Does Fall Anhydrous Ammonia Lead to Greater Nitrous Oxide Emissions Than Spring Addition?

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Background

- Fall application of nitrogen fertilizer results in NO_3^- accumulation prior to freeze-up which would be prone to denitrification.
- Therefore spring fertilization has emerged as one of the strategies of efficient nitrogen management to reduce nitrous oxide emissions on the Canadian Prairies (MAFRI, 2005).
- However, effectiveness of spring fertilization for N_2O emission reduction is yet to be ascertained.

Objective

- To compare fall and spring application timing of anhydrous ammonia on N_2O emissions

Materials and Methods

Study site, treatment structure and experimental design

- The study was conducted in the TGAS-MAN project site in the clay soil of Red River Valley, Southern Manitoba.
- The field layout and treatment structure of the study is presented in figure 1. This study included two plots out of four 200 m x 200 m plots of TGAS-MAN project.
- Both plots were planted with barley in 2010, spring wheat in 2011 and corn in 2012.
- One plot (plot 'b' in fig 1) received nitrogen fertilizer in fall 2010 and spring 2012 whereas another (plot 'a' in fig 1) received same in spring and fall of 2011.
- Nitrogen fertilizer was applied as anhydrous ammonia at the rate of 180 kg N ha^{-1} by using a SCS 330 flow-meter (Raven Industries Inc., Sioux Falls, South Dakota) (fig 2).

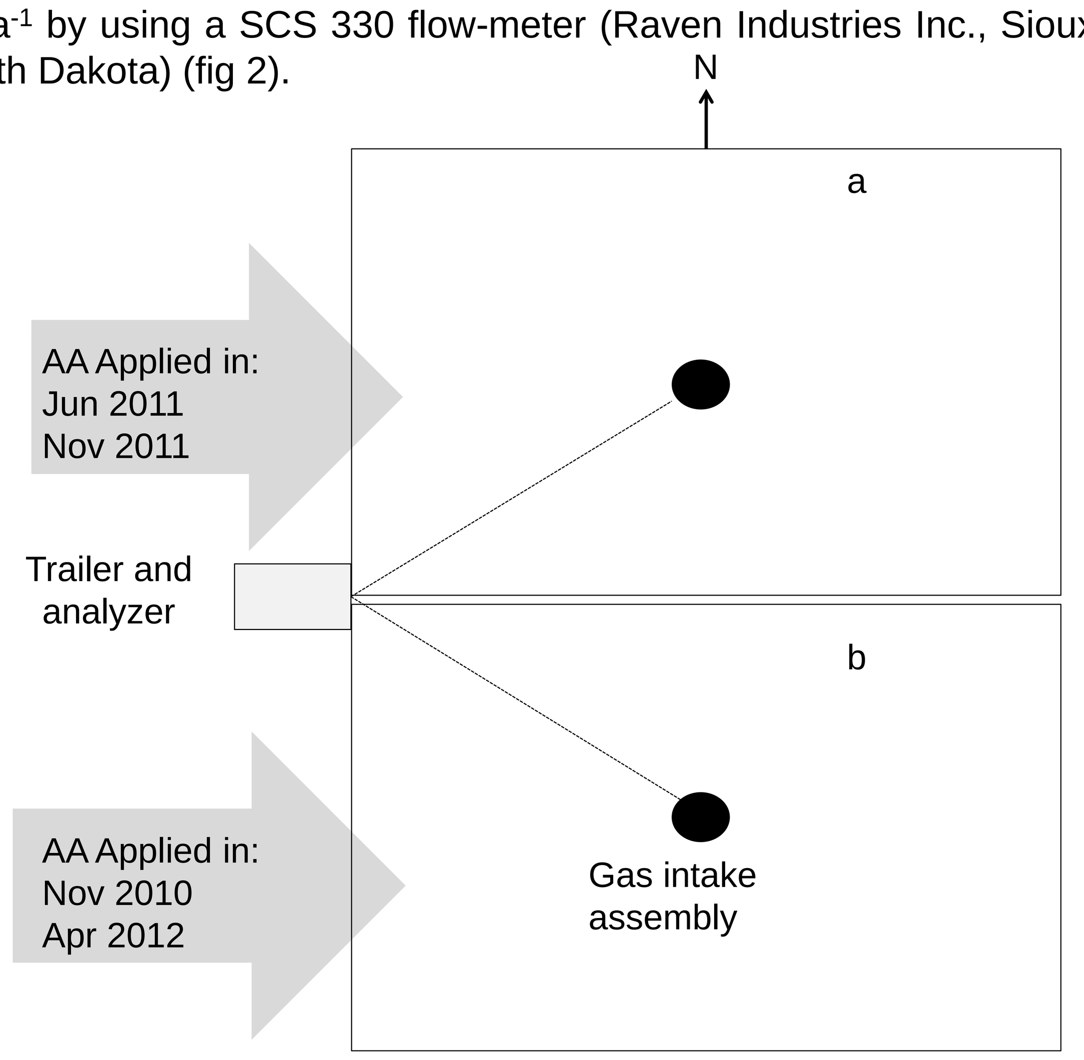

Fig. 1: Two out of four plots of TGAS-MAN study site showing different timing of anhydrous ammonia application and placement of micrometeorological instruments.

Nitrous oxide flux measurement and calculation

The emission of N_2O was measured using the flux gradient method. An instrumentation tower located at the center of each plot took the gas sample by means of sample intakes placed at two different heights above the ground or crop canopy (fig. 3) . Concentration of N_2O in the gas sample was determined by tunable diode laser analyzer (Model TGA100A, Campbell Scientific Inc., Logan, UT, USA) housed in a trailer at the center of all plots (fig. 1).

Fig. 2: Application of anhydrous ammonia in the field. Anhydrous ammonia was injected 5 cm below surface at 50 cm row spacing.

Nitrous oxide flux was calculated as:

$$F_n = -K\frac{\Delta_{N2O}}{\Delta z}$$

where F_n is N_2O flux, K is the eddy/turbulent diffusivity and Δ_{N2O} is the nitrous oxide concentration gradient measured over a vertical distance z.

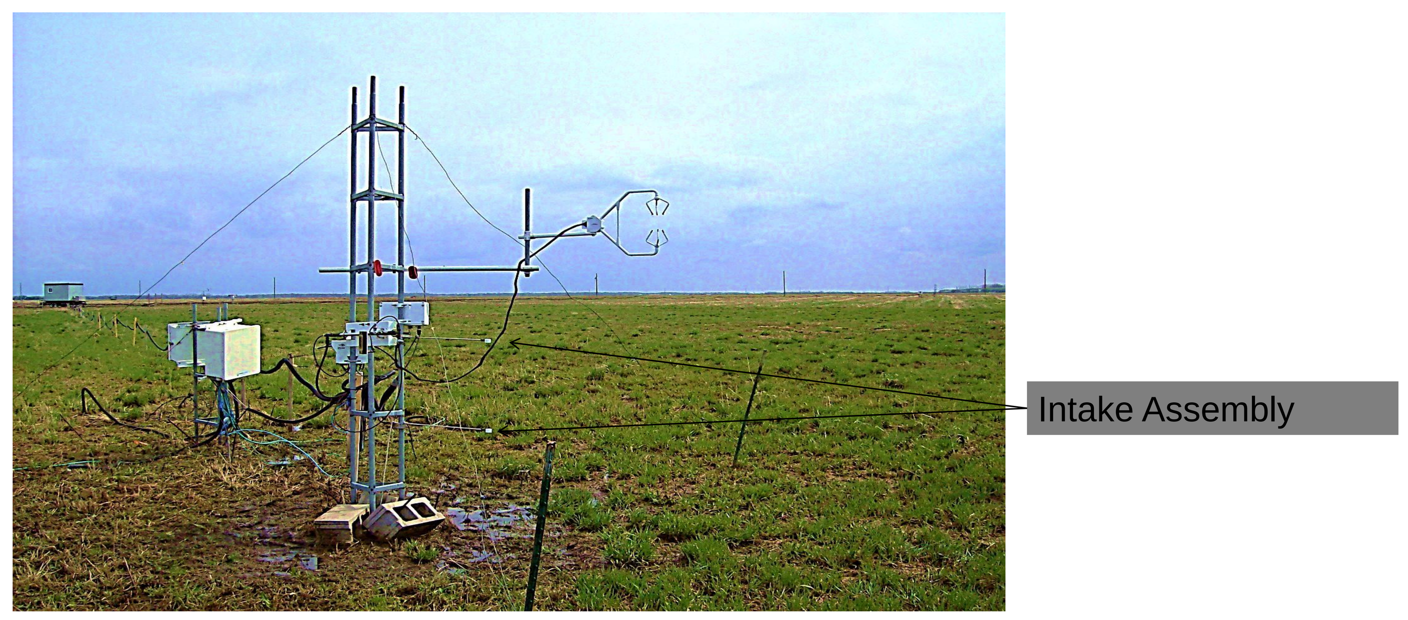

Fig.3: Instrumentation tower at the center of the plot showing gas intake assembly.

Determination of soil mineral nitrogen

Soil content of mineral nitrogen (both NO_3^- and NH_4^+) were determined by taking soil samples from 0-30 cm soil depth. These determinations were made each month starting from the April 2011 until November 2011 and again started from March 2012. Six sampling points were chosen from each plots and soil samples were taken from the same sampling points each time using soil a sampling auger mounted on the back of tractor. Fresh soil samples were extracted using 2 M KCl/0.5 M K_2SO_4 and analyzed for NH_4^+ and NO_3^- using an auto-analyzer.

Results and Discussions

Nitrous Oxide Flux

Fall application of anhydrous ammonia resulted in negligible emissions of nitrous oxide immediately after fertilization probably because of soil freezing. However, fall application induced emissions in spring of following year as soil thawed (fig 4). In contrast, spring application was followed shortly by emission of nitrous oxide for 1-2 weeks. Until November 2011, cumulative N_2O emission was about one and half times higher from spring fertilized plot than from fall fertilize plot. The effect of 2012 spring application is yet to be observed to confirm this finding.

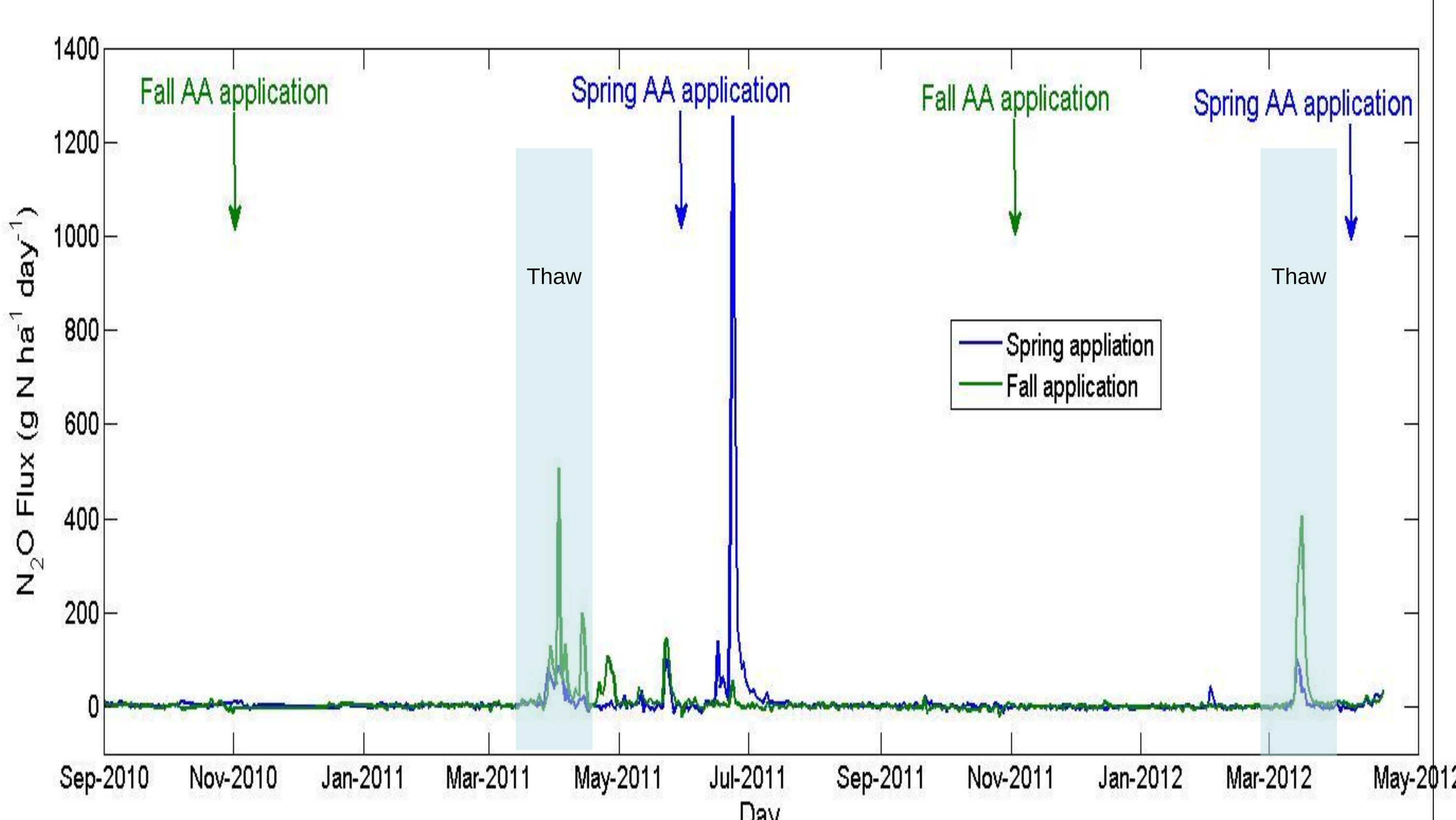

Fig. 4: Daily N_2O emission as affected by fall and spring application of anhydrous ammonia (AA) in Red River Valley, Manitoba. Cumulative N_2O emission (between November 2010 to November 2011) from spring and fall applied plots were 5 kg and 3 kg N per ha, respectively.

Soil Mineral Nitrogen

We observed high soil mineral N immediately after fertilization in both spring and fall fertilized plots. Soil mineral N was comparable between two plots for the rest of the period (fig. 5). Higher N_2O emission from spring fertilized plot coincided with higher mineral N in soil. However, high mineral N in fall fertilized plot immediately after application did not induce high N_2O emission (compare fig 3 and 4).

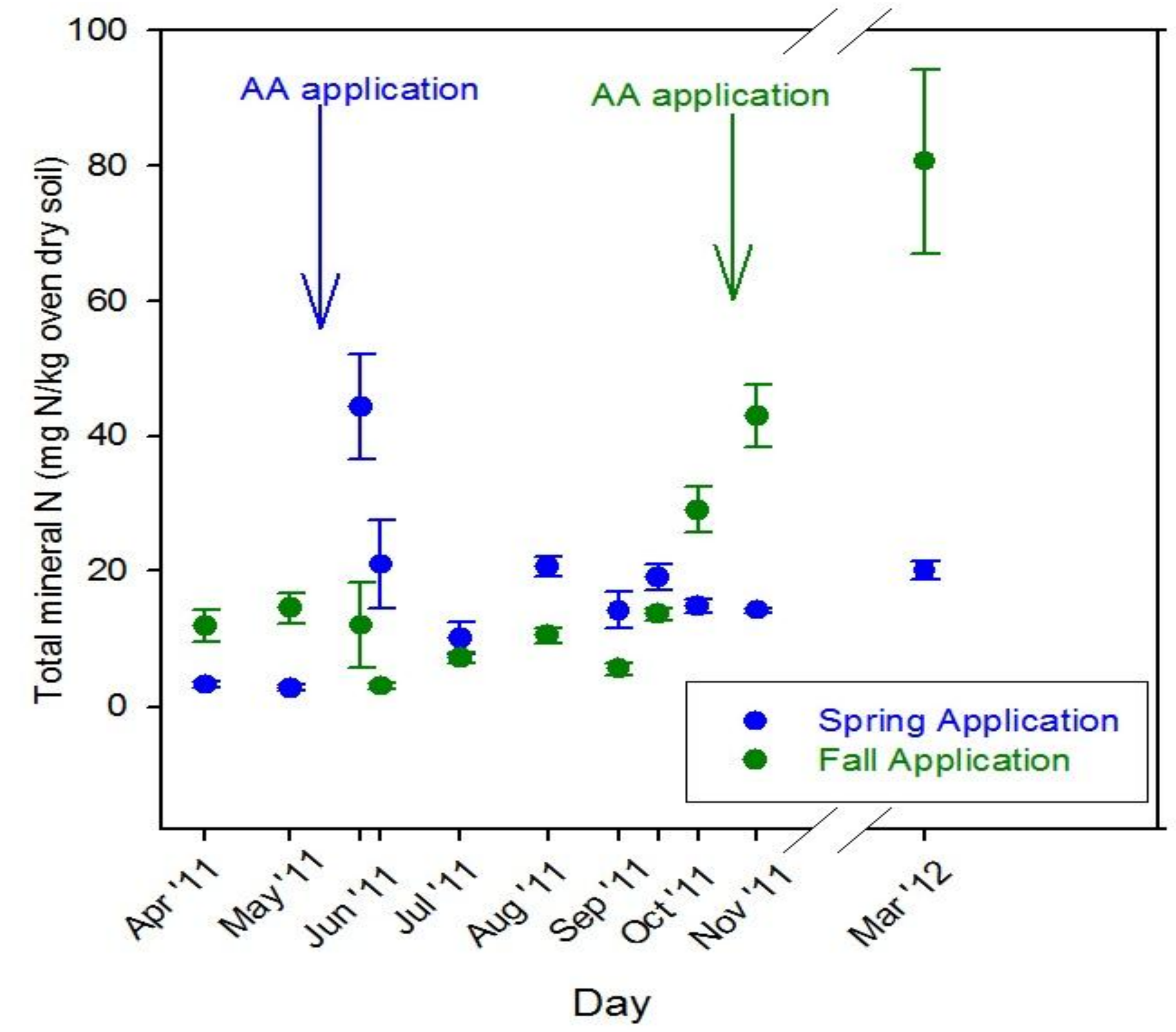

Fig. 5: Soil total mineral N (NO_3^- and NH_4^+) in 0-30 cm soil depth during different times in the study period as affected by anhydrous ammonia application. Values are means ±SE, n = 6).

Conclusion

- Our observations so far indicated that fall application of nitrogen fertilizer did not induce N_2O emission immediately after its application although some emission occurred during spring thaw of the following year.
- Spring application of nitrogen fertilizer induced N_2O emission soon after its application and also the magnitude of emission was higher than that of fall application
- N_2O flux was related to the soil content of mineral N in spring. However, higher soil mineral N in fall did not necessarily induce N_2O emission as the soil condition was not conducive for emission.
- The flux-gradient technique successfully captured the ephemeral nature of N_2O emission events impossible with standard chamber methods.

Acknowledgements

We thank Jenna O. Rapai, Jolene Rutter, Brad Sparling, Mervin Bilous and staff of Glenlea Research station for various help in this study. Funding was provided by the Canadian Fertilizer Institute , Manitoba Rural Adaptation Council, AGGP of Agriculture and Agri-Food Canada, Manitoba Sustainable Agriculture Practices, Canada Research Chair Program (Applied Soil Ecology), NSERC Discovery Grants and Canadian Foundation for Innovation.

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