Greenhouse gases emission from Wisconsin soils in long-term corn-based crop rotations (2012-2013)

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INTRODUCTION

The Midwestern region of the USA is based on intensive corn production. This region has the potential for mitigating the anthropogenic greenhouse gases emission (GHGs) of carbon dioxide (CO_2), nitrous oxide (N_2O), and methane (CH_4). In the USA, agricultural soils account for almost 70 percent of the total N_2O emissions mainly from N fertilizers and other soil management practices. However, an increase of GHGs has recently been reported (1). The increase of CO_2 concentration in the atmosphere is connected to fossil fuel combustion and land use change from management practices that lead to soil organic carbon loss. Therefore, improving these practices has a mitigation potential (2). Unlike nitrogen fertilizer and tillage management practices, crop rotation effects are often overlooked by farmers in relation to GHGs emission. Continuous corn is a rotation that has been recognized to emit the highest amounts of GHGs to the atmosphere and by adding more crops into the rotation we may be able to reduce GHGs (3,4).

Our objective was to compare GHGs emission in years 2012-2013 of six rotation treatments at three locations in Wisconsin. Sufficient time has passed to allow these extended crop rotations experiments to equilibrate differences within treatments.

MATHERIALS & METHODS

Location (LOC)	Arlington, Lancaster, Marshfield, Wisconsin
Data Type	CO_2, N_2O and CH_4 (GHGs) field emission
Sampling Interval	Weekly at Arlington, Biweekly at Lancaster and Marshfield
Treatments (TRT)	1. Continuous corn (C)* 2. Corn-soybeans (CSc) 3. corn-Soybeans (CSs) 4. Corn-soybeans-wheat (CSWc) 5. corn-Soybeans-wheat (CSWs) 6. corn-soybeans-Wheat (CSWw) *Capital = current crop
Method	In-situ closed-cover flux chambers
Chamber Placement	IR-in row, BR- between row (N= 12 per rep)
Detailed Description	Gas fluxes were measured at four-20 minute sampling intervals. Samples are taken from gas traps by inserting a 30 mL syringe into the rubber septa from where 20 mL was used to flush a vented 5 mL glass vial and remaining 10 ml was placed in the glass vial, giving the vial a gas overpressure.
Analysis	The experimental design was a randomized complete block in a split-plot arrangement, with three replications. Whole plot factors were rotation treatment, and the split plot factor was the chamber placement. Analysis of variance for the factors location, rotation treatment, chamber placement, and replications as blocks was performed using the PROC MIXED procedure of SAS (SAS Inst., 2008).

Fig.1. Cumulative N_2O emissions averaged across chamber placement at three locations in Wisconsin. Data compares six different treatments during the 2012 and 2013 growing seasons.

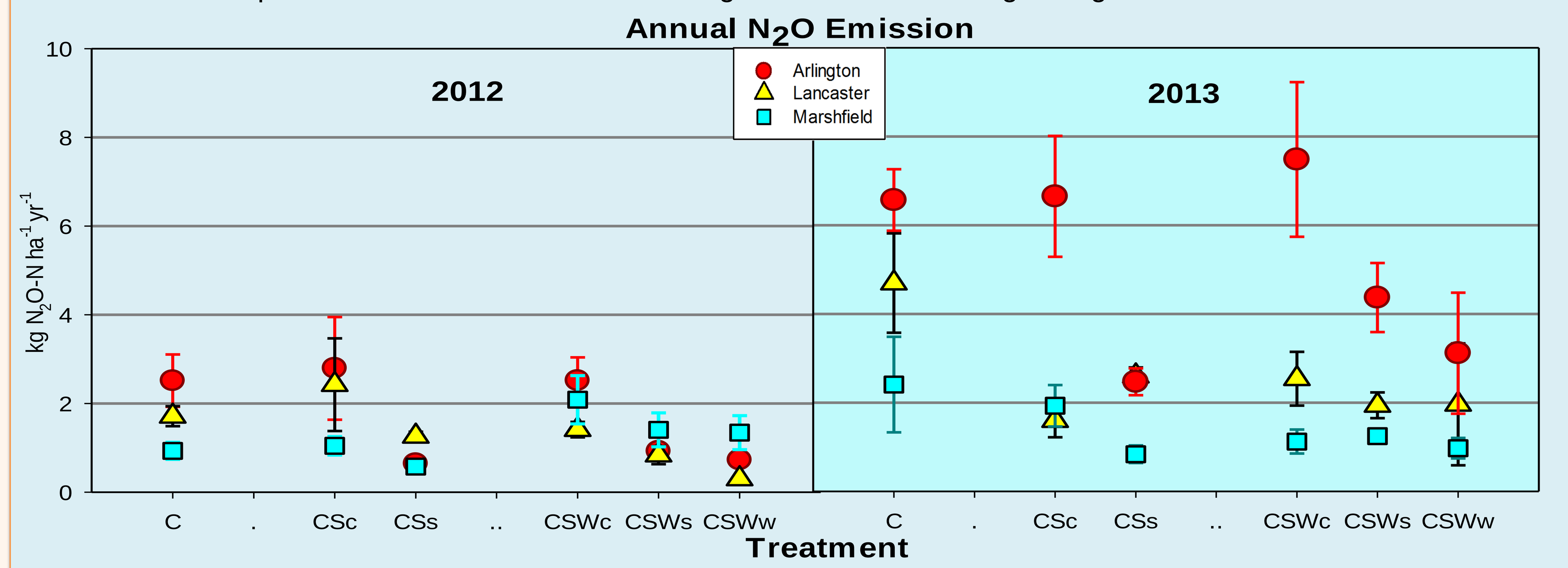


Fig.2. Cumulative CO_2 emissions averaged across chamber placement at three locations in Wisconsin. Data compares six different treatments during the 2012 and 2013 growing seasons.

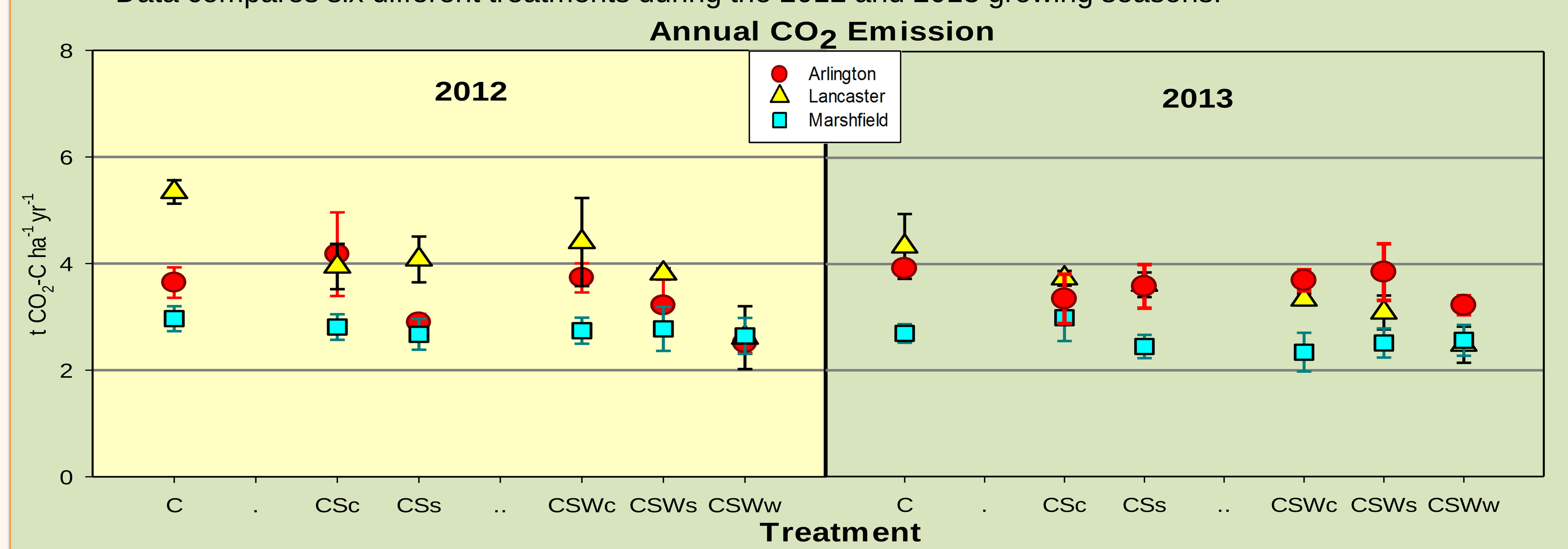
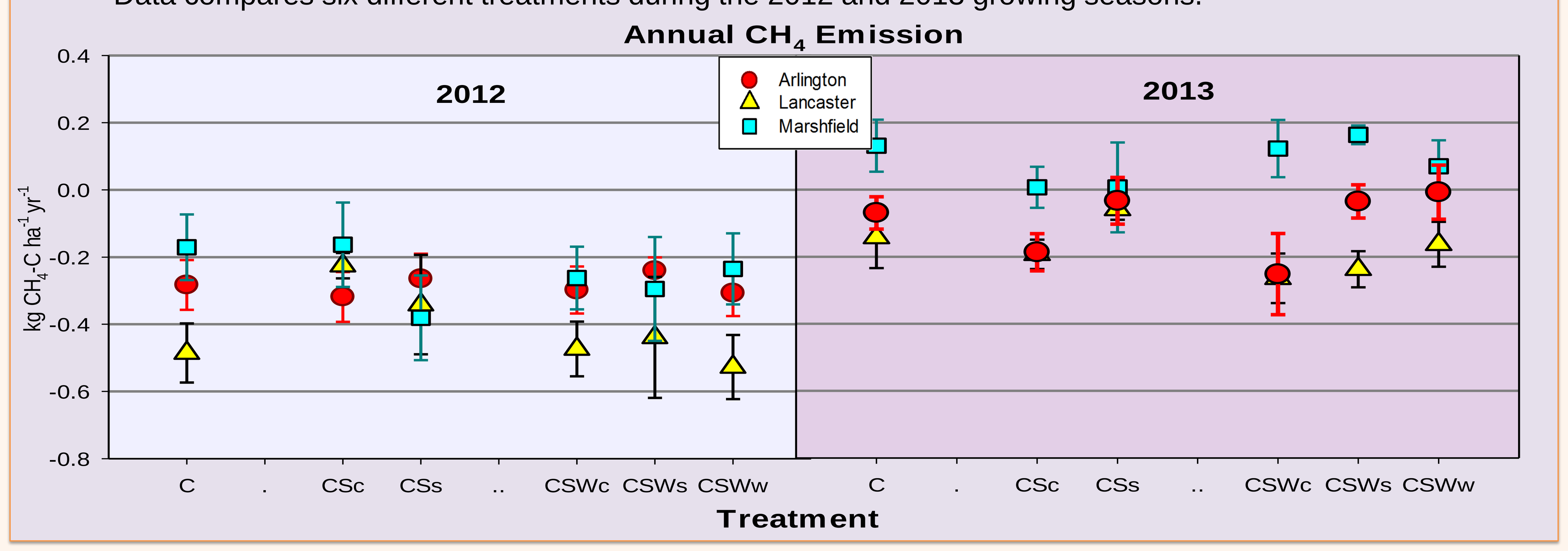
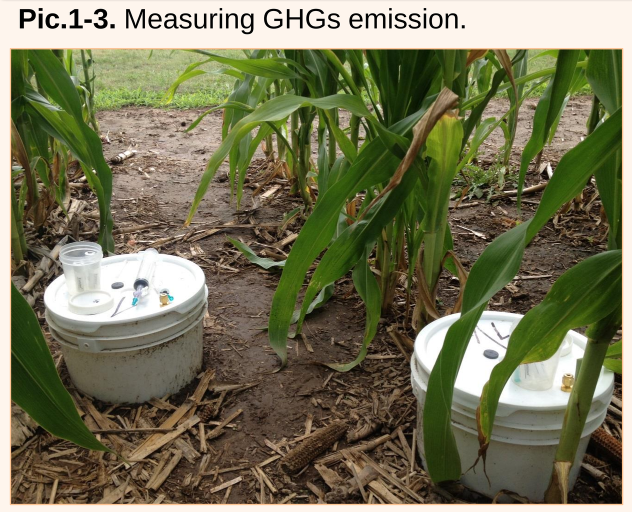


Fig.3. Cumulative CH_4 emissions averaged across chamber placement at three locations in Wisconsin. Data compares six different treatments during the 2012 and 2013 growing seasons.



Pic.1-3. Measuring GHGs emission.

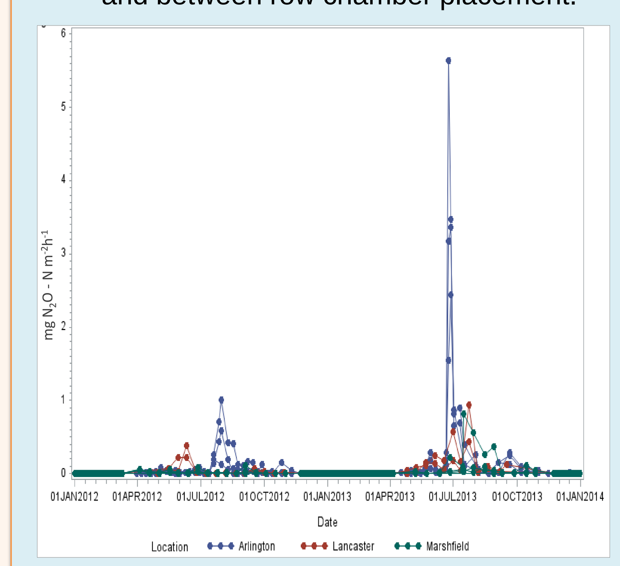


RESULTS

N_2O

Similar to other research (4,5), N_2O emissions were highly controlled by soil moisture and nitrogen fertilizer inputs resulting in different emissions between years (Fig.1). In 2012, there were TRT and TRT x LOC effects ($p<0.05$). In each rotation, the corn phase had the highest emissions. In 2013, LOC and TRT were different ($p<0.05$). Overall, emissions at Arlington were the highest in every corn phase across rotations. Averaged across rotations, 2012 had 67, 48, and 13% lower N_2O emissions than 2013 at Arlington, Lancaster, Marshfield, respectively.

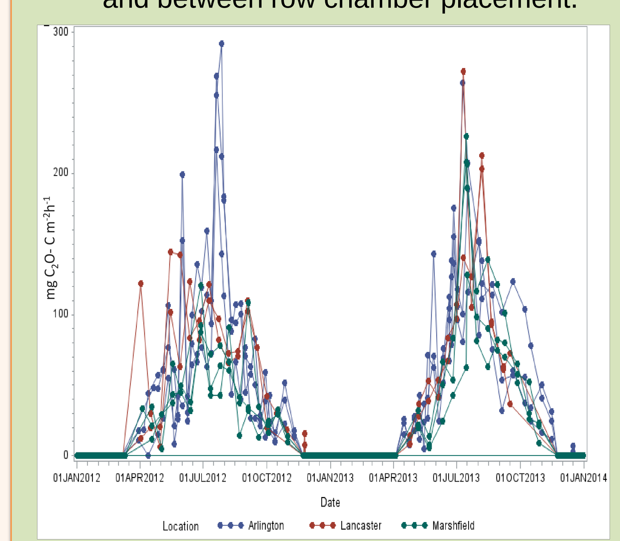
Fig.4. 2012-2013 N_2O emissions at three locations for the continuous corn treatment and between row chamber placement.



CO_2

In both years, CO_2 emissions increased as air temperature increased and crop growth progressed which led to higher respiratory losses from roots (5). There was no year effect on CO_2 emissions ($p>0.05$), therefore; 2012 and 2013 were combined in the analysis (Fig.2). There were significant LOC, TRT, TRT x LOC, and LOC x year effects ($p<0.05$). Marshfield emitted less CO_2 compare to other locations. Continuous corn emitted significantly more CO_2, while winter wheat emitted less CO_2 than other treatments.

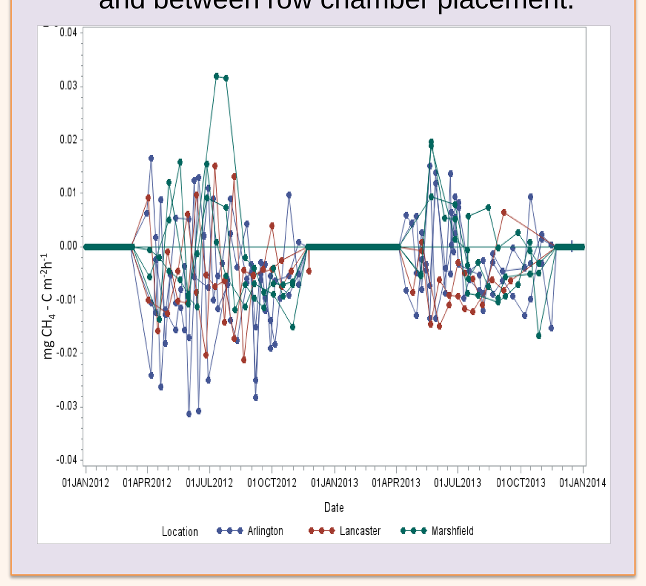
Fig.5. 2012-2013 CO_2 emissions at three locations for the continuous corn treatment and between row chamber placement.



CH_4

Years differed in response to CH_4 emissions ($p<0.05$) (Fig.3). In 2012 under dry conditions, all treatments in all locations appeared to be a small methane sink meaning that the near ground atmospheric methane was consumed by methanotrophic bacteria (6). In 2013, there were significant LOC, TRT, and LOC x TRT effects ($p<0.05$). Under continuous wet conditions, at Marshfield, all rotations produced small amounts of methane. Whereas, rotations at other locations were a slight methane sink.

Fig.6. 2012-2013 CH_4 emissions at three locations for the continuous corn treatment and between row chamber placement.



CONCLUSIONS

- These results provide a better understanding on how weather conditions might affect GHGs emission from agricultural soils.
- These results will help develop best-management recommendations for minimizing GHGs emission from corn-based systems.

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