AGR1117

Quantifying Nitrogen Loss from ^{15}N-enriched Crop Residues: Developing a case for the lowering of N_2O emission factors

INVESTIGATORS

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STUDY SPONSORS

Saskatchewan Pulse Growers Association, Saskatchewan Agriculture Development Fund

TYPE OF STUDY

AGRONOMY

OBJECTIVES

The overall objectives of this study were to quantify and compare N_2O emissions associated with the decomposition of pulse, oilseed, and cereal crop residues. The ultimate goal is to develop emission factors (a measure of the percentage of N lost as N_2O) for these residues and compare these to the emission factor for urea fertilizer. The specific objectives are to:

1. Quantify total- and $^{15}N_2O$ emissions resulting from the decomposition of ^{15}N-labeled pulse and cereal crop residues in Saskatchewan soils

2. Quantify total- and $^{15}N_2O$ emissions associated with the use of ^{15}N-labeled urea fertilizer in Saskatchewan soils

3. Calculate emission factors for the plant residues and fertilizer

WHY STUDY NEEDED

Nitrous oxide (N_2O) is a potent greenhouse gas that contributes to global climate change. Expressed in CO_2 equivalents, it is up to 300 times more potent than CO_2 in affecting climate change. Current estimates of N_2O emissions in Canada indicate that 17% of all agriculture-based emissions are associated with the decomposition of crop residues. Given that the CO_2-footprint of agricultural products is now an important factor in gaining and/or maintaining market access, it is very important to accurately determine the actual magnitude of emissions from residues, and to understand the controls on those emissions so their overall contribution can be accurately reported, and effective mitigation options identified.

This work complements and extends “in-field” comparisons of the effect of crop type and cropping sequence on nitrous oxide emissions by providing more precise information on how different components of prairie cropping systems contribute to the overall greenhouse gas balance. Ultimately, the work will support changes (if warranted) to the Canadian greenhouse

gas inventory and the quantity of greenhouse gases assigned to prairie crop production potentially influencing government policy.

HYPOTHESIS

Emission factors for residue-N would be lower than those for fertilizer-N.

STUDY DESIGN

This research consisted of a series of growth chamber studies using ^{15}N-labeled (stable isotope) plant residues. The stable isotope labeling enables us to identify the specific source of N in the N_2O emissions. Canola, flax, wheat, and pea residues enriched in ^{15}N were generated by growing these crops in soil amended with ^{15}N-labeled fertilizer.

Preliminary studies were conducted to (i) develop the methodology that would be needed to determine $^{15}N_2O$ production during residue decomposition, and (ii) determine rates of residue decomposition (measured as CO_2 production) and N_2O production as affected by soil type. The results of these preliminary studies were used to develop the protocols for the main study.

The main study was carried out using soils from the Black, Dark Brown, Brown, and Gray soil zones and was conducted at 50% and 70% water-filled pore space (WFPS). These values of water-filled pore space represent relatively 'dry' and 'normal' soil moisture conditions. The soils were amended with ^{15}N-labeled residues of wheat, pea, canola, and flax and $^{15}N_2O$ production monitored using a Picarro G5101-i isotopic N_2O analyzer. Daily and cumulative N_2O emissions were calculated for each treatment (i.e., crop residue type/soil-water) combination. Fertilizer and residue induced emissions were calculated by correcting for background emissions; and emission factors calculated for each crop residue/soil-water combination.

FINDINGS

Overall, the research has demonstrated that there is considerable potential for N_2O emissions from decomposing crop residues and that the original hypothesis that emissions factors for residue-N would be lower than those for fertilizer-N is likely not valid. This conclusion is supported by a recent meta-analysis of the published literature that concluded that crop residue amendments did not reduce N_2O emissions from soils and that residue effects were "likely comparable with, if not greater than, the effects of synthetic fertilizers". The results also demonstrated that the emission factor for N applied as a crop residue is not a constant, rather it is a variable coefficient that—in addition to the quantity and quality of the residue - depends on a complex interplay of soil and environmental variables.

Both water content and soil type had an impact on N_2O production. However, there was a clear and consistent trend in the emission factors for the residues; i.e., emissions were always greatest for the canola residue and lowest for the wheat residue and urea fertilizer; emission factors for pea and flax were intermediate, with the flax yielding values often slightly higher than those for the pea. Therefore, the results of this research demonstrate that—under the right environmental conditions—there is considerable potential for N_2O emissions from decomposing crop residues. Moreover, emission factors for the various crop residues

tended to increase in the order: wheat ≤ urea < pea < flax << canola.

A major success of this research was demonstrating that the Picarro G5101-i isotopic N2O analyzer provided a relatively simple, low cost analytical platform for the detection and quantification of $^{15}N_2O$. Together with existing facilities in the University of Saskatchewan Department of Soil Science, this provides a unique capability to track the fate of N in the soil/plant/atmosphere continuum. At present, this is the only laboratory in Canada with this capability.

SIGNIFICANCE OF STUDY

Results from this project provide valuable knowledge about the contribution of crop residues to soil-emitted nitrous oxide. The work will complement and extend “in-field” comparisons of the effect of crop type and cropping sequence on nitrous oxide emissions by providing more precise information on how different components of prairie cropping systems contribute to the overall greenhouse gas balance. Ultimately, the work will support changes (if warranted) to the Canadian greenhouse gas inventory and the quantity of greenhouse gases assigned to prairie crop production.

PUBLICATIONS, PRESENTATIONS, EDUCATIONAL MATERIALS PRODUCED

A presentation was made at the 2014 Annual Meetings of the Canadian Society of Soil Science in May in Banff. A second presentation was made at the International Stewardship Symposium held in Saskatoon in July 2014, as a result of an invitation from the Canadian Fertilizer Institute for Dr. Farrell to speak in the session entitled “Utilizing 4R Nutrient Stewardship to Reduce Greenhouse Gas Emissions from the Application of Fertilizer and Other Crop Nutrients”.

VALUE TO PRODUCERS

The results of this research will help Saskatchewan producers demonstrate that best management practices aimed at producing high quality pulses, cereals and oilseeds and represent responsible environmental management that addresses climate change by minimizing the greenhouse gas emissions that inevitably flow from crop production. This will allow producers to take advantage of environmental marketing opportunities that benefit from enhanced environmental quality and sustainability.