Effect of Irrigation on Displacement of Greenhouse Gases from Soil Pore Space

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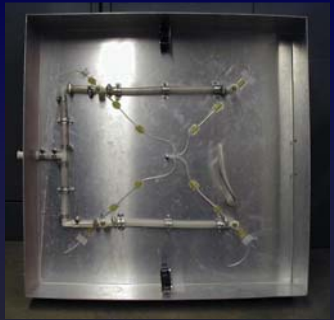

Reason

Fluxes of greenhouse gases (GHGs) (specifically CO_2 and N_2O) from soils are influenced by soil water content. The evolution of N_2O increases as the soil becomes more saturated and anaerobic after rainfall or irrigation events. Biological processes associated with GHG evolution from soil microbial activity are better documented than physical processes. As water begins to infiltrate the soil pore space, the gases already residing in the soil are displaced.

Objective

The goal of this work was to evaluate the physical displacement of GHGs as water infiltrates the soil pore space.

Introduction

Sampling methods for GHG emissions vary greatly among researchers. Most researchers agree that non-continuous point-in-time measurements of gases are not ideal, but are the most cost-effective and practical method. The most popular sampling technique is a vented closed chamber. Despite the potential bias of under- or overestimation of flux over time by missing or hitting peaks, this method will still do a fairly accurate job of comparing treatments when replicated in the field.

Fluxes of GHGs are greatly influenced by soil water content. When the soil becomes saturated after a rainfall or irrigation event, microbial activity in the soil is increased. Denitrification (NO_3 converted to N_2O) occurs as soil microorganisms remove oxygen from the NO_3 molecule. The resulting N_2O gas is released into the atmosphere. Most data indicate that GHG emissions are maximized from 18-30 h after a rainfall/irrigation event. However, there is little information in the literature related to the physical displacement of gases already residing in the soil, which are forced out as water moves into the soil pore space. This experiment addresses this subject to determine if point-in-time sampling methods are missing large flushes of gases from physical displacement, which would lead to an underestimation of overall gas flux.

Materials and Methods

Date: 12 June 2006.
Location: Shelton, NE.
Experimental Design:
Randomized Complete Block.
Treatment Effects:
1. Non-irrigated
2. Irrigated
Replications: 4
Sampling Method: vented chamber:
- Steel anchors (76 cm x 76 cm) buried to a depth of 8 cm.
- Aluminum spacers (76 cm x 76 cm x 15 cm) placed over anchors and sealed with water (to match nozzle height with desired spray circumference).
- Aluminum lids (76 cm x 76 cm x 15 cm) placed over spacers and sealed with water.
- Lids fitted with tubing/nozzle system to irrigate soil while chambers are deployed.

Irrigation: supplied at 1.45 L min^{-1} for 12.7 mins [total = 1.25 inches].
Time Interval: gas samples taken at 5, 10, 15, 30, 60, and 90 mins to determine flux.
Data Analyses: linear regression over two time periods:
1. Irrigation Period (t = 5-15 mins)
2. Infiltration Period (t = 15-90 mins)

Flux Equation: $F = k\, d\, (273/T)\, (V/A)\, (\Delta C/\Delta t)$

Results

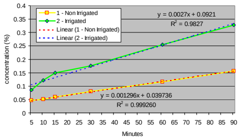

Fig. 1 Example of CO_2 Flux from a Non-Irrigated and Irrigated plot.

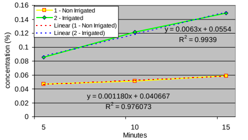

Fig. 2. Example of CO_2 Flux from a Non-Irrigated and Irrigated plot during irrigation period (5-15 mins).

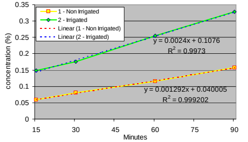

Fig. 3. Example of CO_2 Flux from a Non-Irrigated and Irrigated plot during the infiltration period (15-90 mins).

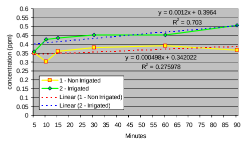

Fig. 4 Example of N_2O Flux from a Non-Irrigated and Irrigated plot.

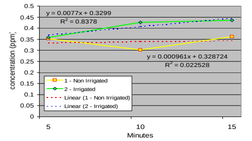

Fig. 5. Example of N_2O Flux from a Non-Irrigated and Irrigated plot during irrigation period (5-15 mins).

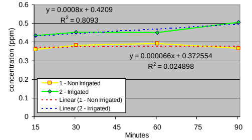

Fig. 6. Example of N_2O Flux from a Non-Irrigated and Irrigated plot during the infiltration period (15-90 mins).

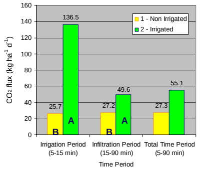

Fig. 7. CO_2 emissions for the irrigation, infiltration, and total time periods (n=4).

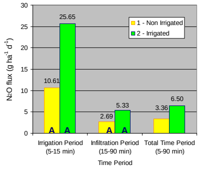

Fig. 8. N_2O emissions for the irrigation, infiltration, and total time periods (n=4).

Discussion and Conclusions

Concentration increases for CO_2 during the total time period (Fig. 1), irrigation period (Fig. 2), and infiltration period (Fig. 3) had high R^2 values, while the concentration curves for N_2O (Figs. 4-6) were noisier (lower R^2 values). Because of this, significant differences at $P \leq 0.05$ were seen in CO_2 data (Fig. 7), but not in N_2O data (Fig. 8) for this specific date. Inclusion of data from additional dates and sites will clarify the effect of water infiltration on N_2O efflux.

The trends for both analyzed gases were very similar between treatments. During the irrigation period, emissions were 2.4 (N_2O) to 5.3 (CO_2) times greater in irrigated conditions. The fluxes in the irrigated treatment were approximately double those of the non-irrigated treatment for the infiltration and total time periods.

These trends show that displacement of gases from soil pore space occurs quickly upon wetting and water infiltration. Since most closed chamber methods can not account for this physical displacement at initial wetting, many researchers may be underestimating total gas fluxes.