SOIL CONSERVATION COUNCIL OF CANADA
CONSEIL DE CONSERVATION DES SOLS CANADA

Global Warming and Agriculture

Nitrous Oxide

This issue, dealing with nitrous oxide (N_2O), is the fourth in a series of information sheets intended to create an awareness of global warming and its relationship with agriculture in Canada. The first issue identified the three main greenhouse gases — carbon dioxide (CO_2), nitrous oxide and methane. The last two issues explored the role of CO_2; the next will highlight methane.

Nitrous oxide - what is it?

Nitrous oxide (N_2O) occurs naturally in the atmosphere. Existing at low concentrations compared to $C0_2$ [0.3 parts per million by volume (ppmv) compared to 270 ppmv], N_20 still poses a potential environmental threat. It is potent greenhouse gas with an atmospheric life of about 120 years and a global warming potential 310 times more powerful than CO_2. Currently its increasing at a rate of about .3% a year. Like other greenhouse gases, N_2O traps reflected sunlight and contributes to global warming. Concentrations in the upper atmosphere also indirectly deplete the ozone layer, thereby reducing its ability to filter harmful rays form the sun.

Agriculture is a main source of this greenhouse gas, accounting for about 70% of N_2O emissions from human activity globally.

Most of the N_2O emitted by Canadian agriculture comes from soils, through fertilizer and applied manure. With livestock production and nitrogen (N) inputs from fertilizer and manure on the rise, Canadian producers have a significant role to play in reducing the nitrous oxide emissions from these sources.

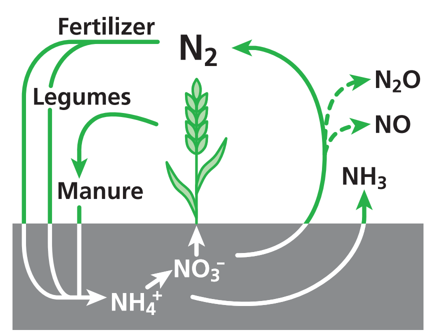
The Nitrogen Cycle

The atmosphere contains a huge pool of nitrogen, existing as N_2, a form not directly available to plants. Most plants must obtain the nitrogen (N) they need through their roots, by absorbing nitrate ($N0_3$-) and ammonium (NH_4+) from the soil. When the plants later die, the N in the plant residue becomes soil organic matter. Soil microorganisms decompose this organic matter back into nitrate and ammonium, once again ready for plant uptake, completing the nitrogen cycle. In natural environments, this give-and-take cycle between soil and plants can continue almost indefinitely, with only very small inputs of N from lightning or specialized soil bacteria.

Agriculture disrupts this cycle. When a crop is harvested the N (protein), concentrated in the grain and plant, is removed. Consequently, to continue the cycle and maintain the soil's growing conditions, inputs from alternate sources must replace the lost N.

The N is often replaced by applying chemical fertilizers. These are made through an energy-expensive process of converting N_2 into a NH_4+ form for plant uptake. Another approach is by using legumes to "fix" N_2. In this case, the nodules in the roots of these plants contain bacteria that convert N_2 into a form useable by plants. When the plant dies and decomposes, it releases N back into the soil as NH_4+.

Although the injection of N sustains food production, losses of N into the environment can occur. Some of this loss is in the form of N_2O. Most of this comes from the pool of plant-available N (NH_4+ and NO_3-). Consequently, losses are highest when producers add these forms in amounts greater than the plants can use, or at a time when plants are not growing.



Conceptual nitrogen cycle in an agricultural system

- Adapted from Janzen et al., 1998

Nitrous Oxide - How it's formed

N_2O can originate from two places in the nitrogen cycle - during nitrification (converting NH_4+ to $N0_3-$) and during denitrification (converting NO_3- to gaseous N_2). While either or both of these "converting" stages can emit N_2O, emissions from denitrification are often several times higher than those from nitrification. Generally, denitrification is at its worst when moisture content is high, oxygen is restricted, and NO_3- and C concentrations are elevated.

What farmers can do

The rate of N_2O emitted to the environment is highly sensitive to conditions in the soil and farming practices. Consequently, soil management is one of the keys to reducing greenhouse gases. Action needs to be taken to minimize NO_3- build-ups and discourage conditions which favour denitrification. In many settings, the practices listed below can help reduce N_2O emissions as well as help improve the efficiency of costly N fertilizer:

Match fertilizer to plant needs: Apply just enough N so that crops can reach maximum yield without leaving behind any available N. Base fertilizer rates on soil testing and estimate N release from residue and organic matter. Applying N fertilizer at different rates in fields where fertility needs vary (precision farming) may improve the match between the amount applied and the amount taken up by a crop.

Avoid excessive manure application: Manure can emit a lot of N_2O because it adds both N and available C, both of which promote emissions. Apply manure at rates that supply plant demands rather than exceed them.

Optimize timing of fertilizer application: Timing is as important as the rate of application. The amount of N_2O released is related not to the amount of N applied, but to the amount of N unused by the crop. Apply just prior to the time of maximum uptake by the crop. Avoid applying fertilizer and manure in fall. Plough down N-rich crops so that N release coincides with future crop demands.

Improve soil aeration: Denitrification favours low oxygen levels. Therefore denitrification can be discouraged by managing soil water through draining soils prone to water-logging, avoiding over-irrigating and using tillage practices that improve soil structure.

Use appropriate fertilizer placement: Placing fertilizer near crop roots can improve fertilizer efficiency and thus allow lower rates of application. On the other hand, placing the fertilizer too deep in the soil, or concentrating forms like urea in bands, may increase N_2O emissions.

Use improved fertilizer formulations: There is some evidence that higher emissions come from ammonium nitrate, while the lowest emissions come from fertilizers containing NO_3-. When applicable, consider slow-release fertilizers such as sulfur-coated urea.

Use nitrification inhibitors: Certain chemicals applied with fertilizers or manures, suppress N_2O formation and loss of N into groundwater.

Grow cover crops: Where the season is long enough, farmers can sow crops after harvest to extract excess soil NO_3-, which prevents it from leaching or converting to N_2O.

Lime acid soils: N_2O emissions can be suppressed by applying neutralizing lime to acid soils.

Reduce tillage intensity: Though results are inconsistent, studies suggest that N_2O emission may be lower in no-till that conventional tilling.

Sources

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