Effects of N Fertilization and Irrigation on Nitrification and Denitrification Pools of N_2O: Acetylene Inhibition Microplot Study

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INTRODUCTION

Assessment of nitrification and denitrification pools of N_2O is required for mitigation of the effects of agricultural practices on global climate change. Acetylene is used for preventing nitrification and therefore eliminating respective pool of nitrous oxide by deactivating ammonia monoohygenase enzyme, which catalyzes ammonia oxidation process. The inhibition reaction happens at 0.1-10Pa (0.01%) concentrations of acetylene. At 100Pa (0.1%) concentrations acetylene also affects denitrification by inhibiting reduction of nitrous oxide to nitrogen gas. The current study was designed to evaluate the effects of acetylene injection in situ, N fertilization and repeat water additions on N_2O and CO_2 emissions in no-till winter wheat system in Pacific Northwest.

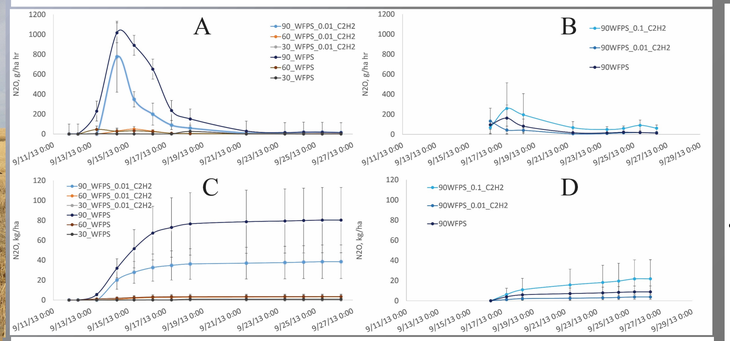
MATERIALS AND METHODS

We implemented two Li-Cors 8100A coupled with two LGR 23r N_2O analyzers in continuous flow through chamber system for monitoring of CO_2 and N_2O emissions in the short term microplot study between September 11 and September 21, 2013. The following treatments were established following the first irrigation event: 1) three treatments of 150 kg NH_4NO_3-N ha^{-1} and acetylene injection at 0.01% at 9:00, 21:00 and 9:00 the following day, respectively; 2) no fertilizer N added and acetylene injection at 0.01% at 9:00, 21:00 and 9:00 the following day, respectively; 3) a treatment of 150 kg NH_4NO_3-N ha^{-1} and no fertilizer without acetylene injection. This was followed with the irrigation events at 21:00 on September 13, 7:30, 13:00 and 17:00 on September 14, and 7:30 on September 15. The treatments were modified as follows at 9:00 on September 15: three treatments of 150 kg NH_4NO_3-N ha^{-1} applied to plots, which were not fertilized on September 11 and acetylene levels were established at 0.1%, 0.01% and no acetylene, respectively. The plots were further irrigated at: 16:00 on September 16, 13:00 on September 17, 13:00 on September 18, 17:00 on September 19, 10:00 on September 20.

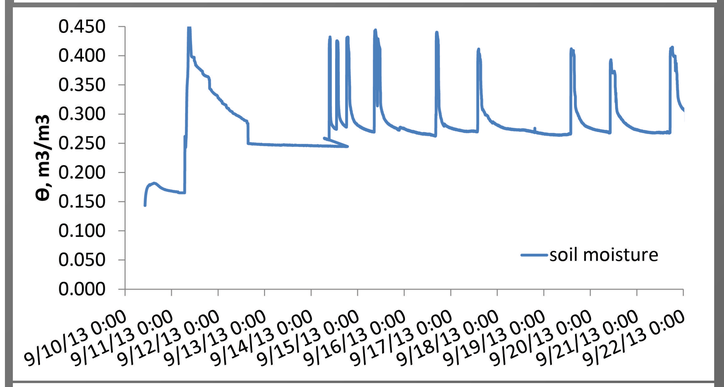
A soil core incubation was established concurrently with in-situ acetylene injection study to obtain nitrification to denitrification as well as potential denitrification ratios to predict actual and potential denitrification for field chamber dataSoil cores from 20cm depth were placed in the 30cm clear plastic tubes, which were inserted in soil in the field adjacent to the chamber study, and the following treatments were established: 1) 150 kg NH_4NO_3-N ha^{-1} at 0.01% of acetylene and no acetylene at 90%, 60% and 30% water-filled pore space (WFPS); 2) 150 kg NH_4NO_3-N ha^{-1} at 0.1%, 0.01% of acetylene and no acetylene at 90% WFPS. The cores were maintained sealed for 22 hours at a time; an air sample from the headspace of each core was then collected and analyzed in laboratory on gas chromatograph for nitrous oxide concentration.

RESULTS AND DISCUSSION

Soil Core Incubation:

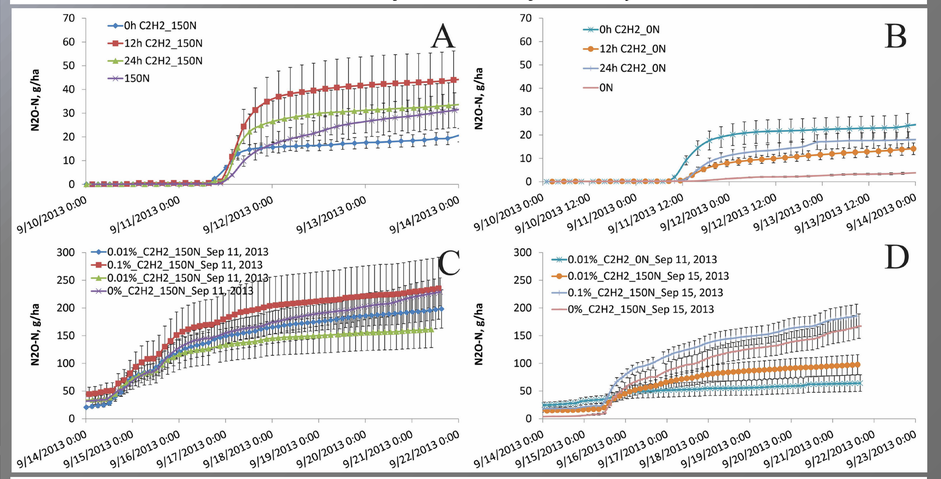


The levels of N_2O were highest in the 90% WFPS no acetylene treatment **(A, B)**. This showed that a combination of nitrification and denitrification produces most N_2O upon initial wetting at near saturation levels. The levels of N_2O for 0.01% acetylene treatments were lower than no acetylene treatments at 90%, 60% and 30% WFPS **(A, C)** indicating that both nitrification and denitrification processes contribute to N_2O production across all moisture levels. The fraction of N_2O originating from denitrification was 0.93 at 60%WFPS, 0.48 at 90%WFPS and 0.1 at 30%WFPS **(C)**. This was likely due to slow rate of nitrification at 90%WFPS, resulting in prolonged nitrification-borne N_2O levels compared to the 60%WFPS treatment, which favors faster nitrification. Denitrification potential was 2x higher than actual N_2O and 8 times higher than the level of N_2O from denitrification at 90%WFPS (D).

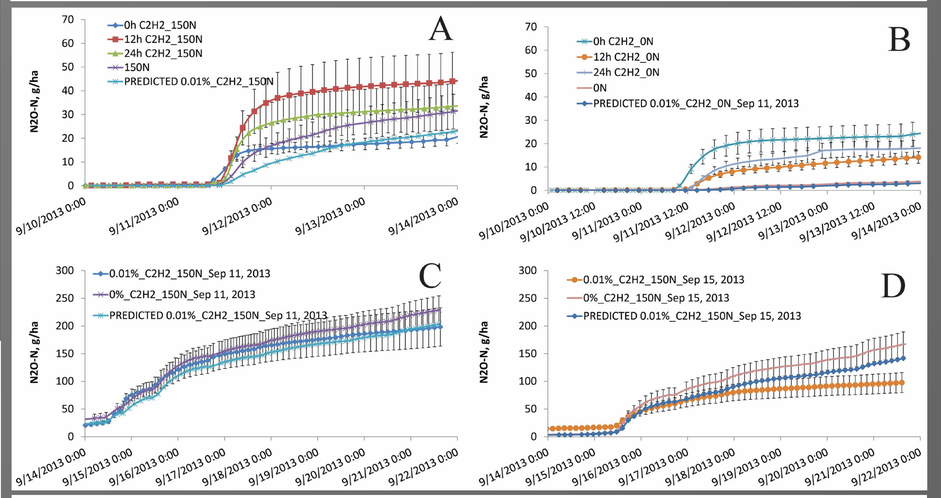


Irrigation events to achieve temporary saturation at 15 cm

Automatic Static Chamber Study with Acetylene Injection in Situ:



Only several days of irrigation and acetylene injections could be efficient in blocking nitrification and reduction of N_2O to N_2.



Predicted levels of denitrification based on the core incubation data matched well with the measured denitrification levels after several irrigation and acetylene injection events (Figure 5). The data showed that 85-88% of all N_2O emissions in the field originated from denitrification.

CONCLUSIONS

- Core incubation experiment demonstrated much higher rates of N_2O than the in-situ chamber microplot study.
- Increased N_2O emissions in the core incubation were attributed primarily to 90% WFPS and 60%WFPS.
- Lower cumulative N_2O rates in the in the microplot study were likely a result of short lived spikes in soil moisture due to drainage even with repeat irrigation events.
- Rapid nitrification in situ could result in low NH_4^+ and increased NO_3^- leaching under repeat irrigation.
- In situ chamber measurements in the combination with the core incubation are required to obtain realistic nitrification and denitrification pools of N_2O.

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