Manure Management to Reduce Greenhouse Gas and Ammonia Emissions

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Study 1:
Manure Management to Reduce Greenhouse Gas and Ammonia Emissions

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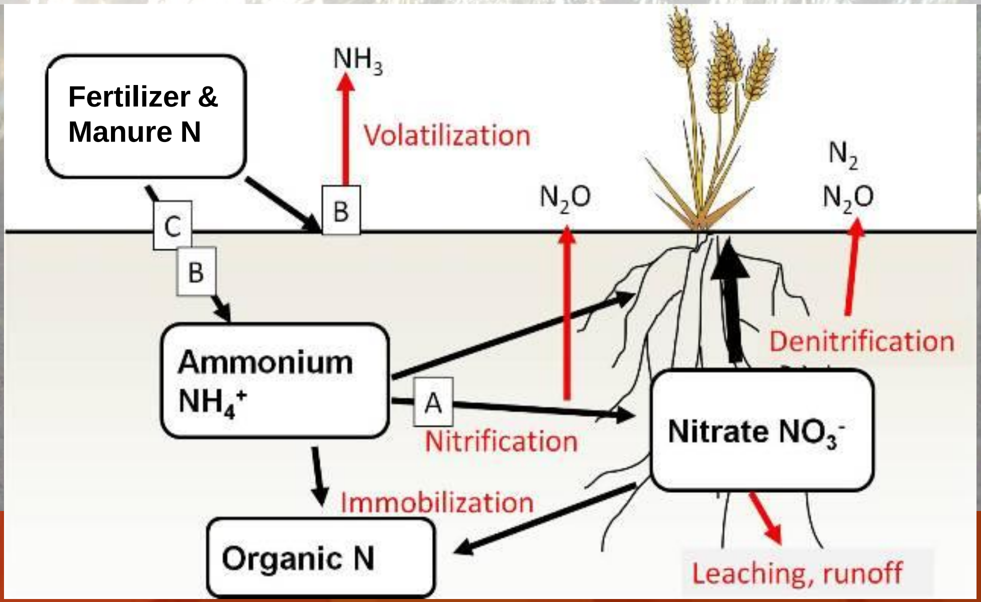
Claudia Wagner-Riddle

Manure Management

- Livestock manure is a significant source of crop nutrients.
- Agriculture Operations Practice Acts (AOPA) sets nitrogen based application guidelines and time limits for incorporation.
- Air Quality (Clean Air Strategy) and Water Quality
- 4R Nutrient Stewardship:
  Right Source @ Right Rate, Right Time, Right Place,
- Nitrous oxide Emission Reduction Protocol (NERP)
  Alberta Carbon Offset Market

Nitrogen Losses

- N-Cycle is open ended with many pathways for inputs and losses; controls can be difficult.
- Several reactive N forms (NH_3, NH_4^+, NO_x, HNO_3, NO_3, N_2O and organic N forms)
- Potential loss mechanisms include: volatilization, leaching, runoff and denitification.



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N_2O and NH_3 Concerns

- **N_2O is a significant greenhouse gas**
  - **GWP: 296 – 310 times greater than CO_2**
  - **Ozone depleting agent**
- **NH_3 volatilization decreases nutrient value of manure, contributes to soil acidification and eutrophication, and combines with nitric acid to form airborne nitrate particles that have serious effects on human health.**
- **Indicator of inefficiencies in N recovery from soil, fertilizer and manure sources.**
- **Pervious work indicated potential trade-offs between NH_3 and N_2O emissions depending on placement.**

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Project Objective

- Determine the impact of liquid dairy manure management based on 4R Nutrient Stewardship to mitigate N_2O and NH_3 emissions.

- Identify management options to mitigate N_2O and NH_3 emissions
  - Source
  - Placement
  - Timing
  - Rate

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Research Design

- Manual static chambers were used to quantify N_2O and NH_3 emissions for a series of liquid dairy manure field applications at two agriculture field sites:
  - Ellerslie U of A Experimental Farm
  - Lacombe AAFC Research Farm
- Field treatments: timing (fall vs spring), placement (surface broadcast vs injected), rates (1X and 2x), plus 2 check treatments (undisturbed and disturbed).
- Application rates 1X = 5,000 Imp gal/ac (56,000 L/ha)
  2X = 10,000 Imp gal/ac (112,000 L/ha)
- A split plot design with 4 replications.
- Dairy manure from a local source was used at each site.
- Crop grown was barley silage.

Research Design






Sampling Equipment & Protocol

- **N_2O Gas Sampling**
  - Plexiglas vented chambers (0.1 m^2 soil surface area and 10-L headspace volume); 20 ml syringes and # 20 needles; 10 ml evacuated exetainers (stored in a Cooler)
  - Sampling using time step method - 15, 30 and 45 minutes after placing cover on chamber; ambient air samples are considered as time 0
- **Lab Analysis**
  - Gas Chromatograph (Varian 3800 with ECD)
- **Sampling Schedule**
  - Fall to harvest (October – July) – fall and spring manure application
- **Sampling Frequency**
  - Weekly and/or high moisture events
- **Data Processing**
  - Excel spreadsheet calculator - Dr Richard Farrell (U of S)
  - Calculator tests both linear and quadratic models

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Sampling Equipment & Protocol

➢ **NH_3 Gas Sampling**

- vented chamber method consisting of a white PVC tube 20 cm long and 15 cm in diameter inserted in the soil to a depth of 3 to 5 cm.
- A foam disk impregnated in an acid solution is inserted inside the chamber to absorb NH_3-N evolved from the soil; a scrubber foam disc closes the top of the chamber to allow for exchange of air between the chamber and the surroundings while scrubbing any NH_3-N generated outside the chamber

➢ **Lab Analysis**

- 0.5 M KCl solution is used to extract NH_4-N from the foam disk for laboratory analysis.

➢ **Sampling Schedule**

- Ammonia losses were measured for 2 weeks after fall and spring manure application,

➢ **Sampling Frequency**

- Day 1, 2, 4, 8, 16

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Soil and Manure Nitrogen Summary

	Soil Test (0-90 cm)		Manure 1X		Manure 2X	
	NH_4-N	NO_3-N	Total NH_4	Total N	Total NH_4	Total N
	kg ha^{-1}	kg ha^{-1}	kg ha^{-1}	kg ha^{-1}	kg ha^{-1}	kg ha^{-1}
Ellerslie						
Fall 2013	38	37	143	268	287	537
Spring 2014	52	60	140	275	280	551
Lacombe						
Fall 2013	34	50	80	160	160	320
Spring 2014	51	74	71	127	141	254

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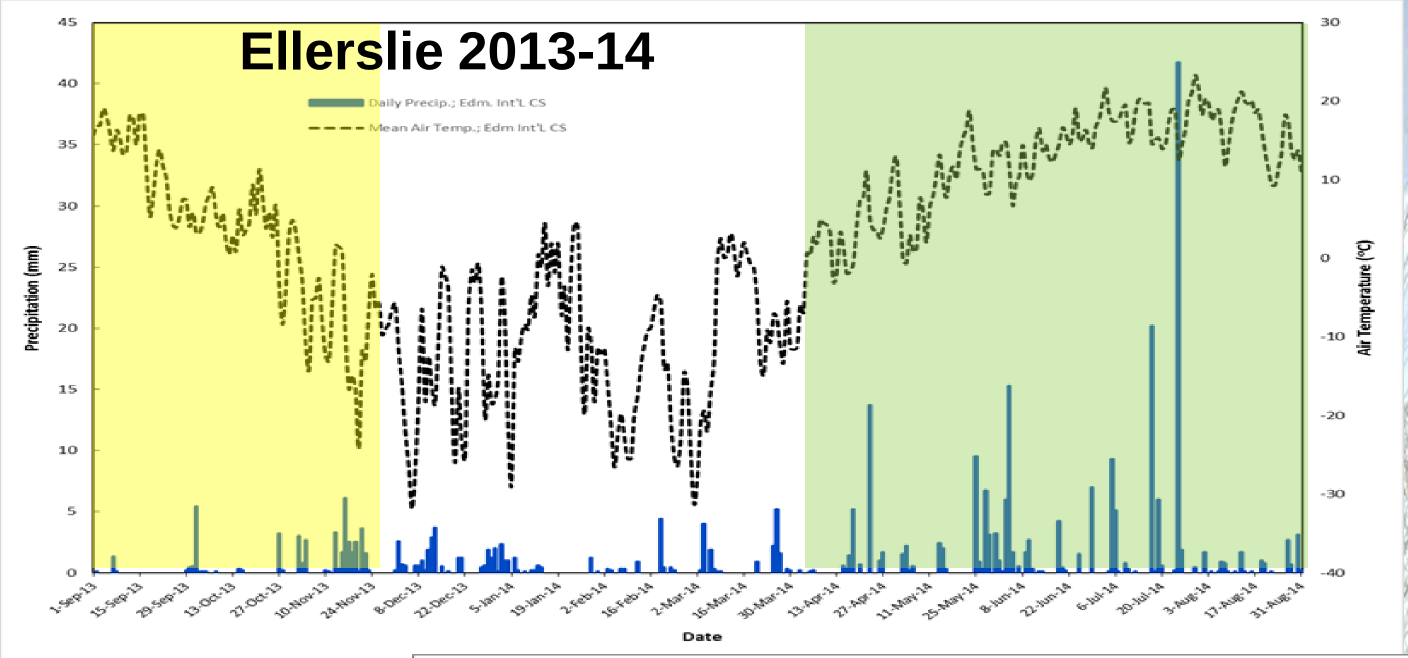
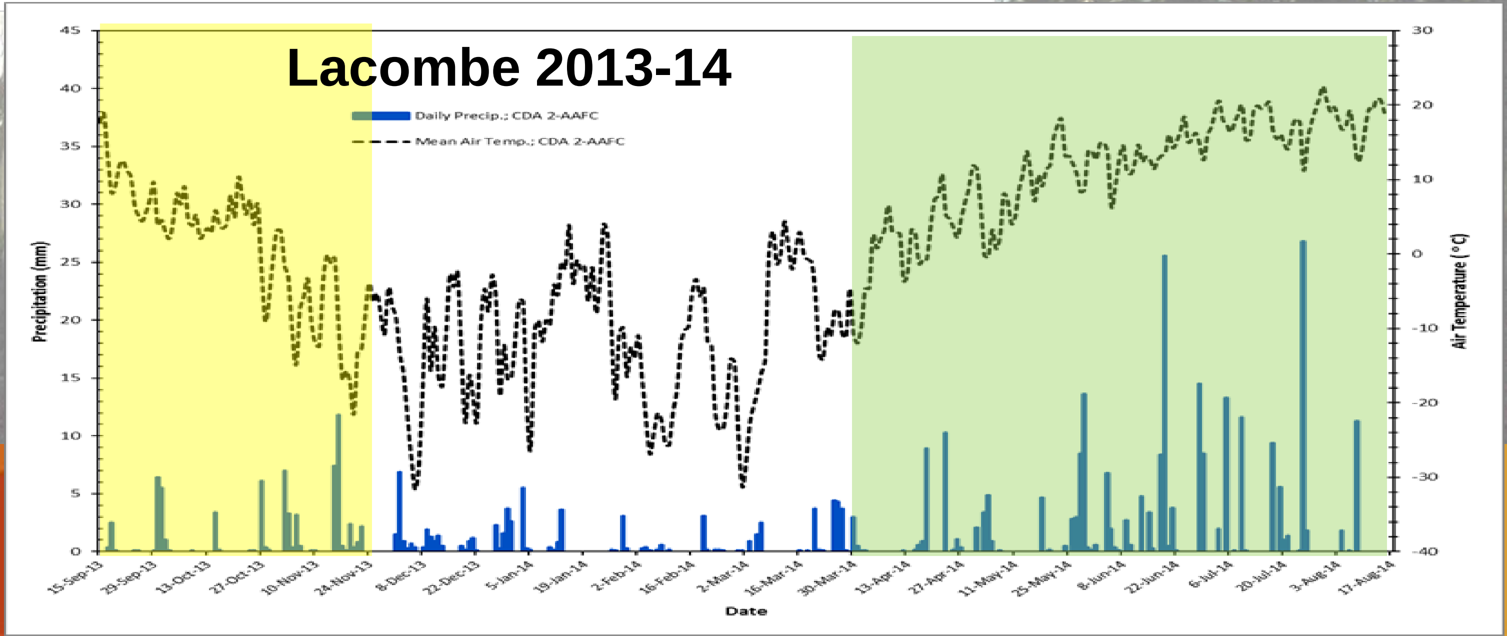
Meteorological Summary

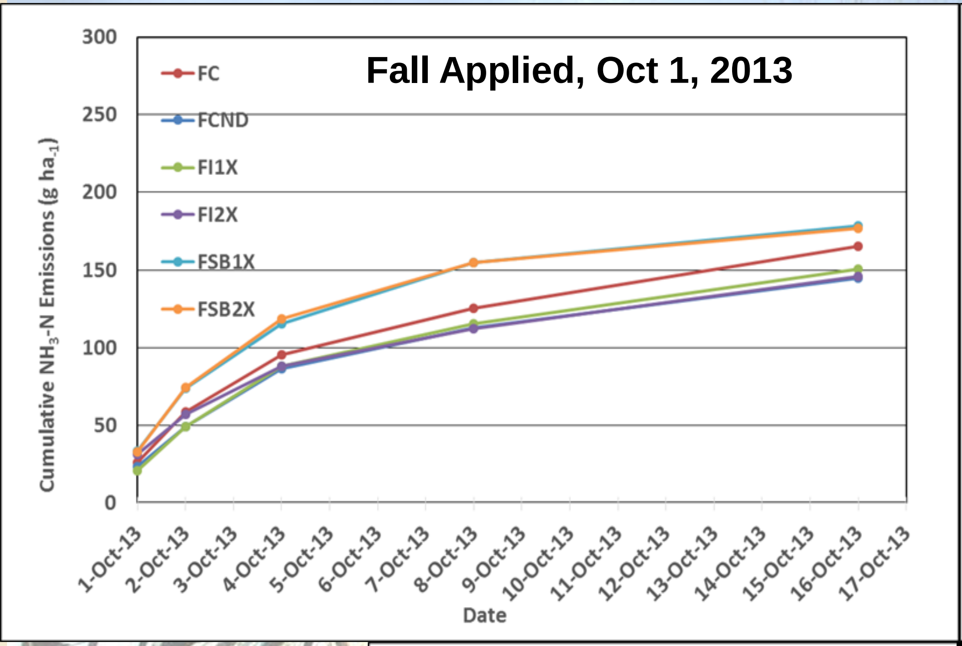


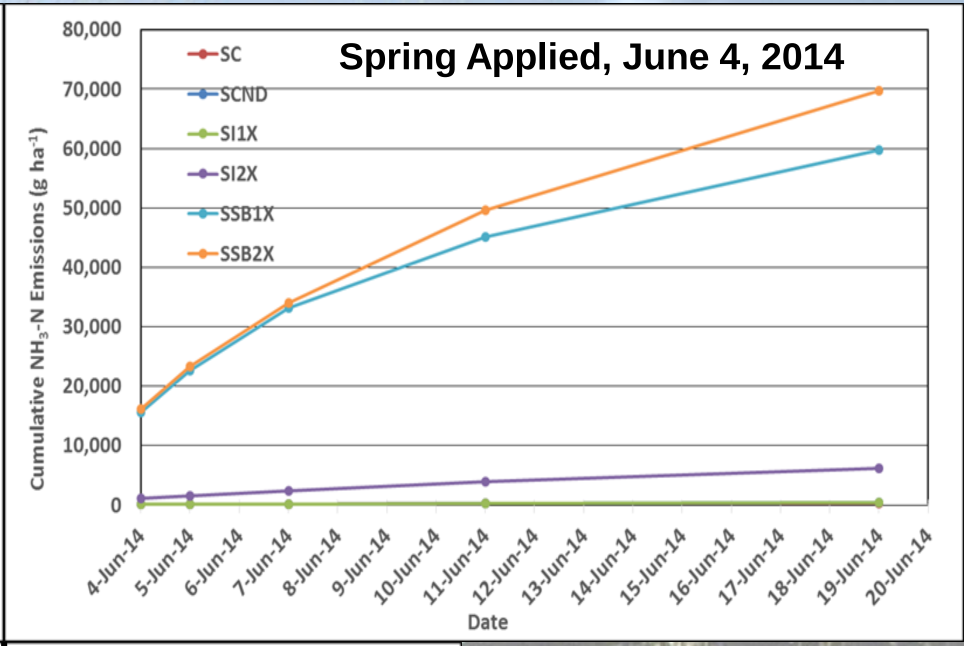


Precipitation Summary

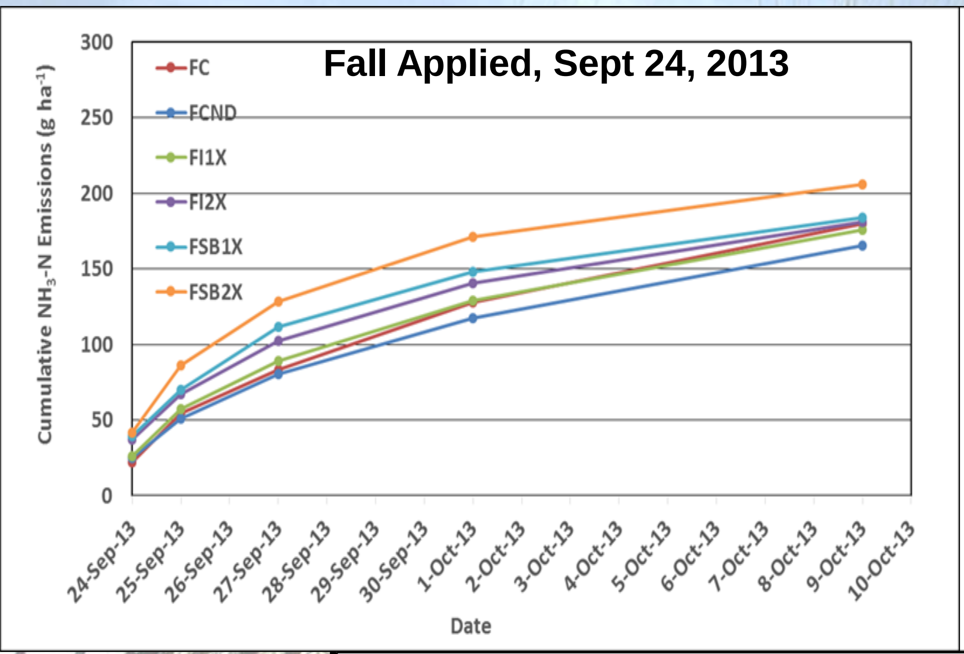
Experiment	Site	Time Period	Total Precipitation (mm)	Long-Term Normal Precipitation (mm)	Precipitation as % of Long-Term Normal
4	Ellerslie	Sept 2013 – Dec 2013	66.8	95.0	70.3
		Jan 2014 – Aug 2014	277.1	354.7	78.1
5	Lacombe	Sept 2013 – Dec 2013	104.3	88.6	117.7
		Jan 2014 – Aug 2014	283.3	350.7	80.8

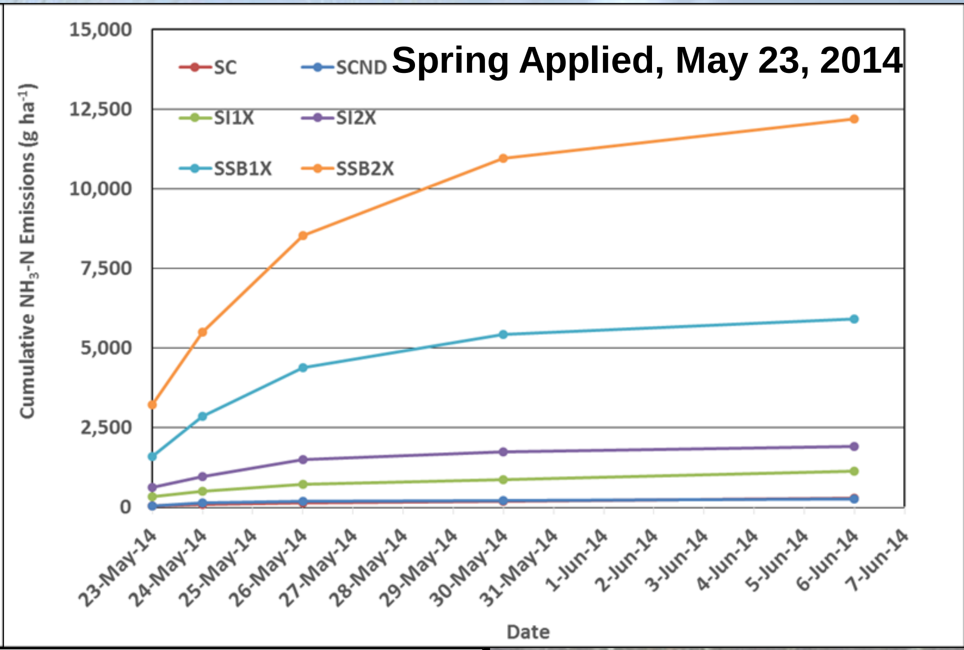
NH_3 Emission Results Ellerslie, 2013-14

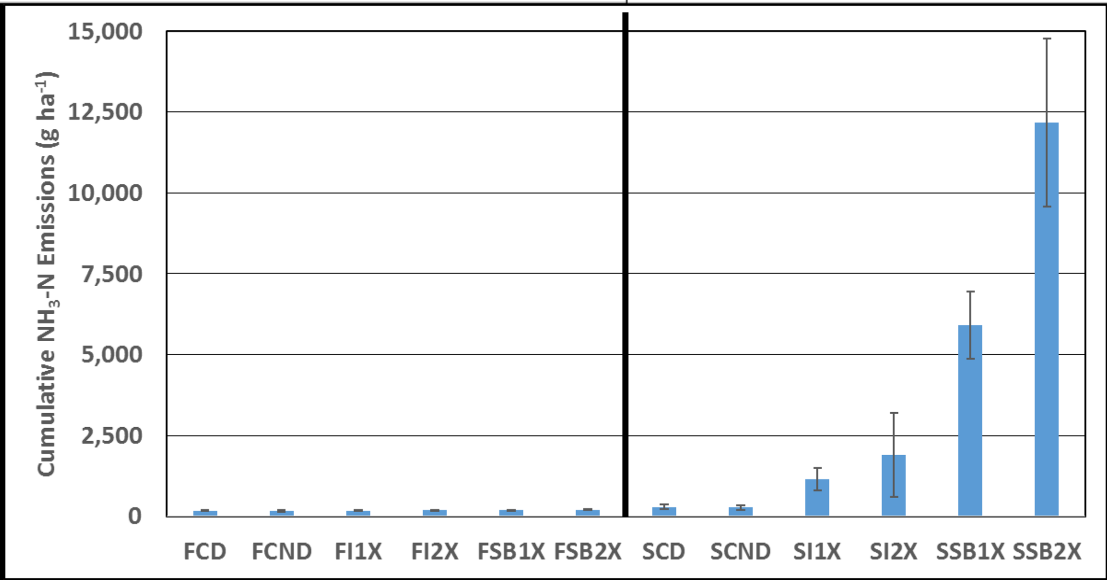




NH_3 Emission Results Lacombe, 2013-14







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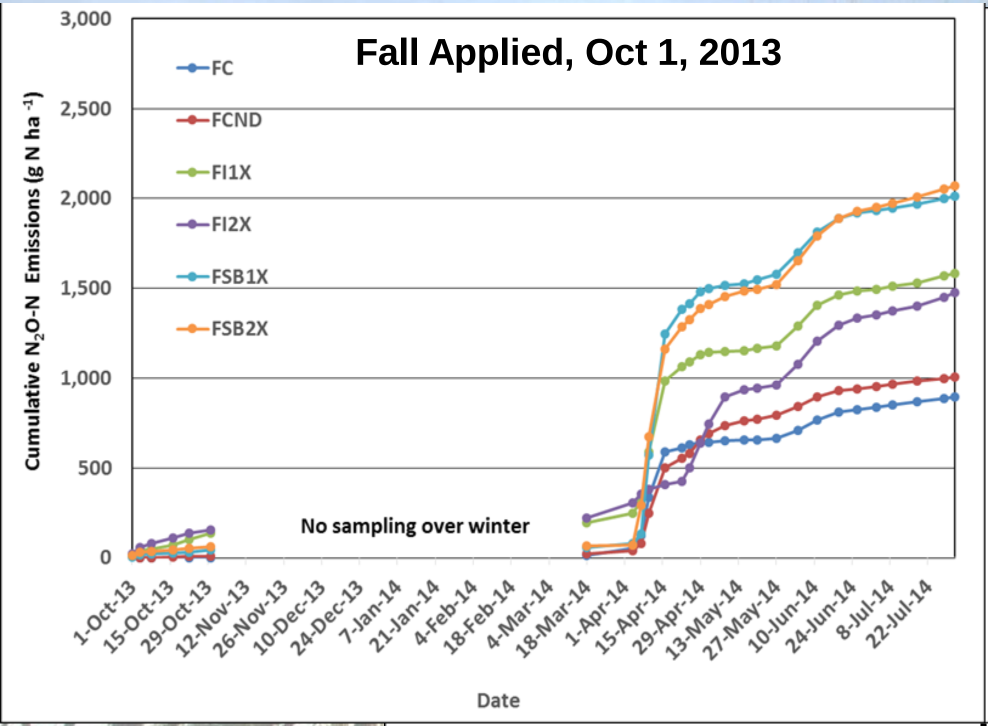
NH_3 Emission Summary

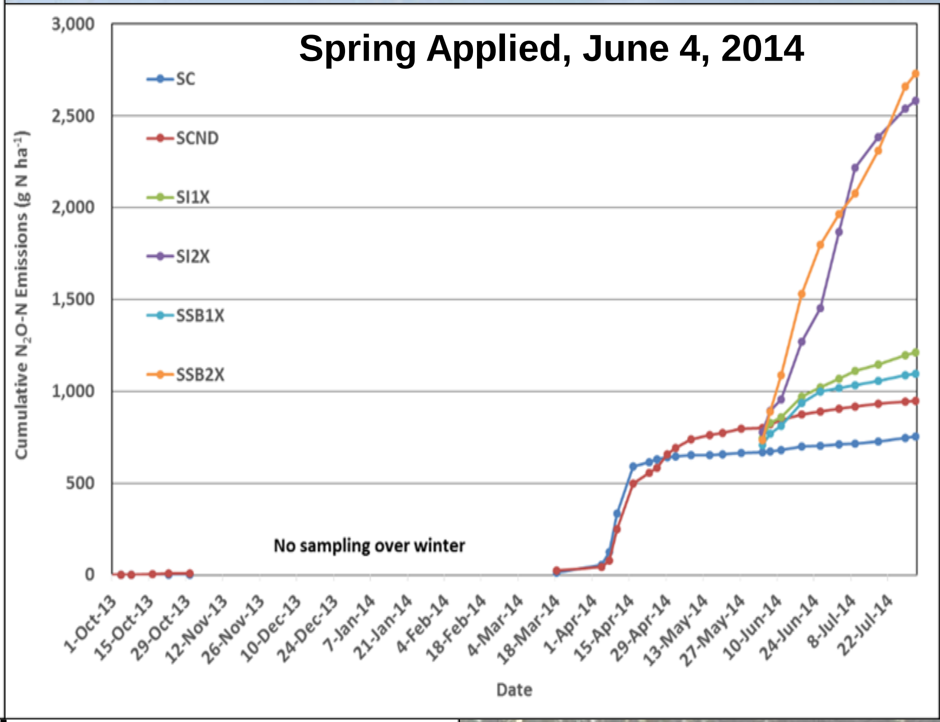
- Fall application for both sites resulted in lower NH_3 than spring application for all placements and rates

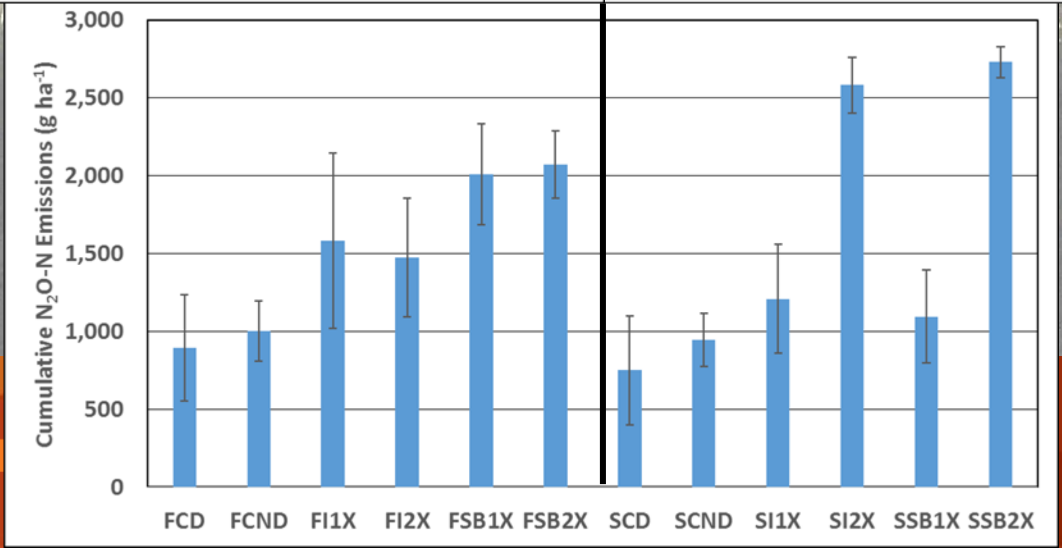
- Spring application NH_3 emissions was greatest for Surface Banding application with increasing emissions with increasing rate of manure application and increasing N content of manure.

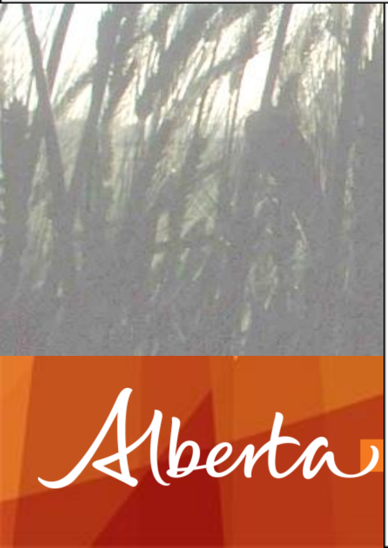
- Source differences characterized by nitrogen content was an important influence on NH_3 emissions. Higher N content resulted in greater NH_3 emissions especially for Surface Banded application.

N_2O Emission Results: Ellerslie, 2013-14

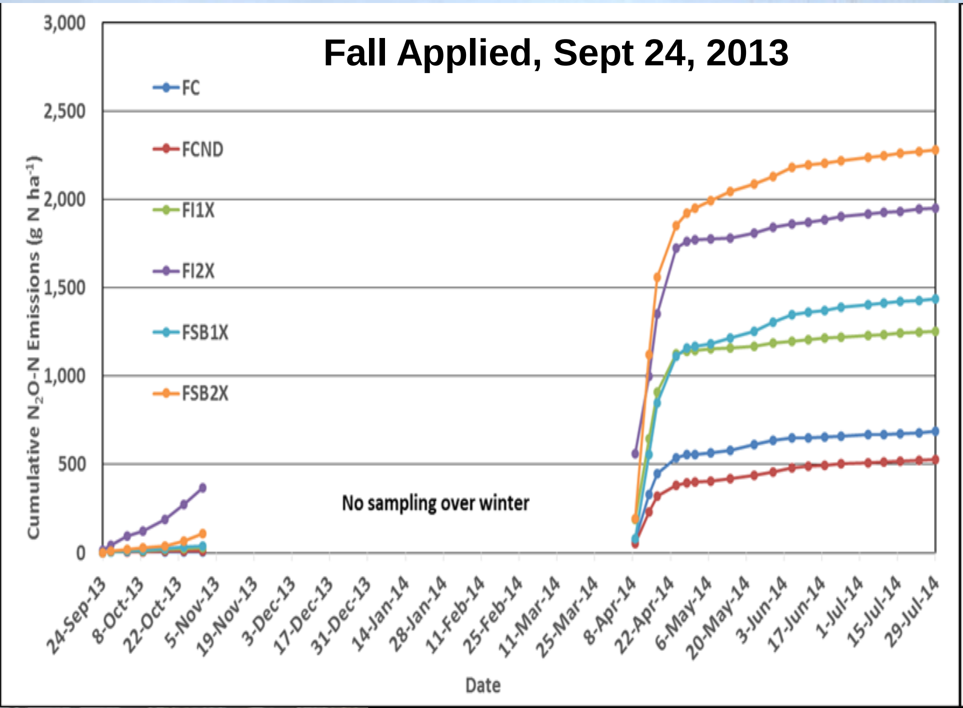


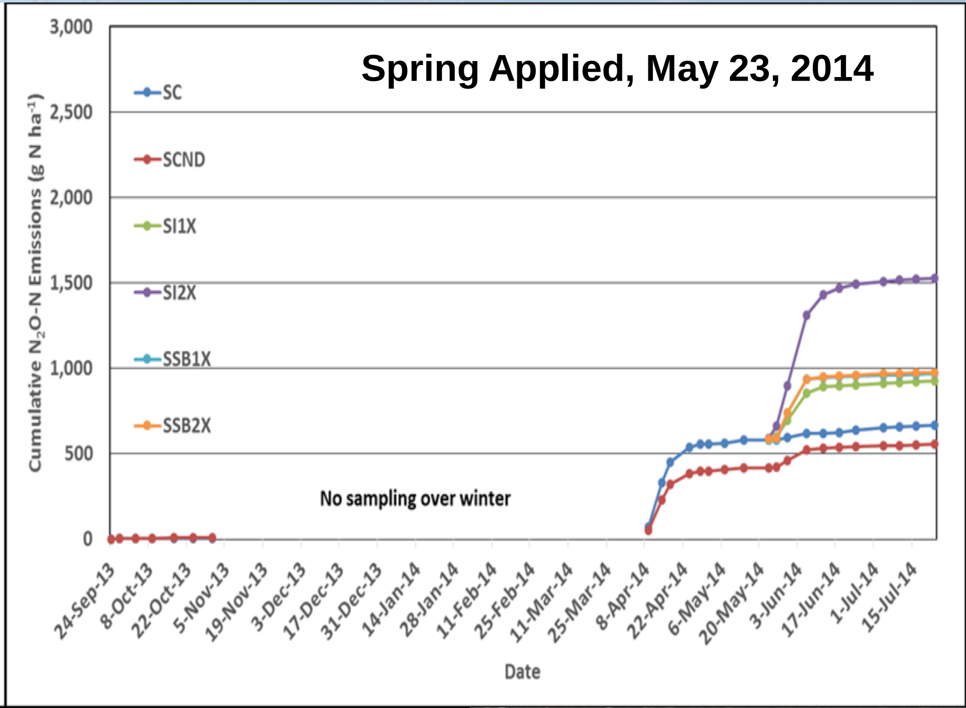


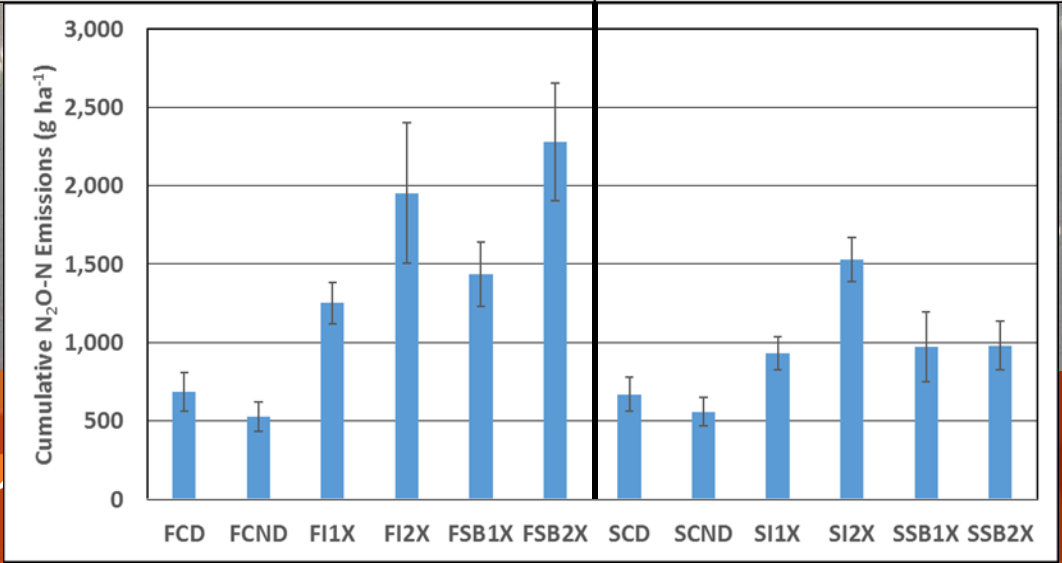




N_2O Emission Results: Lacombe, 2013-14







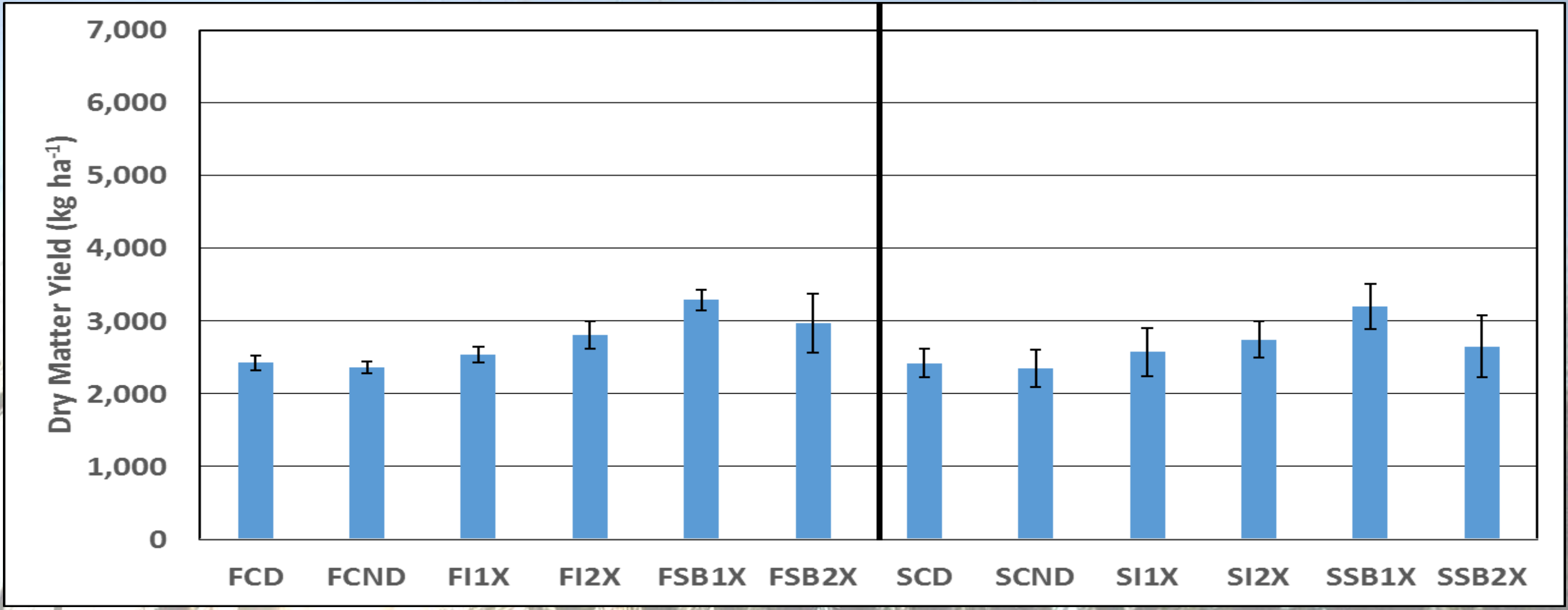
N_2O Emission Summary

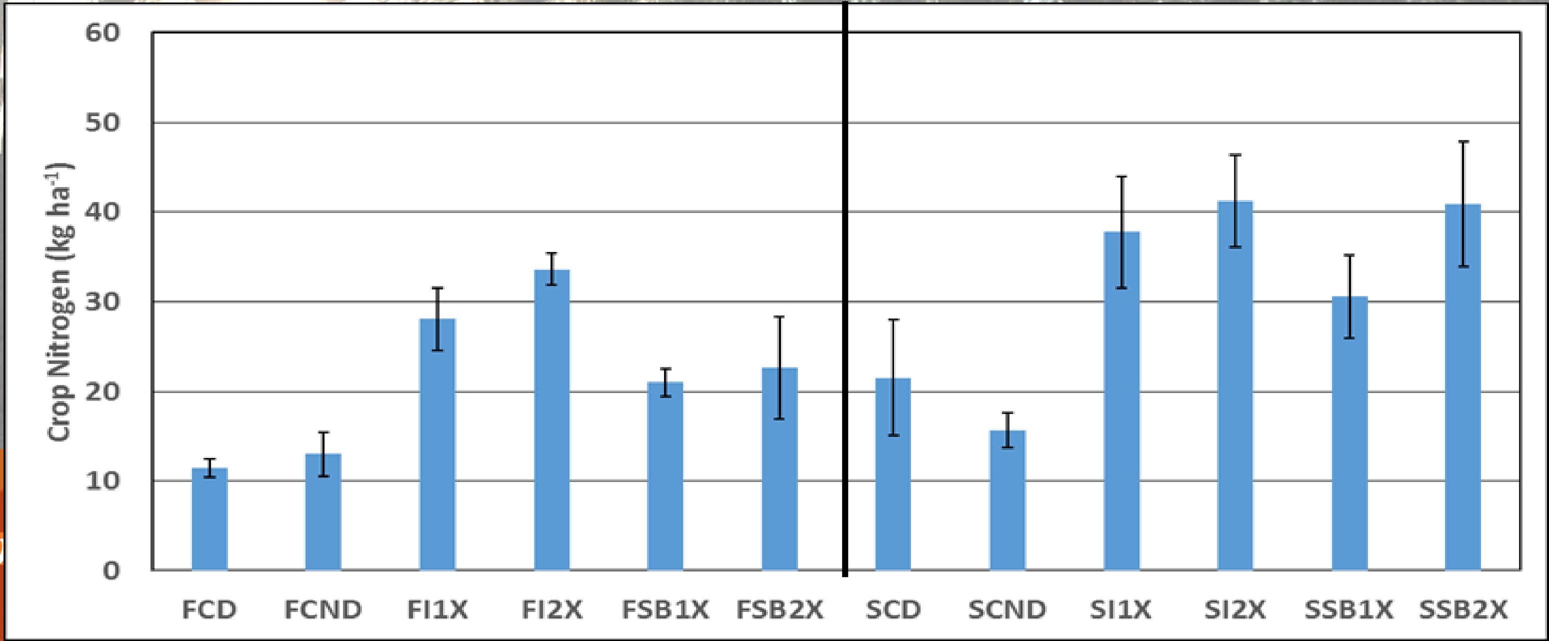
- Greater variability for N_2O emissions

- For Ellerslie:
  - For fall application, Surface Banding greater N_2O emissions than Injected.
  - For spring application, the rate of manure application was the greatest factor

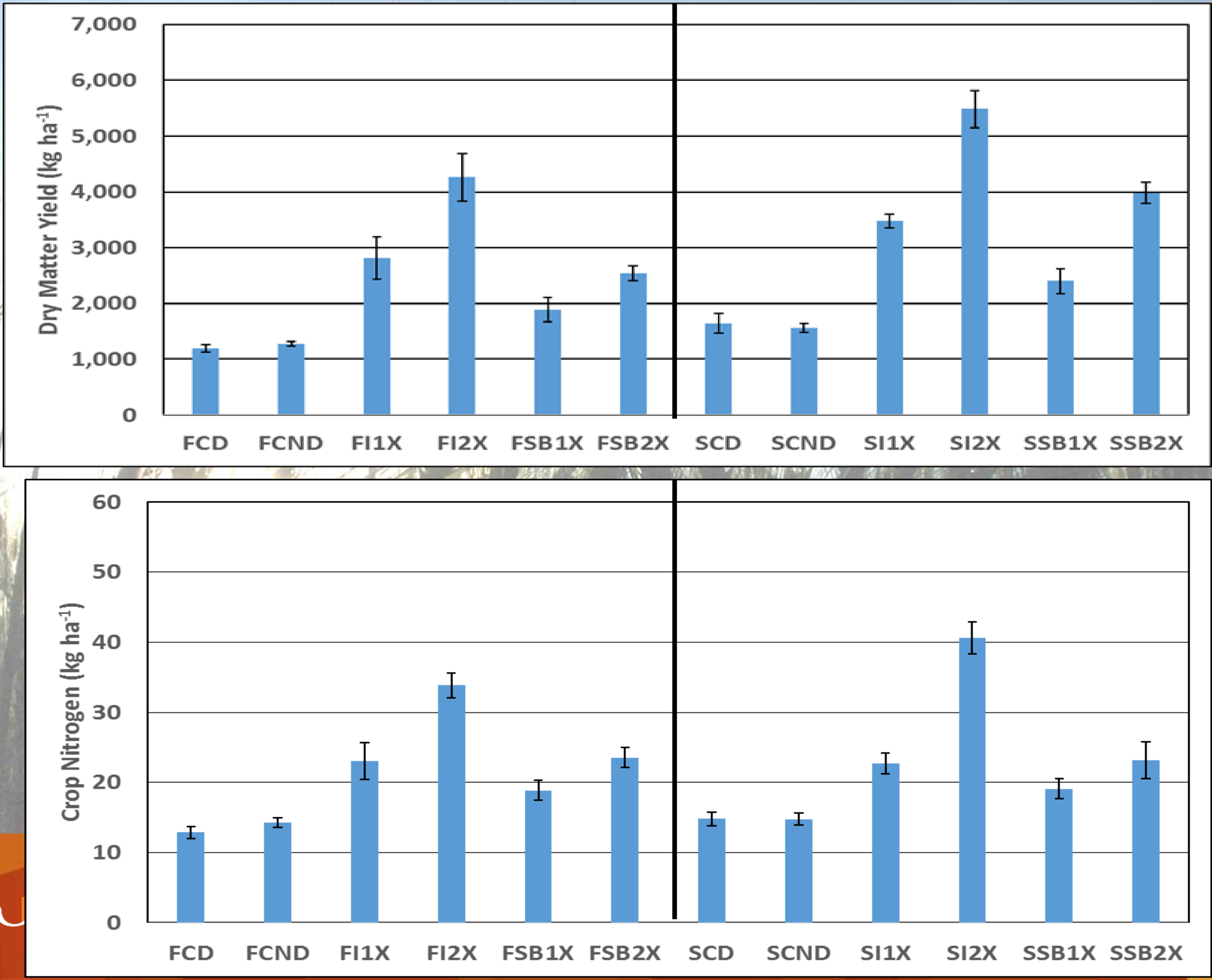
- For Lacombe:
  - For fall application, the rate of manure application was the greatest factor – Higher rate higher emissions.
  - For spring application, Injection increased N_2O emissions

Agronomic Results - Ellerslie





Agronomic Results - Lacombe



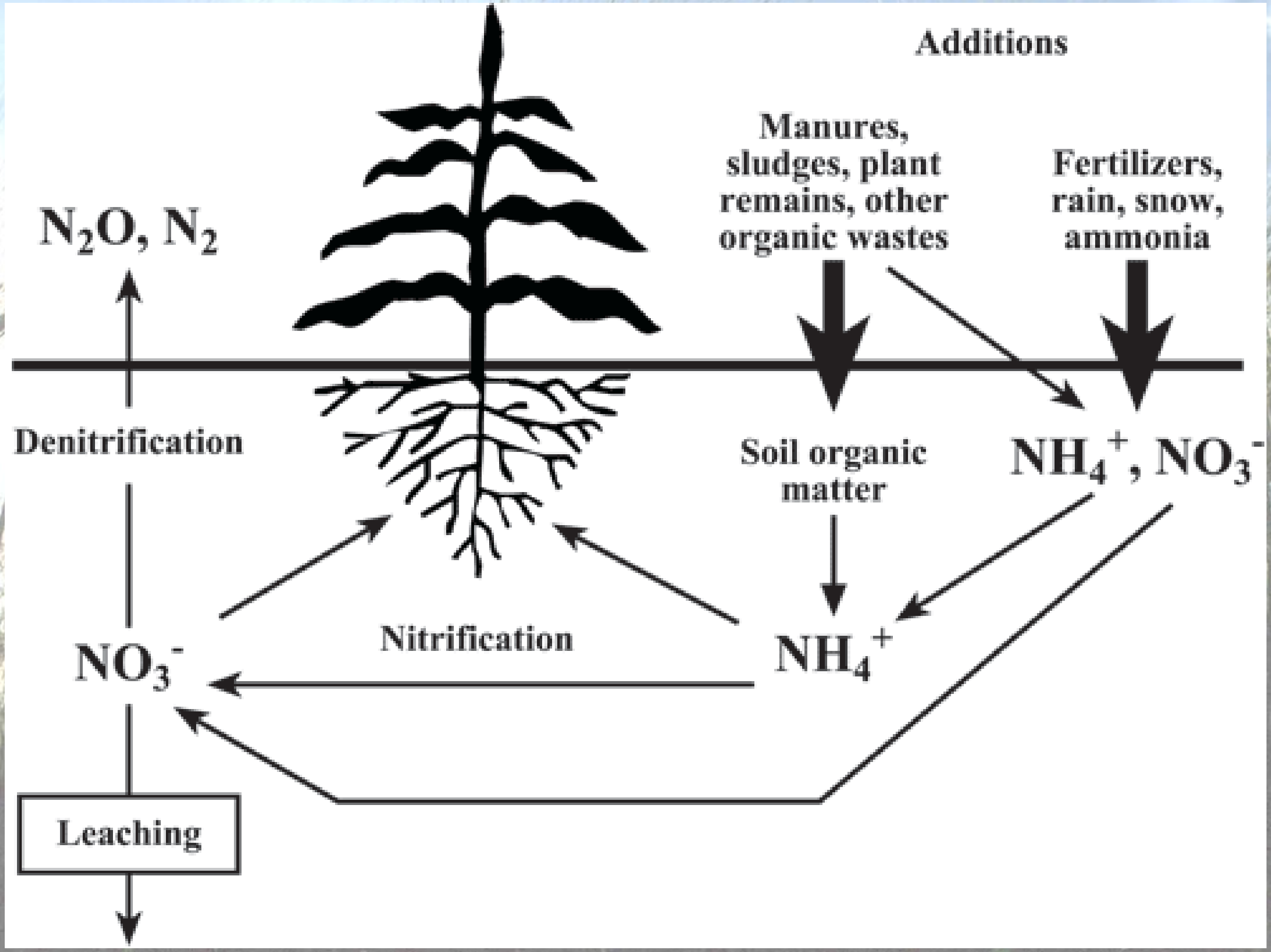
Agronomic Summary

- Crop yield response
  - Lacombe > Ellerslie – pptn
  - Ellerslie's slightly drier conditions resulted in no significant differences in crop yield among manure treatments.
  - Lacombe had significant yield differences among manure treatments; spring > fall, Injected > surface banding; 2X > 1X rate
- Crop nitrogen
  - Ellerslie > Lacombe – manure nitrogen content
  - Ellerslie had significant crop N differences among some manure treatments, spring > fall.
  - Lacombe had significant crop N differences due to primarily manure application rate 2X > 1X.

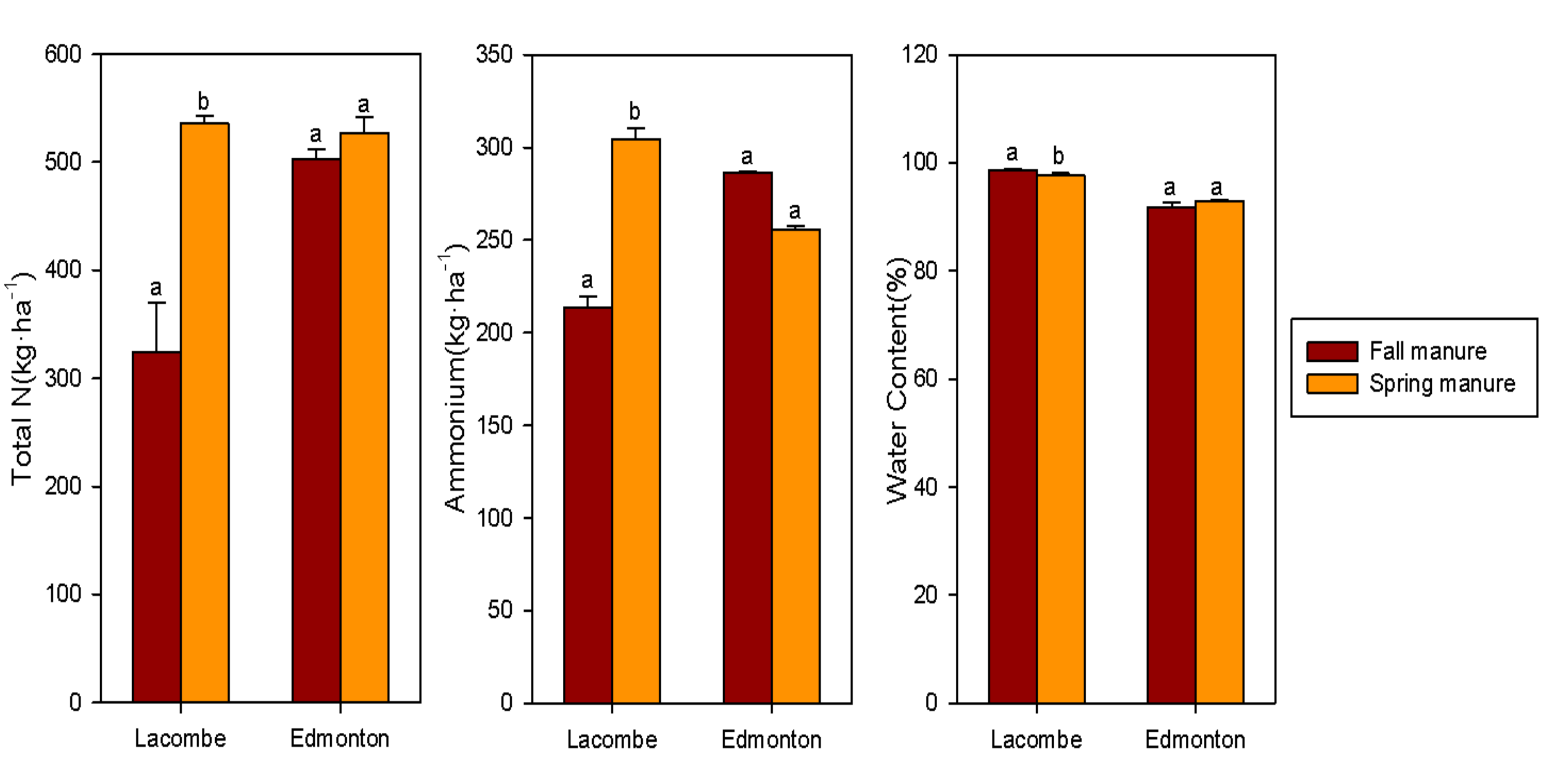
Study 2: Nitrous Oxide Emission Reduction as a Function of Timing of Liquid Manure Injection and Use of Nitrification Inhibitors

Sisi Lin, Guillermo Hernandez Ramirez, Len Kryzanowski, Trevor Wallace, Robert Grant, Rory Degenhardt, Nils Berger, Craig Sprout , Germar Lohstraeter, Leigh-Anne Powers

How Nitrification Inhibitors Reduce Nitrous Oxide Emissions



Manure Application



Manure and Inhibitor Application

Manure:
Swine in Lacombe,
Dairy in Edmonton

Manure application rate: 6600 gal/ac = 74,100 L/ha

Nitrification Inhibitors:
Nitrapyrin (N-Serve) and
DMPP (ENTEC®)
(0.5 kg active ingredient/ha)

These compounds suppress microbial activity for a few days to weeks depending on soil moisture and soil type

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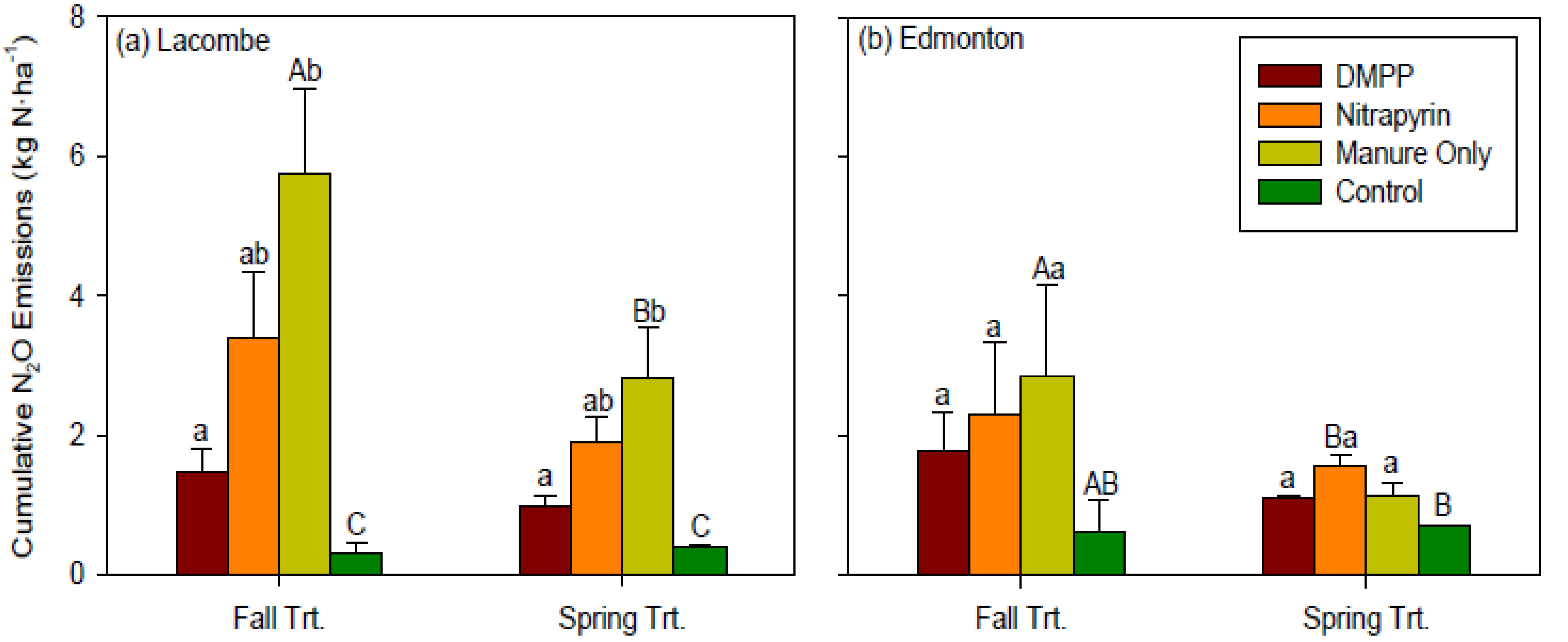
Nitrification Inhibitors to Reduce Nitrous Oxide Emissions



Note: Error bars correspond to standard error. Different letters indicate significant differences between treatments (α=0.05). Different capital letters indicate significant differences between manure injection timing. Different lowercase letters indicate significant differences between additive treatments.

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Inhibitor Summary

- Nitrification inhibitors in fall and spring manure treatments in Lacombe reduced the N_2O emissions by 59.7% and 55.3% respectively compared to manure only treatment.
- Nitrification inhibitors in fall manure treatments in Edmonton appeared to reduce the N_2O emissions by 30.5% compared to the treatment with manure only. Differing response in spring treatments could be due to drier weather condition.
- When applied at the same active ingredient rate, DMPP seemed to be more effective than nitrapyrin as an inhibitor.
- Fall treatments showed higher N_2O emissions at beginning of subsequent spring following snow-melt and soil thawing.
- Need economic analysis.

Key Messages

- 4R Nutrient Stewardship for livestock manure management can help influence N_2O and NH_3 emissions mitigation. There are significant benefits and co-benefits, but also costs, trade-offs and unintended consequences that need to be recognized.
- Environmental conditions (soil moisture and temperature) have a significant impact on losses, crop yield and N uptake.
- Liquid manure application rate not only influences the amount of N applied, but also the amount of water applied. Higher manure rates will increase the soil saturation zone along with the higher N applied and influence losses.
- Nitrification inhibitors have potential to reduce N_2O emissions.
- Limiting N emission losses from farming operations can have environmental, agronomic and economic benefits.

Thank You

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