AGRONOMIC MANAGEMENT OF NITROGEN TO REDUCE N_2O EMISSIONS IN MANITOBA

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INTRODUCTION

Nitrous oxide (N_2O) is recognized as a powerful greenhouse gas, with National Inventory values of N_2O-N emission set at 1% of applied N fertilizer. For a 100 lb N/ac application rate this loss is agronomically insignificant but environmentally is equivalent to 462 lb CO_2e/ac.The federal government has set a target to reduce 2020 N_2O emissions from fertilizer by 30% by 2030 and is currently offering a number of incentives for mitigating practices.

MATERIALS AND METHODS

University of Manitoba studies have documented emission reductions and yield impact of many of these practices. N_2O losses are measured in MB studies by 2 methods: Continuous measurement flux-gradient technique – from a permanent research site at University of Manitoba's Glenlea farm on heavy clay soil. The static vented chamber technique is used at off-station sites with sampling twice per week, generally amounting to 30 samples over the season.

In this article, summary details are presented, according to the management practice, displaying the cumulative reductions in N_2O and yield effect compared to a "standard practice". The reductions for nitrogen fertilizer practices are greater if considering only emissions from N fertilizer additions. This is because background N_2O that can occur without the addition of fertilizer are included. Surprising values are noted.

Practices that have been studied and shown impact on N_2O include the 4R Nutrient Stewardship components Rate, Source, Placement and Timing as well as cropping system factors of rotation with legumes, organic production and cover cropping.

RESULTS

N_2O release occurs in 2 main episodes in Manitoba (Figure 1): denitrification at spring thaw (usually amounting to 25-35% of cumulative emissions) and 1-4 weeks after N application coinciding with rainfall events and rapid nitrification through a nitrifier-denitrification process. Rapid nitrification appears to outpace diffusion of O_2, and with scarce O_2, denitrifiers reduce some NO_2^- to N_2O. N_2O may also be emitted during partial denitrification of nitrate under saturated soils, but usually denitrification is complete as N_2.

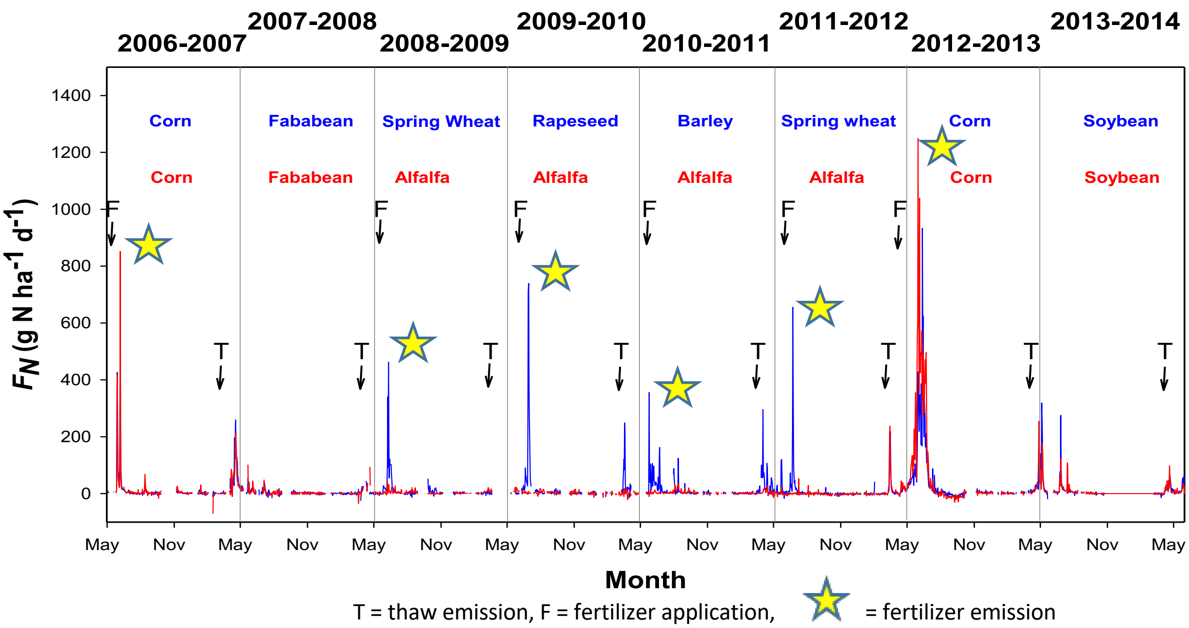

Figure 1. N_2O emissions in relation to thaw and fertilizer application events at Glenlea.[6]

FERTILIZER SOURCE

Table 1. Influence of polymer coated urea (ESN) and nitrification inhibitors on N_2O emission and crop yields.

Crop(s)	Site-yrs	Source	N_2O Reduction (%)	Yield difference (%)	Reference
HRS wheat, canola	2	ESN	48	-30*	1
HRS wheat	4	ESN	26	-2	2
Potato	3	ESN	15	0	3
HRS wheat	6	ESN	2	+3	11
corn	2	ESN	64	+8	6
Mean (ESN)	16		23	+2	
HRS wheat,	4	SuperU (DCD & NBPT)	29	-2	2
HRS wheat	6	SuperU (DCD & NBPT)	39	0	11
canola	6	SuperU (DCD & NBPT)	25	-1	9
HRS wheat	6	eNtrench (nitrapyrin)	33	0	11
Mean	22		32	-1	

* a spring application of ESN as 100% N source released too slowly for wheat and canola uptake. In practice, a blend of ESN with urea is applied.

FERTILIZER TIMING

Split Application

Table 2. Influence of Split N Application on N_2O emission and crop yields.

Crop(s)	Site-yrs	Treatment	N_2O Reduction (%)	Yield difference (%)	Reference
Potato	2	Split	59	0	3
Potato	2	Fertigation	49	0	3
Corn	3	Split	60	-5*	6
Canola	6	Split	38	-3	9
Mean	13		48	-2	

* Surface UAN split in corn was stranded in dry summers, but performed well in wet years.

Fall vs spring application

Table 3. Influence of Fall N Application on N_2O emission and crop yields.

Crop(s)	Site-yrs	Treatment	N_2O Reduction (%)	Yield difference (%)	Reference
Corn	1	Late fall	33	-8*	7
HRS wheat	6	Late fall	Increase 47**	0	11
Mean	22		36	-1	

* In the corn study, late fall banded NH_3 led to N_2O emissions during thaw the following year, but less than N_2O emissions following spring banded NH_3. Corn yield reduction was due to excessive wetness that delayed seeding, encouraged early weed growth and denitrification as N_2.

**In the hard red spring wheat studies, 2 sites had particularly high spring thaw N_2O emissions and higher cumulative emissions than spring applications. Both were heavy clay soils where high rainfall events caused saturated spring-thaw conditions.

When fall applications of N fertilizer convert to nitrate, high N_2O emissions occur during thaw the next spring, particularly on saturated clay soils

PLACEMENT

Table 4. Influence of banded N placement on N_2O emission and crop yields.

Crop(s)	Site-yrs	Treatment	N_2O Reduction (%)	Yield difference (%)	Reference
HRS wheat,	4	Deep sideband	14	2	2
HRS wheat	4	Deep mid row band	18	-4	2
potato	2	Deep band	9	0	3
canola	6	Deep band Shallow band**	Increase 16 increase 89	-2 -5	11
Mean	16	Deep band	3	-1	

RATE

N_2O emissions are proportional to N fertilizer application rates. An additional study of variable rate N application found high yield zones had the lowest emission levels despite receiving more fertilizer than field average target yields, suggesting more efficient crop N use in those areas with greater production potential.[5]

CROPPING SYSTEMS

Crop rotations, organic farming and cover crops

Table 5. Influence of previous legumes on N_2O emission and crop yields.

Crop(s)	Site-yrs	Treatment	N_2O Reduction (%)	Yield difference (%)	Reference
Wheat/soy	2	soybean	49	na	10
Field crops	11	Various legumes	65	na	8
HRS wheat	2	soybean	54	na	9
Mean			61		

Table 6. Influence of organic production and cover crops on N_2O emission and crop yields.

Crop(s)	Site-yrs	Treatment	N_2O Reduction (%)	Yield difference (%)	Reference
HRS wheat	2	Organic, alfalfa	17	-32	7
Canola, oat,soy	4	Rye cover crop	1	na	In progress

SUMMARY

Several practices result in considerable decreases in N_2O emissions from field crop production in Manitoba and likely the entire Prairies. The above individual studies are summarized in Table 7. Also noted is the current adoption level of practices used in wheat/canola and corn based on current Fertilizer Use surveys by Fertilizer Canada and crop commodity associations[9] and the level of confidence that N_2O emissions will be reduced.

Use of polymer coated urea and nitrification inhibitors (collectively called enhanced efficiency fertilizers) fertilizer N can well achieve N_2O emissions reduction targets of 30% from fertilizer N use by 2030. However, incentives may be necessary since yield responses are infrequent, they are more costly and they only make up some 10% of fertilizer use.

Split applications of N fertilizer, with some placed before or near seeding and the remainder during the growing season significantly reduces emissions. This may be a suitable strategy for long-season growing crops or those with delayed N uptake, such as corn and potato. Canola and cereals may also be considered for split application, but current adoption is low. Dry summer conditions risk stranding surface applications.

Table 7. Summary of production practices on N_2O emission and crop yields.

Management Practice	N_2O Reduction %	Yield Impact %	Current practice Wheat/ canola	Corn	Confidence
Polymer coated urea (ESN)	23	2	10%	11%	High
Nitrification inhibitors	32	-1	6%	8%	High
Split N Application	48	-2	1%	4-12%	Moderate
Banding depth - Deep (>2”)	3	-1	91%	63%	Low
Shallow (<2”)	Increase 89	-5			
Late fall application	Increase 36	-1	27-45%	41%	Moderate
N fixing legumes	61	NA	21-40%	40%	High
Organic Production	17	-32	-		Low
Cover crop	1		-		Low
Variable rate	yes	+	14%	14%	Low

Traditional studies have shown 20% greater efficiency with in-soil N banding than broadcast, indicating broadcast rates may need to be 20% greater to achieve similar yield. This efficiency is a direct reduction in N_2O emissions when application rates are adjusted accordingly, but in the reported studies, similar N rates were applied. Results were variable with deep banding N across a number of crops and placements. Shallow side-banding of N is common when seeding small seeded crops such as canola, but it can increase emissions and should be avoided.

N fixing legumes such as alfalfa, soybean, faba bean and field pea emit very little N_2O above what would occur without N fertilizer application. Organic production can result in a modest decrease in N_2O emissions however, yields are also lower. These organic yields will need to be increased if this system is to reduce emission for the same amount of food produced using conventional methods. High emissions can result when green manure crops leave high levels of overwintering nitrate. Cover crops do not increase N_2O emissions and to what extent they increase,soil C capture is unknown.

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