Nitrous oxide production and sources in response to a simulated fall-freeze-thaw cycle

Sisi Lin[1]; Guillermo Hernandez Ramirez[1]

E-mails: slin4@ualberta.ca and ghernand@ualberta.ca

1. Department of Renewable Resources, University of Alberta

Introduction

- **Thaw-induced N_2O** emissions have been evaluated to **account for 30-90% of annual** N_2O emissions;
- **Soil moisture** content plays an **important** role **on N_2O production**;
- In addition, **increased precipitation in fall and winter** season is expected in near future due to climate change;
- Therefore, it is relevant to evaluate the N_2O release induced by soil thawing under various soil water contents.

Objectives

The main objective was to investigate the **N_2O production and sources** under **elevated soil moisture contents** in response to **a simulated fall-freeze-thaw cycle.** Specifically, this study aimed to explore the dynamics of the priming effect regarding the N_2O emitted during thawing from soils with different N management history and water contents.

Materials and Methods

1. Soil collection and preparation

Collection:

- **Two** Chernozemic **soils** (0-20 cm) **with contrasting management histories** were collected from the same research field:

  CT = the control soil without liquid manure addition

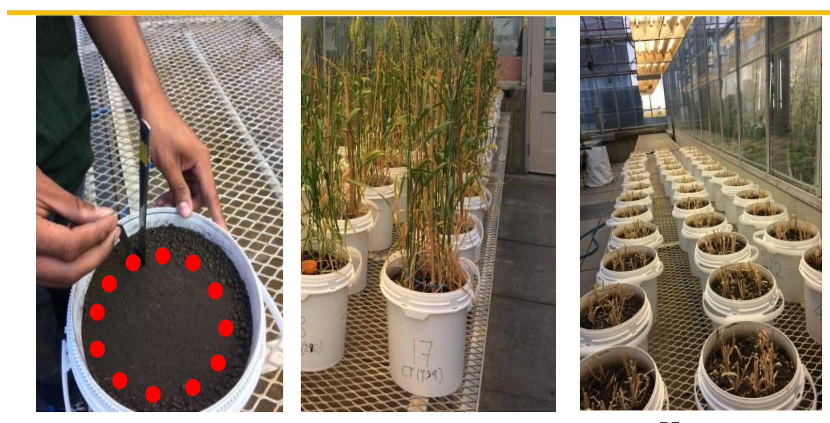
  SW = the soil receiving repeated 2-year spring liquid manure additions

Preparation:

- 8-mm sieve and mixing
- ρ_b = 1.1 g/cm^3 (similar to the field bulk density)

2. Wheat greenhouse growth + drying

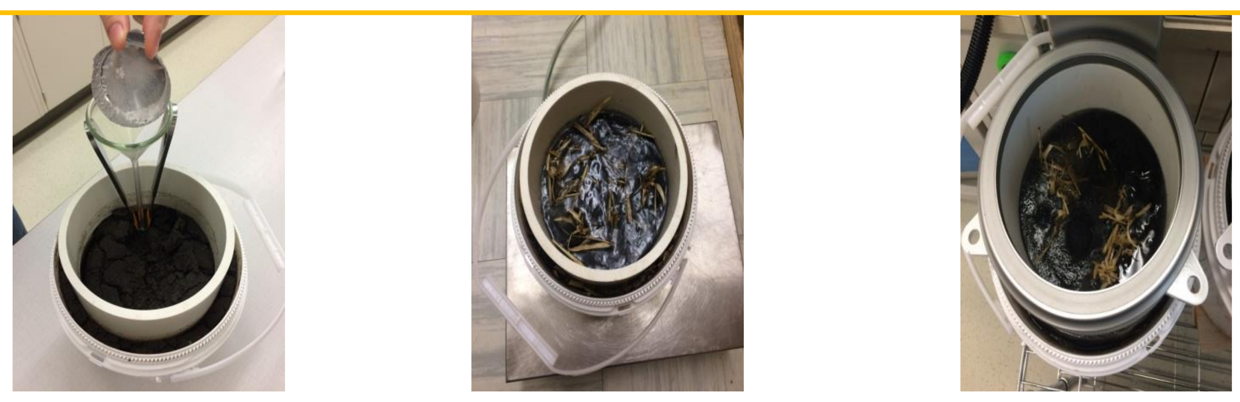
- Water: (~57% WFPS), 2-3 times/week
- Fertilizer: ~51 kg N/ha per pot



Planting Growing Harvest

3. A simulated fall-freeze$_{winter}$-thaw$_{spring}$ cycle

- Fall (2ºC): Urea and 2°C DI water added at the beginning of the fall stage
- Freezing (-18ºC): 2°C DI water was added three times to simulate the winter snow packs;
- Thawing (23ºC): soil pots were moved from -18ºC to room temperature



Urea and water additions Freezing Thawing

4. N_2O measurements

Mixing ratios of ^{14}N-^{14}N-^{16}O, ^{14}N-^{15}N-^{16}O (α) and ^{15}N-^{14}N-^{16}O (β) : mid-infrared quantum cascade laser (Aerodyne Research, Inc., Billerica, MA, USA)

Chamber for gas sampling Aerodyne instrument Computer

Results

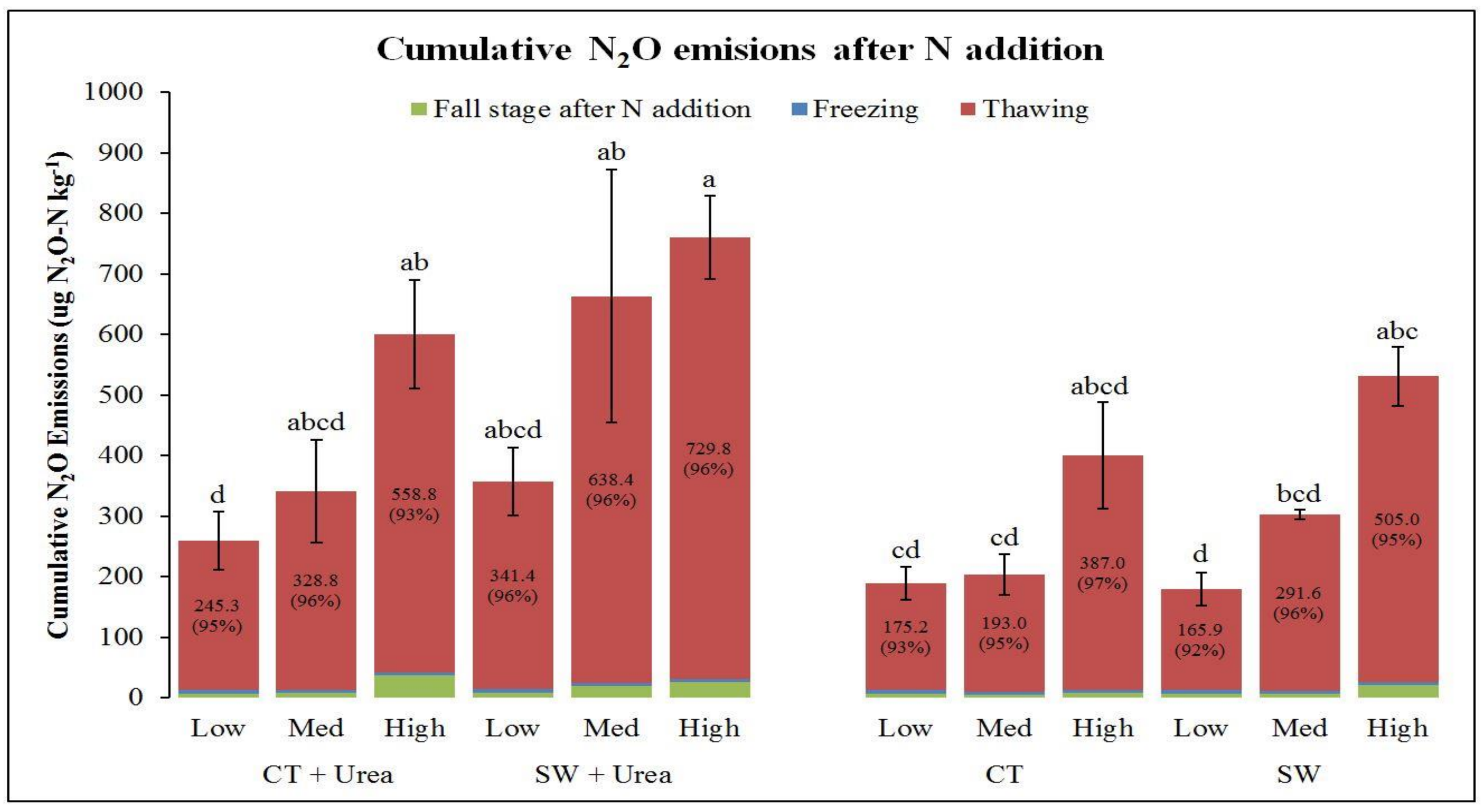


Figure 1. Cumulative N_2O emissions during the fall, freeze and thaw phases for the soil with (SW) and without (CT) historical manure additions at low (Low), medium (Med) and high (High) water contents. Different letters indicate significant differences among the treatments (P < 0.05). **Numbers above the brackets represent the thaw-induced emissions and numbers in the brackets represent the percentage of thaw-induced emissions to the total budget.** Error bars correspond to one standard error.

N_2O Production:

- Thaw-induced N_2O emissions accounted for at least 92% of total emissions.
- Increasing soil water content in resulted in an increase in total N_2O emissions.

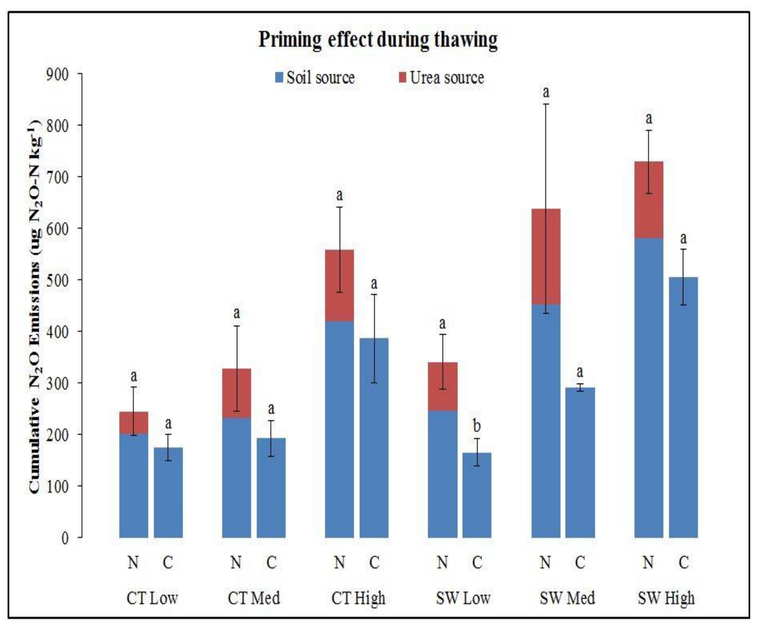


Figure 2. Priming effect of N addition on cumulated N_2O emissions during thawing for the soil with (SW) and without (CT) historical manure additions at low (Low), medium (Med) and high (High) water contents. **Different letters indicate significant difference between the soil with (N) and without (C) urea additions within each treatment group (*P* < 0.05).** Error bars correspond to one standard error.

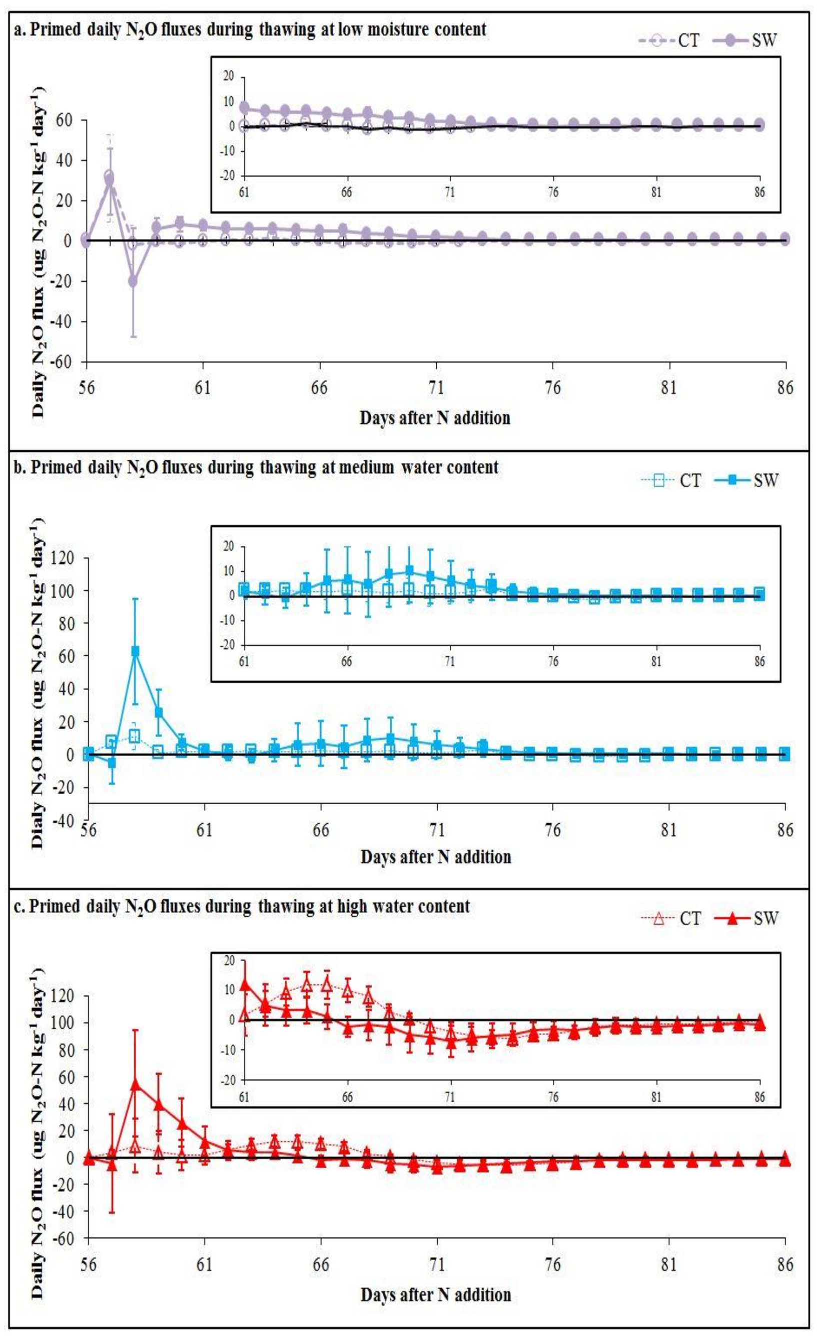


Figure 3. Primed daily N_2O fluxes during thawing for the **soil with (SW) and without (CT) historical manure additions** at **(a) low (Low), (b) medium (Med) and (c) high (High) water contents**. Positive and negative primed daily N_2O fluxes represent a positive and negative daily priming effect, respectively. Error bars correspond to one standard error.

N_2O Sources:

- The fall-applied N fertilizer induced more soil-derived N_2O emissions, which means a positive priming effect;
- Larger net positive priming was found in the SW compared to the CT soils;
- Apparent negative primed N_2O fluxes took place in both soils at the high rather than the lower water contents.

Summary

- The increased N_2O emissions caused by increasing soil water content indicates potential accelerated N losses as response to prospective greater precipitation in the fall and winter as induced by climate change;
- The positive priming effect observed in the thaw-induced cumulated N_2O emissions indicates an excessive mineralization caused by the fall-applied urea;
- Larger net positive priming effects in the SW soil could be due to that the SW soil would have more easily decomposable organic matter (OM) which was associated with historical manure amendments;
- Negative primed N_2O fluxes indicates an immobilization at the high water contents.

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