Nitrous Oxide emissions in Agriculture: impacts on the GHG mitigation issue

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Key Words: climate change, greenhouse gas, nitrous oxide

Abstract

Nitrous oxide (N_2O) is responsible for about two thirds of the emissions from agriculture. With a global warming potential (GWP) that is 310 times greater than CO_2, management of N_2O emissions is critical to achieve reductions. Mitigation research aimed at identifying strategies for reducing emissions from agriculture has shown that many of the "best management practices" (BMP) for achieving sustainable agricultural development in Canada also reduce GHG emissions. As such, mitigation strategies are often practices that have demonstrated economic and environmental benefits and fit within Canada's overall sustainability objectives for the sector.

Introduction

Canada, as a signatory of the December 1997 Kyoto Protocol, agreed to reduce its inventory of GHG emissions to 94% of 1990 levels during the first commitment period, which is 2008 to 2012. However, since the signing of the Kyoto Protocol, emissions have continued to increase in most countries of the world. In Canada it is projected that emissions will be between 100 and 150 Tg higher in 2010 than in 1990 (Figure 1), so to meet the Kyoto target, first commitment period emission reductions will have to be about 20 to 25%.

Crop and livestock production activities contribute about ten percent of Canada's greenhouse gas (GHG) emissions and they are expected to increase at about the same rate as emissions from other sectors of the economy. Mitigation research has shown that substantial reductions in GHG emissions from agriculture are possible if BMP related to the management of soils, fertilizer use, and manure storage and handling are adopted.

International Agreements and Agriculture: Kyoto Protocol, Bonn Agreement and the Marrakech Accords

Under the Kyoto Protocol, Parties must included emissions from agricultural sources in their annual inventory of emissions. Sources from agriculture are emissions from enteric fermentation, manure management, rice cultivation, agricultural soils, burning of savannas, and burning of agricultural residues. Of those, rice cultivation and burning of savannas do not apply to Canadian agriculture, and only soil management, manure management and burning of crop residues produce N_2O emissions.

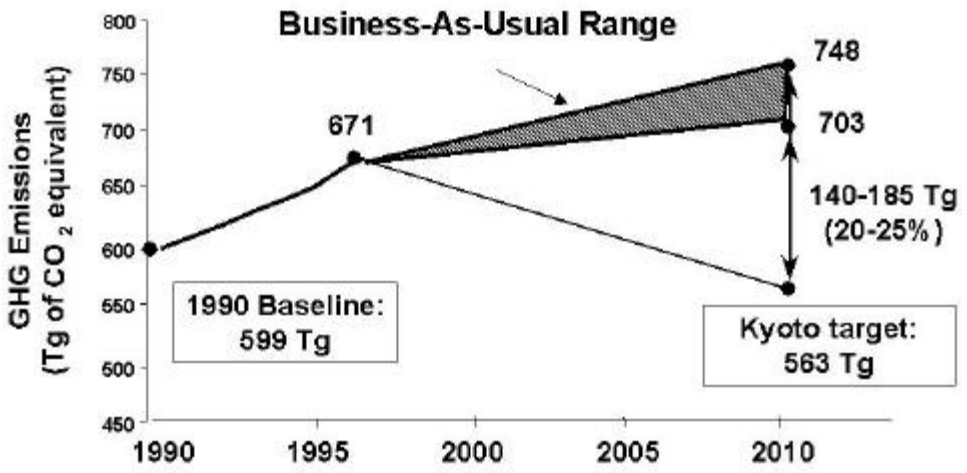

Figure 1. Canadian projected emissions and Kyoto target gap by the first commitment period.

At the negotiations that followed the Kyoto Protocol, Canada took the position at the accounting for agricultural was not balanced because emissions from soil had to be included in the emissions inventory, but carbon sequestration and soil sinks could not be included. However, this imbalance was addressed at COP6 in July 2001 in the Bonn Agreement, where it was agreed that credits could be earned for sinks associated with cropland management, grazing land management or revegetation activities. The sinks decision in the Bonn Agreement maintains the environmental integrity of the Protocol by requiring that for land on which sinks credits will be claimed, all gains *and losses* of soil organic carbon, and any *associated emissions of N_2O and CH_4* must be accounted in the first and all subsequent commitment periods. Counties cannot therefore chose to take credits while their soils are a sink, but remove them from the inventory when they are a source. In addition, countries cannot get sinks credits for practices that actually result in a net increase in emissions of N_2O and CH_4.

At the COP7 meetings in Marrakech in November, 2001, the rules for reporting and accounting, including for agricultural sources and sinks were agreed, and countries can now determine whether or not to ratify the Kyoto Protocol.

Implications of N_2O Emissions for Sinks Accounting

Nitrous oxide emissions associated with agricultural soils will either be accounted in the Canada's inventory of emissions, or under the net-net sinks accounting rules if Canada elects to claim credits for cropland management, grazing land management or revegetation. That means that sink-enhancing practices will only result in credits if the increase in soil carbon is not offset by larger increases in N_2O or CH_4.

The net-net accounting rules for agricultural sinks are illustrated in Figure 2. In the commitment period (2012), it is expected that agricultural soils in Canada will be a net sink of CO_2, whereas they were a small net source in 1990. The associated N_2O and CH_4 are also expected to increase between 1990 and 2012. The credit that could be earned from soil management is the difference between net sources and sinks in 2012 and net sources and sinks in 1990 – net-net accounting. The important point is that to achieve sinks credits, it will be as necessary to prevent large increases in non-CO_2 emissions as it is to enhance sinks.

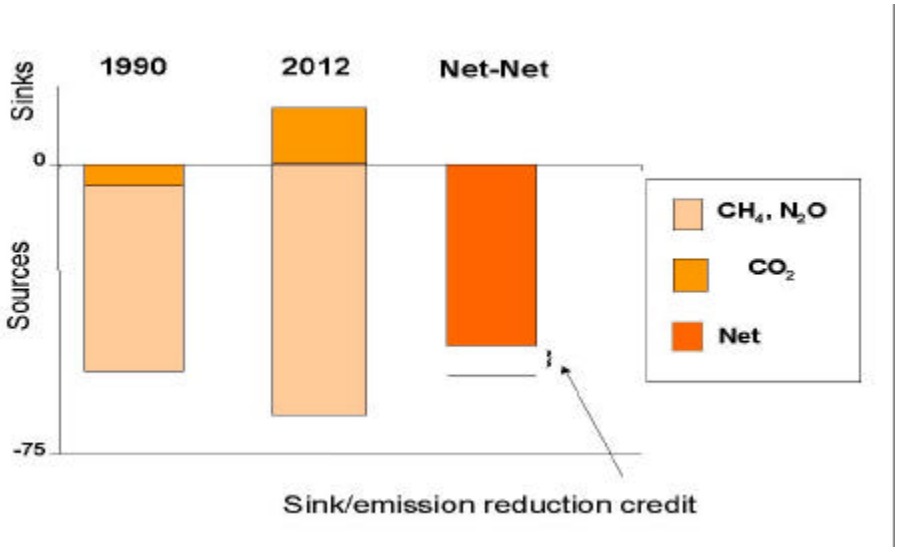

Figure 2. Net-net accounting for soil sinks.

Mitigation of N_20 Emissions from Agriculture

One of the main processes responsible for nitrous oxide emissions is denitrification, a process of conversion of nitrate into reduced forms of N that occur when oxygen availability is limited, such as in wet soils or wet manure. Reducing N_2O emissions is therefore a matter of limiting the amount of N that is available at times when soils are likely to be wet (e.g., snowmelt) or in manures.

The management and storage of manure from livestock production is one of the major agricultural sources of N_20 emissions, although emission levels can vary depending on the amount and type of manure, and the type of storage system. Emission reductions can be achieved by shifting from wet to dry or solid storage systems, by applying manure to the land more frequently (reduced storage time) and by reducing the N content of the

manure through careful feeding strategies that match the animals protein requirement with the feed quality.

In agricultural soils, N fertilizers, manure applied to the land, N-fixing crops and crop residues are the major sources of N_20 emissions. The main source of N_20 from land mangement is nitrogen that is "stranded" in the soil during the non-growing season. Nitrogen that is taken up by crops is not available in the soil and at risk of being denitrified, leached or volatilized, and therefore poses less risk of loss to the atmosphere as N_20. Any nutrient management practice that increases N-use efficiency by crops will mitigate GHG emissions, and offer an economic efficiency as well. Some mitigation strategies that have been proposed include avoiding fall application of N fertilizer and high rates of manure and matching N application rates to crop need or soil test recommendations. It is also possible to reduce N_2O emissions by eliminating the practice of summerfallow. Under the warm, moist soils conditions of summerfallow, soil organic matter tends to decompose at a relatively high rate, making mineral forms of N available in the soil at a time when there is not crop to take it up.

Policy Implications

If Canada ratifies the Kyoto Protocol, we have only until 2008 to develop emission reduction strategies for the agricultural sector. However, since many of the practices identified as GHG mitigation strategies are also "best management practices" within the overall sustainability objectives for the sector, meeting the targets of the Kyoto Protocol will provide other environmental and economic benefits to producers and society. For example, reducing N_20 emissions is achieved largely through practices that increase the N-use efficiency of synthetic fertilizer and manure, which offers economic benefits to producers as well as a reduced risk to water quality.

The "Kyoto mechanisms", which will allow carbon/sinks trading and emission reduction trading, make the Kyoto Protocol the first global environmental agreement to propose the use of market mechanisms to incent behavior. The trading options could work well for agriculture by providing economic incentives for the adoption of what are essentially "conserving" practices, such as carbon sequestration which improves soil quality, or emission reductions, which can improve input use and production efficiency.

It may not be possible to achieve sufficient emissions reductions through trading and the market mechanisms to meet the Kyoto target, in which case there may be costs to the agriculture sector. However, the costs of mitigation must be balanced against the costs of adaptation if climate change adversely affects Canada's agricultural productivity. Mitigation choices can be made from a fairly wide range of options, either through enhanced sinks or reduced emissions, whereas adaptation might not offer the same flexibility. It may be preferable to elect to undertake any mitigation activities that "make sense" for a wide range of environmental and economic reasons, and thus reduce the potential costs of adaptation, than to hope that the costs of adaptation are small.