



# 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  $CO_2$  [0.3 parts per million by volume (ppmv) compared to 270 ppmv],  $N_2O$  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 from 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

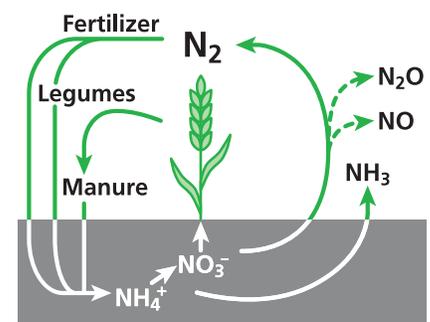
The atmosphere contains a huge pool of nitrogen, existing as  $N_2$ , a form not directly available to plants. Most plants must obtain the nitrogen (N) they need through their roots, by absorbing nitrate ( $NO_3^-$ ) and ammonium ( $NH_4^+$ ) from the soil. When the plants later die, the N in the plant 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  $NO_3^-$ ) 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 than conventional tilling.

## Sources

Agriculture and Agri-Food climate Change Table. 2000 Options Report: Reducing Greenhouse Gas Emissions from Canadian Agriculture. Publication No. 2028/E.

Janzen, H.H., Desjardins, R.L., Asselin, J.M.R. and Grace, B. 1998. The health of our air: Toward sustainable agriculture in Canada. Agriculture and Agri-Food Canada, Ottawa, ON

For more information visit the Soil Conservation Council of Canada website: [www.soilcc.ca](http://www.soilcc.ca)

