashed arrows indicate date of alfalfa plow down.**

- Two N_2O emission episodes occurred in 2014 after urea application both following rain events.
- Largest flux was 68 g N_2O-N /ha in the conventional wheat on DOY 167 and 5 g N_2O-N /ha in the organic wheat on DOY 149.
- One N_2O emission episodes occurred in conventional soybean and organic alfalfa; 42 g N_2O-N /ha and 8 g N_2O-N /ha respectively.
- No emission episode occurred after alfalfa plow down or during spring thaw (DOY 70 – 118). Possibly due to low soil moisture conditions (Figure 7) .

Results: 2015 Growing Season Daily Flux

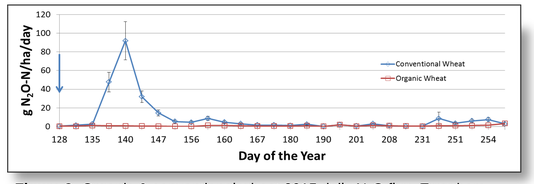


Figure 9: Organic & conventional wheat 2015 daily N_2O flux. Error bars indicate standard error. **Blue solid arrow indicates date of fertilizer application**.

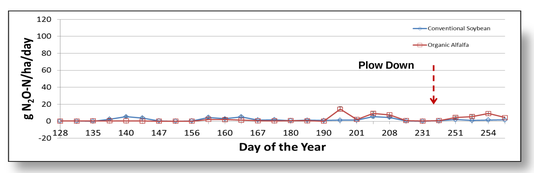


Figure 10: Organic alfalfa & conventional soybean 2015 daily N_2O flux. Error bars indicate standard error. **Red dashed arrow indicates date of alfalfa plow down.**

- One N_2O emission episode occurred in 2015 after urea fertilizer application in conventional wheat (DOY 135 – 160). The largest flux occurred on DOY 140 with 92 g N_2O-N /ha.
- No emission episode occurred in organic wheat through out 2015 growing season.
- Low N_2O emissions in both conventional soybean and organic alfalfa.
- Small N_2O emission episode occurred in organic alfalfa (14 g N_2O-N /ha) on DOY 198.
- Small emission episode (9 g N_2O-N /ha) after alfalfa plough down in 2015 possibly due to higher soil moisture content compared to the 2014 plough down (Figure 8 & 14)

Results: 2014-2015 Soil N and Water Conditions

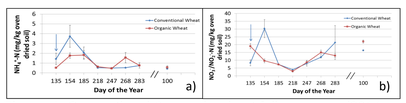


Figure 4: Conventional & organic wheat full crop year (2014-2015) soil NH_4^+ (a) & NO_3^-/NO_2^-(b) concentrations 0-15cm.

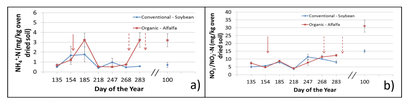


Figure 5: Conventional soybean & organic alfalfa full crop year (2014-2015) soil NH_4^+ (a) & NO_3^-/NO_2^-(b) concentrations 0-15cm. Dashed arrow indicates alfalfa plough down.

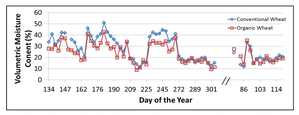


Figure 6: Soil VMC (0-5cm) in conventional & organic wheat for 2014 full crop year.

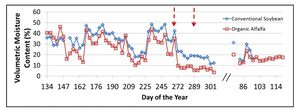


Figure 7: Soil VMC (0-5cm) in conventional soybean & organic alfalfa for 2014 full crop year.

Results: 2015 Soil N and Water Conditions

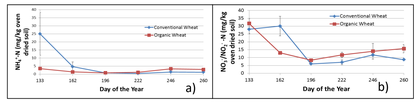


Figure 11: Conventional & organic wheat 2015 soil NH_4^+ (a) & NO_3^-/NO_2^-(b) concentrations 0-15cm.

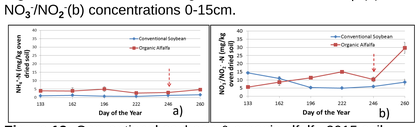


Figure 12: Conventional soybean & organic alfalfa 2015 soil NH_4^+ (a) & NO_3^-/NO_2^-(b) concentrations 0-15cm. Dashed arrow indicates alfalfa plough down

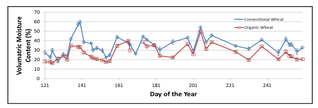


Figure 13: Soil VMC (0-5cm) in conventional & organic wheat for 2015.

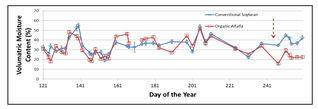


Figure 14: Soil VMC (0-5cm) in conventional soybean & organic alfalfa for 2015

Results: Cumulative and Yield Scale Emissions

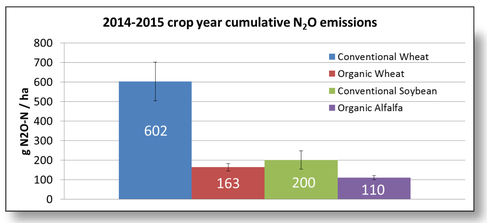


Figure 9: Organic & conventional wheat, organic alfalfa & conventional soybean 2014 crop year cumulative N_2O emissions. Error bars indicate standard error.

- Cumulative emissions calculated by linear interpolation.
- Conventional wheat and soybean had greater cumulative emissions than both organic wheat & organic alfalfa.

Table 2: 2014 average spring wheat yield, protein content (%), and yield scaled emissions for conventional and organic cropping systems.

Management	Yield (kg/ha)	Protein Content (%)	Yield Scaled Emissions (g N_2O-N kg grain $^{-1}$)
Conventional	3488	14.5	172
Organic	2450	13	66

- Grain protein was above 13% in both conventional and organic wheat therefore both crop would receive highest economic return; however organic wheat had 30% lower yields. Economically price premiums received in organic production may offset this yield loss.

Conclusions:

- The use of alfalfa as a N source in organic cropping systems emitted less N_2O than the conventional urea fertilizer.
- Wheat yields in organic cropping system were approximately 30% lower; however yield scale emissions were half that of conventional wheat yield scale emissions.
- Higher N_2O emissions in the fertilized treatments were attributed to higher amounts of available inorganic N early in the growing season in the conventional plots.
- Higher N_2O emissions in the 2015 plough down alfalfa crop compared with the 2014 alfalfa crop were attributed to greater soil moisture content in 2015.
- The use of alfalfa in organic cropping systems could be used as a N_2O mitigation strategy however further research is needed to increase yields in organic systems.

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NSERC CRSNG

Western Grains Research Foundation

Agriculture and Agri-Food Canada

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