Influence of Tillage, Crop Residue, Controlled-Release N Fertilizer and Liquid Swine Manure Management on Greenhouse Gas Emissions in Saskatchewan, Canada

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Tillage and Straw Management Experiment

Background

- Long-term return of crop residues to soil and elimination of tillage (ZT) increases organic C and N in soil. This may also increase the potential for greenhouse gas (GHG) emissions.

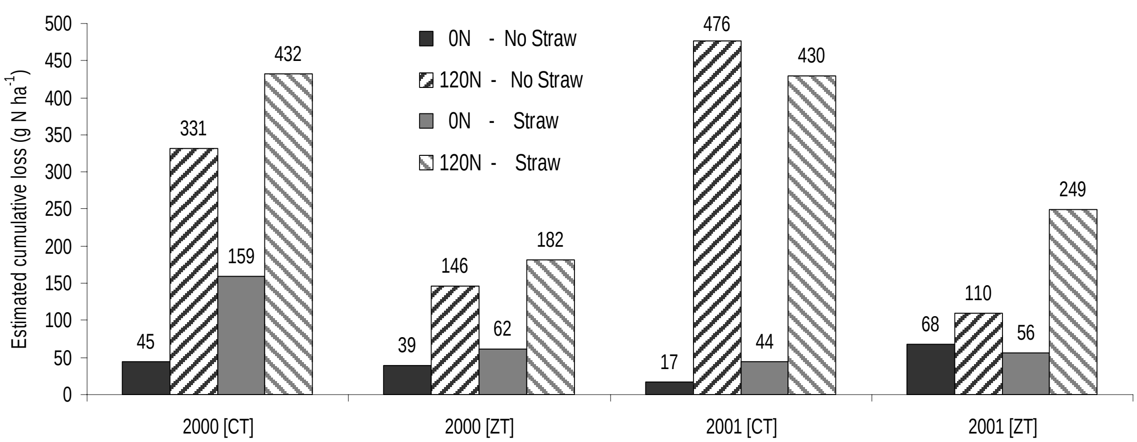
Materials and Methods

✓ An 8-year barley-pea-wheat-canola rotation experiment was established in 1998 at Star City (Gray Luvisol – Boralf).

✓ Treatments were **two tillage systems** (zero tillage, ZT and conventional tillage, CT), **two levels of straw** (straw retained, and straw removed) and **four levels of N fertilizer** (0, 40, 80 and 120 kg N ha^{-1}; no N to pea).

Summary of Results

- The N_20 emissions were higher in treatments receiving N fertilizer than the zero-N treatments.
- The N_20 emissions were substantially higher in CT plots than ZT where fertilizer N was applied.



Estimated cumulative N_2O-N loss for various treatments during the period March 28 to June 5, 2000 and April 23 to August 9 2001 at Star City, Saskatchewan.

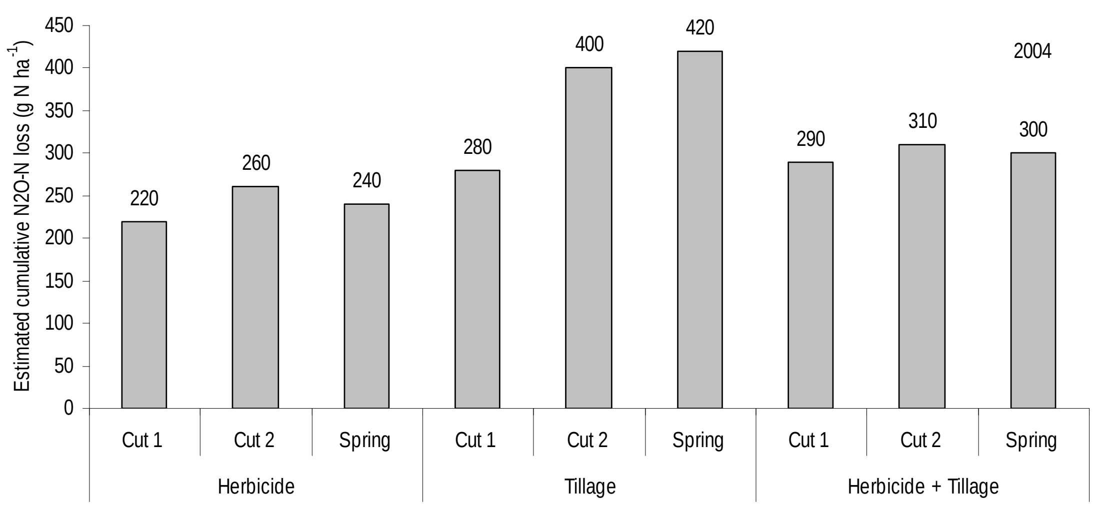
Alfalfa Termination Method and Timing

Materials and Methods

- ✓ Stand termination treatments were initiated on a 7-yr old alfalfa stand in summer 2003 at Star City (Gray Luvisol - Boralf) in a 5-yr study.
- ✓ The 36 treatments were **3 x 3 x 4 factorial** combinations of **3 methods of termination** (herbicide – NT, tillage and herbicide + tillage), **3 times of termination** (after first cut, after second cut and spring) and **4 rates of N** (0, 40, 80 and 120 kg N ha^{-1}).
- ✓ Herbicides used were Lontrel + 2,4-D and Glyphosate + 2,4-D.

Summary of Results

- Mean cumulative N_2O loss ranged from 220 to 420 g N ha^{-1} in 2004 (first growing season), and 330 to 730 g N ha^{-1} in 2005.
- In 2004, N_2O loss tended to be lower with termination after cut 1 than the other termination times, and emissions from stands terminated by tillage were significantly higher than those terminated by herbicides.
- In 2005, N_2O loss was highest from the herbicide treatments and lowest from the tilled treatments.
- When 2004 and 2005 cumulative losses were combined, cumulative loss was very similar across the termination methods.



Estimated cumulative N_2O-N emissions in the zero-N treatment for 3 termination methods and 3 termination times in 2004 at Star City, Saskatchewan.

Slow Release N Fertilizers

Background

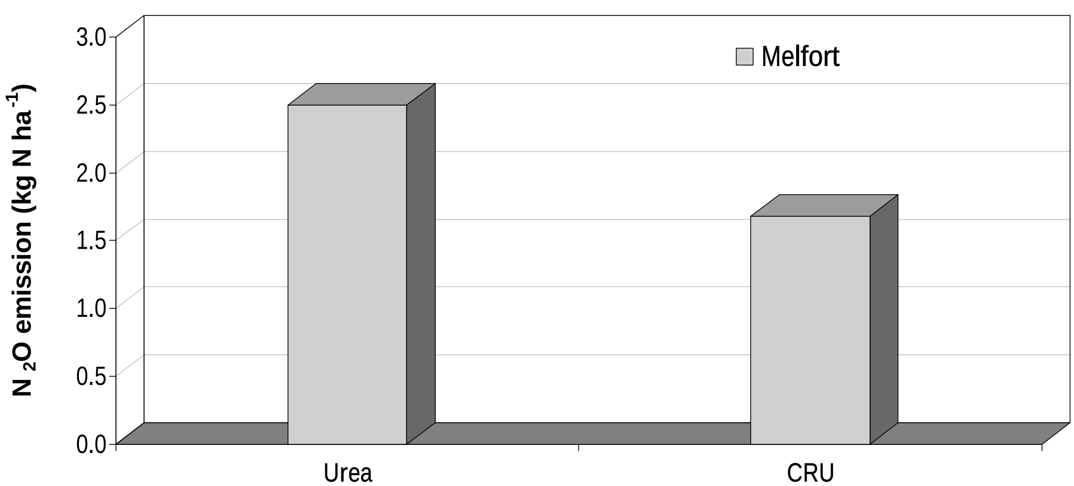
- N losses occur due to volatilization, leaching and **denitrification.**
- Production of ammonium and **nitrate** well in advance of crop demand can contribute to accelerated losses.
- N losses can be **reduced** by **matching supply** of available N closely to crop uptake by using slow release N fertilizers.

Materials and Methods

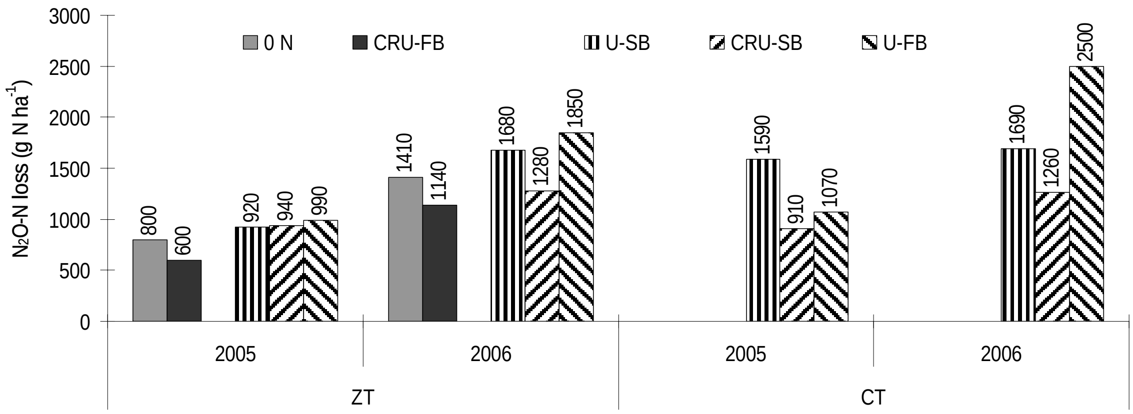
1. Control (0 N); **2.** Urea @ 30 kg N ha^{-1} SB in spring; **3.** Urea @ 60 kg N ha^{-1} SB in spring; **4.** Urea @ 90 kg N ha^{-1} SB in spring; **5.** CRU @ 30 kg N ha^{-1} SB in spring; **6.** CRU @ 60 kg N ha^{-1} SB in spring; **7.** CRU banded @ 60 kg N ha^{-1} in fall; **8.** Urea banded @ 60 kg N ha^{-1} in fall; **9.** Urea split @ 30 kg N ha^{-1} SB at seeding + 30 kg N ha^{-1} broadcast at tillering; and **10.** Blend application banded in spring @ 30 kg N ha^{-1} urea + 30 kg N ha^{-1} CRU.

Summary of Results

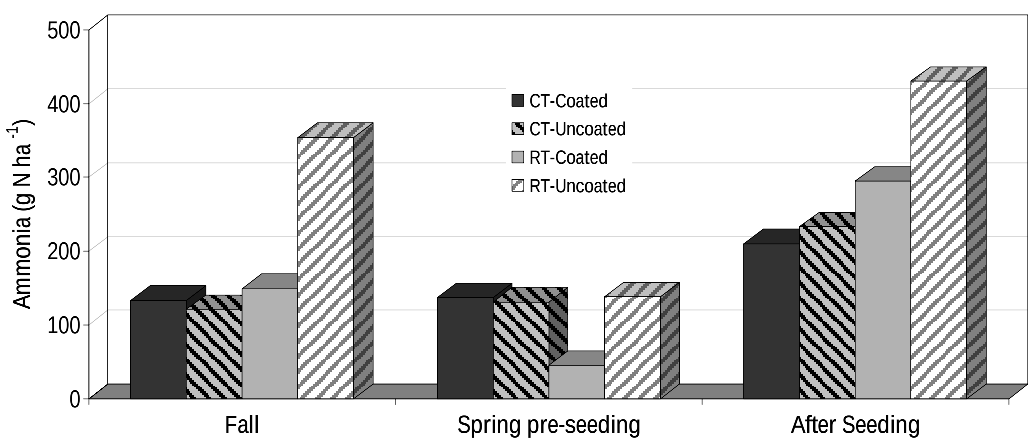
- CRU may reduce ammonia-N emissions. Emissions are usually low, except where band-sealing is poor.
- Overall, the N_2O-N losses were low and CRU tended to reduce GHG.



Effect of fall-applied N on N_2O-N loss under RT during growing season (2006) at Star City, Saskatchewan.



Nitrous oxide N (N_2O-N) emissions from soil as affected by timing of application for uncoated urea versus coated urea (CRU) at Star City, Saskatchewan.



Ammonia-N (NH_3-N) losses from fall and spring banded CRU and urea (Brandon ZTF site, courtesy of Dr. C. Grant).

Liquid Swine Manure

Background

- Liquid swine manure (LSM) contains high concentrations of ammonium, which is rapidly nitrified when applied to soil.
- Nitrification not only produces N_2O, but also supplies nitrate – the substrate required by denitrifiers.
- LSM provides easily decomposable organic C, this can induce anaerobiosis by stimulating O_2 demand, and increase the potential for soil-emitted N_2O loss.

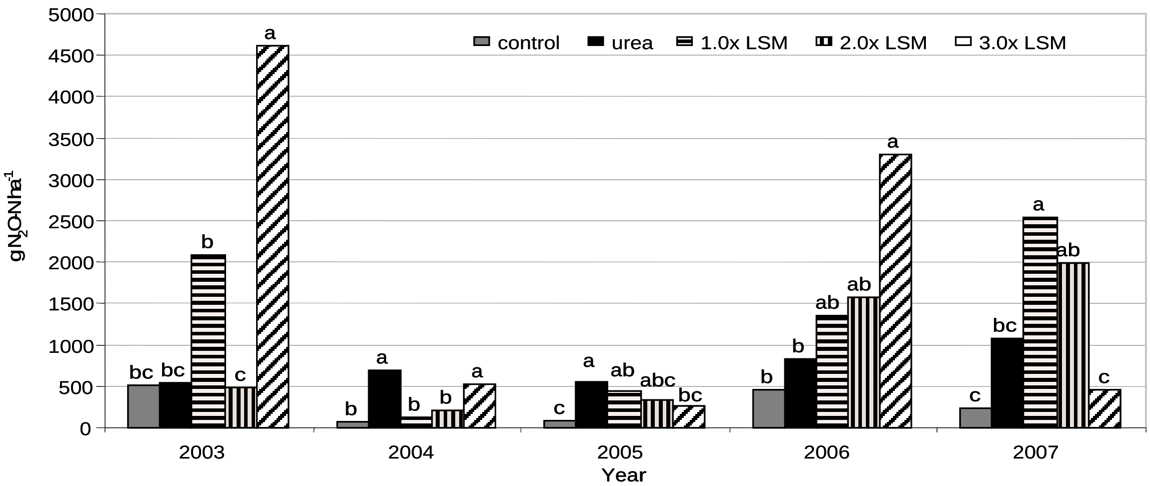
Materials and Methods

- Long-term study was initiated in 2000 at Star City to determine the influence of application rates and frequencies/timings of LSM and to compare those N_2O emissions to commercial N fertilizer.

- LSM was injected at 3000, 6000 and 9000 L ha^{-1}for1x (annually), 2x (after every 2 years) and 3x (after every 3 years) rates.
- Cereal/oilseeds seeded each year and harvested for yield.
- Nitrous oxide collected from early spring to late fall in 2003-2007.

Summary of Results

- Regardless of rate and timing, N_2O emissions from long-term LSM treatments were higher than urea – both on a 5-year cumulative basis and as a percentage of N lost as N_2O.
- Applying LSM at the 3-times rate once every third year had higher emissions than applying the manure at the 1.0X rate each year, implying that 1.0X rate is more environmentally friendly.



Cumulative N_2O-N emissions estimated for each of five sampling periods for various liquid swine manure (LSM) treatments (2.0X LSM treatment received applications in 2004, and 2006; 3.0X LSM treatment received applications in 2003 and 2006) at Star City, Saskatchewan.

Cumulative (5-year) emissions of N_2O-N and percentage of N applied lost as N_2O from various treatments from a study at Star City, Saskatchewan.

	5-year Cumulative Emission *kg N ha^{-1}	N lost as N_2O-N %
Control	1.4 d	-
Urea	3.7 cd	0.6
1.0x LSM	6.5 b	1.0
2.0x LSM	4.6 bc	0.8
3.0x LSM	9.2 a	1.3

*Values followed by the same letters are not significantly different at p = 0.05.

Anaerobically Digested Swine Manure

Background

- Management of animal wastes for intensive livestock operations (ILO) must be economical, environmentally friendly and socially acceptable.
- Anaeraobic digestion is a promising technology that could provide a cost-effective option to manage animal waste from ILO and may reduce GHG emissions by utilizing methane produced during digestion to displace fossil-fuels and by reducing emissions during lagoon storage.

Materials and Methods

- Three year study (2006-2008) at two field sites, (Swift Current and Star City) was conducted to compare agronomic performance and gaseous N loss of land-applied (injected) anaerobically digested swine manure (ADSM) to conventionally treated swine manure (CTSM).
- Barley seeded each year, and harvested for seed and straw yield.
- Nitrous oxide collected using non-static vented chambers.
- Ammonia volatilization measured using "double-sponge open-chamber" technique.

Fall:

- CTSM and ADSM at 3x rate applied once at beginning of study (9000 and 6375 gal/ac).
- CTSM & ADSM at 1x rate applied annually (3000 & 2125 gal/ac).
- ***Spring:***
- CTSM & ADSM at 3x rate applied once at beginning of study.
- CTSM & ADSM at 1x rate applied annually.
- UAN at 1x rate applied annually.
- Control.

Summary of Results

- Ammonia losses for all treatments at Star City and for 1x application rates at Swift Current were low (< 1 kg yr^{-1}); more substantial (2-10 kg yr^{-1}) losses occurred on the 3x application rates at Swift Current.
- Ammonia loss from ADSM = CTSM except CTSM-3x rate.
- Nitrous oxide losses highest from CTSM > ADSM = UAN.

Estimated ammonia-N (NH_3-N) loss over three sampling periods from various treatments at Star City and Swift Current, Saskatchewan.

		Star City		Swift Current	
		3-year net loss	Loss response	3-year net loss	Loss response
Time[z]	N source and rate[z]	g N ha^{-1}	g N kg^{-1} applied N ha^{-1}	g N ha^{-1}	g N kg^{-1} applied N ha^{-1}
Fall	ADSM-3x	2600 b	13 ab	5500 bc	26 cd
	ADSM-1x	1200 b	6 b	800 c	4 d
	CTSM-3x	8100 a	24 a	10300 b	31 bc
	CTSM-1x	3000 b	10 b	2100 c	7 cd
Spring	ADSM-3x	1100 b	5 b	12100 b	51 b
	ADSM-1x	1700 b	8 b	800 c	4 b
	CTSM-3x	1700 b	6 b	31400 a	107 a
	CTSM-1x	2500 b	10 ab	1500 c	6 d
	UAN	800 b	6 b	600 c	7 cd

The amounts of total N applied over three years were 214, 205, 403, 360, 257, 255, 343, 326 and 180 kg N ha^{-1} respectively in the fall and spring treatments as indicated in the table (moving from top to bottom).

Estimated annual and three-year cumulative N2O-N loss from various treatments at Star City, Saskatchewan.

Application Time	N source and rate	2006	2007	2008	3-year cumulative
			kg N_2O-N ha^{-1}		
Fall	ADSM-3x	2.9	1.1	3.4	7.4 (2.0)[z]
	ADSM-1x	1.3	2.2	2.0	5.5 (1.1)
	CTSM-3x	16.3	1.8	3.4	21.5 (4.5)
	CTSM-1x	3.6	5.9	7.3	16.8 (3.8)
Spring	ADSM-1x	1.7	2.1	2.2	6.0 (1.1)
	CTSM-1x	3.2	5.4	6.7	15.3 (3.7)
	UAN	1.1	1.1	2.3	4.5 (0.7)
	Control	0.8	0.8	1.6	3.2

[z]In brackets, the values represent the percentage of applied N lost.

Acknowledgements

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