NEWS & VIEWS

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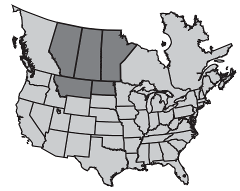

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Nitrous Oxide Emissions from Fertilizer Nitrogen

THE ATMOSPHERIC CONCENTRATIONS of nitrous oxide (N_2O), carbon dioxide (CO_2), and methane (CH_4) have been found to be increasing. There is concern about this because all three gases absorb long-wave radiation, thereby increasing the amount of heat trapped in the earth's atmosphere. In addition, N_2O is involved in the destruction of stratospheric ozone, which shields the earth from biologically harmful ultra-violet radiation.

The Kyoto Protocol, with Canada as one of the signatory countries, is committed to significantly reducing greenhouse gas emissions within the next decade. There is still considerable political debate surrounding the Protocol, and about what plan Canada should adopt to reduce greenhouse gas emissions. However, this issue will likely remain a concern for the foreseeable future. While CO_2 is the major concern for most industries, the main greenhouse gases emitted by the agricultural sector are N_2O and CH_4.

Some N_2O is emitted from agricultural soils as a consequence of naturally occurring processes; however, farming practices can strongly increase the amount of N_2O produced. This is of some practical concern since the N (nitrogen) in N_2O is an important crop nutrient. While the amount of N lost as N_2O is generally small (a few pounds per acre) in the northern Great Plains, most often N_2O is accompanied by a much larger (as much as 10 times more) loss in other gaseous N forms. **Thus, limiting N_2O emissions from farming operations can be beneficial from both an environmental as well as an agronomic standpoint.**

Relative to CO_2, N_2O is considered to have 310 times the net atmospheric warming potential per molecule. Some estimates indicate that agriculture contributes 60% of all Canadian anthropogenic N_2O emissions, with more than 50% of the agricultural total being associated with N fertilizer use. This is particularly important for western Canada, as 82% of all fertilizer N used in Canada occurs in the three prairie provinces of Manitoba, Saskatchewan, and Alberta. None of the Intergovernmental Panel on Climate Change (IPCC) estimates of N_2O emissions considered the environment in this region.

A collaborative project indicates N_2O emissions are comparatively low from well-managed cropping systems in the northern Great Plains. Optimal N management is more important than the fertilizer system selected.

Have you ever wondered about the N_2O emission estimates being used by the IPCC? Well, we did and wanted to evaluate how fertilizer use in western Canada influenced the loss of N_2O. Working with groups from various parts of Europe and North America, the IPCC established values that could be used to calculate direct N_2O emissions from fertilizer N use in various parts of the world. This value was set at 1.25% of the N fertilizer applied being lost as N_2O.

The relationship between the amount of N applied and the N_2O emitted is not considered to be linear. Rather, it is governed by a complex interaction between environmental conditions, soil properties, and the form, placement, and timing of the fertilizer N. When N is applied close to the time of crop requirement, N-use efficiency should be increased and N_2O emissions reduced. While band application of fertilizer N has been shown to increase

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crop uptake, concentration of N in bands can also cause alterations in soil pH, osmotic potential, and free ammonia concentrations, all of which may impact N_2O losses. Nitrogen fertilizer form has been suggested as a major factor influencing the loss of N_2O from fertilizer bands. In fact, anhydrous ammonia (NH_3) has been reported to have losses five times those found with other N sources. We decided it was time to clarify these reported differences.

This 3-year study includes field experiments at six locations: Swift Current, Scott, Indian Head, and Star City in Saskatchewan, and Brandon and Winnipeg in Manitoba. Measurements presented were made on spring wheat. Treatments that will be referred to here consist of urea and NH_3 banded in the fall or spring, and urea broadcast in the spring. Spring banded N was placed either to the side of the seed row (side-row band) or midway between alternate crop rows (mid-row band). Nitrogen fertilizer was applied at 71 lb N/A at Star City, Indian Head, Brandon, and Winnipeg, and 53 lb N/A at Swift Current and Scott.

All sites received applications of phosphorus (P) fertilizer (11-51-0), at rates of 15 lb P_2O_5/A at Scott and Swift Current, 20 lb P_2O_5/A at Star City and Indian Head, and 35 lb P_2O_5/A at Brandon and Winnipeg. Phosphorus was placed with the seed except for the side-banded urea treatments where both N and P were placed in the side-row band. A blanket treatment of potassium sulfate (K_2SO_4) was broadcast prior to seeding at all sites to ensure sufficiency of these nutrients. Trace gas samples were collected using vented soil chambers and sample collection and analysis followed accepted protocols. Annual estimates of N_2O loss are the sum of N_2O lost during the growing season plus the following spring thaw period.

This collaborative project was established between the Canadian Fertilizer Institute and researchers at Agriculture and Agri-Food Canada and the University of Manitoba to measure the loss of N_2O from fertilizer N additions using common practices characteristic of western Canada. To address these issues the project established a series of questions for which answers were pursued.

How much N from fertilizer is lost directly as N_2O under western Canadian conditions?

The study results found that N_2O emissions increased with fertilizer N application, and that within the range of fertilizer N rates considered (53 to 71 lb N/A), emissions were found to increase in a linear fashion. For five of the six trial locations, the great majority of measured losses were at or below 0.4%. At the sixth site, Winnipeg, the values were higher at 0.82%. The results of this study clearly indicate that the IPCC N_2O loss coefficient of 1.25% applied to western Canada is grossly in excess of measured results.

Does fertilizer N source influence direct losses of N_2O?

The study found that N_2O emissions were similar from NH_3 and urea. There were weak trends for emissions to be higher when urea was broadcast rather than banded, and when the fertilizer N was mid-row (double the localized concentration) rather than side-row banded. Interestingly, urea appeared to provide slightly better yields at one location, but NH_3 and urea appeared to perform equally at the other five locations.

Does application time (spring vs fall) influence direct losses of N_2O?

Results from this study found that fall banded N and broadcast urea are less efficient than their spring banded at seeding counterparts. In both instances, these fall application methods place fertilizer at random into the soil system, avoiding the linkage with the seed rows in spring banding. In addition, over-winter losses of N by leaching or denitrification could account for some of the differences observed.

Does fertilizer placement influence agronomic performance and/or direct losses of N_2O?

Yes. In 16% of the cases considered in the project, there was a difference in the agronomic performance of the fertilizer placements evaluated. When these differences occurred, the advantage in agronomic performance was divided equally between the side banded and the mid-row banded treatments. However, in none of these measured cases was the difference in agronomic performance reflected in any direct loss of N_2O.

Summary

The results of this study indicate that N_2O emissions are comparatively low from well-managed cropping systems in the northern Great Plains, and suggest that the specific N fertilizer system selected (side-row vs. mid-row, NH_3 vs. urea) is of less consequence than ensuring the optimal use of N fertilizer additions. There is little argument that the N_2O emissions, and amount of fertilizer-induced N_2O emitted, was significantly different among the sites with much lower emissions from the more arid locations. The great majority of the measured losses were at or below 0.4%. It is important to point out again that a total of 82% of all fertilizer N used in Canada is applied in the prairie region of Manitoba, Saskatchewan, and Alberta.

Despite the high degree of uncertainty surrounding the estimates in this study, the results clearly indicate a need to modify downward the N_2O loss coefficient of 1.25% that is currently applied to fertilizer N use in western Canada. ■