CAPITALIZING ON THE ROTATION EFFECT TO INCREASE YIELD: THE ROTATION EFFECT ON GREENHOUSE GAS EMISSION FROM WISCONSIN SOILS

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Climate change projections suggest an increased variability of extreme climate conditions, such as sustained drought or prolonged precipitation (IPCC, 2007; USDA, 2012). The early growing season for 2012 and 2013 contrasted significantly in Wisconsin, where 2012 was one of the driest seasons ever recorded while 2013 was one of the wettest. These events had a negative effect on Wisconsin crop production.

Agriculture plays a significant role in the global flux of three major greenhouse gasses (GHG - CO_2, N_2O and CH_4), which when trapped in the atmosphere warms the surface of the Earth via infrared radiation (IPCC, 2007; USDA, 2012). A large amount of these gas fluxes are thought to be derived from soil through crop intensification (USDA, 2012). Improved management practices like reduced tillage, controlled fertilization (Snyder et al., 2009) or extended crop rotation (Drury et al., 2008) are of particular interest because they have a high potential to mitigate gas emissions. Corn rotation is a management practice of high mitigating potential, but due to recent economic influences is often neglected. The effect of crop rotation on GHG emissions is usually positive for mitigation (Drury et al., 2008; Adviento-Borbe et al., 2007; Venterea et al., 2005). Unlike nitrogen fertilizer and tillage management practices, crop rotation effects are often overlooked by farmers in gas emissions.

Our objective was to compare early-season GHG emissions between 2012 to 2014 of six rotation treatments at the Arlington Research Station, WI. Sufficient time has passed to allow these extended crop rotation experiments to equilibrate differences within treatments.

Materials and Methods

Three fields at different locations in Wisconsin, were established (i) to assess potential opportunities in mitigating GHGs emission by comparing the fluxes from monoculture corn (C), 2-yr corn-soybean rotation (CS), and 3-yr corn-soybean-wheat rotation (CSW) (ii) to compare GHG emission of different corn phases within rotations with each phase measured, and (iii) to determine how seasonal and spatial variability during crop production influences emissions under identical N fertilizer management.

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. Sufficient time has passed since plot establishment in 2000 to allow these extended crop rotation experiments to equilibrate differences within

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treatments. Gas fluxes were measured using *in situ* closed-cover flux chambers at four 20-minute sampling intervals permanently installed in the rows (IR) and between the rows (BR). 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. Sampling was done on weekly or biweekly schedules between March and November. Gas fluxes were measured using a gas chromatograph. GHG emissions were influenced by weather conditions and peaks of N_2O additionally followed N application.

Analysis of variance for the factors location, treatment, chamber placement, and replications as blocks was performed using the PROC MIXED procedure of SAS (SAS Inst., 2008).

Results and Discussion

We observed significant (p<0.05) rotation and chambers placement effects on CO_2 and N_2O fluxes in all locations. Generally, across locations and rotations, CO_2 and N_2O fluxes from corn plots were significantly (p<0.05) higher than from soybean which was significantly higher than from wheat. Even though there was no difference between rotation treatments in CH_4 emission, they all appeared to be a slight sink differing between locations. These results suggest that application of extended corn rotations, preferably CSW rotation, may potentially contribute to global GHG mitigation.
At Lancaster, chambers placed between rows emitted 36 and 33% more CO_2, 75 and 35% more N_2O and captured 49 and 64% more CH_4 than Arlington and Marshfield, respectively. Chambers placed in-row at Lancaster emitted 41 and 37% more CO_2, 69 and 13% more N_2O and captured 2 and 41% more CH_4 than Arlington and Marshfield, respectively. Arlington noticeably contributed the least N_2O, which might be explained with unusually dry weather conditions.

Generally, across locations and chamber placement, the rotation treatments cS, cSw, and csW, compared to continuous corn, emitted to the environment less CO_2 by 34, 27, and 29%, and less N_2O by 38, 25, and 48%, respectively.

N_2O emissions were highly controlled by soil moisture. Under very wet conditions in 2013, averaged emissions were 132% higher IR and 385% higher BR compare to 2012, where winter wheat surprisingly had the highest emissions. There was an effect (p<0.05) of year, treatment, chamber placement and year x place.

Averaged between all treatments, 2013 had 43% higher emissions BR and similar IR to 2012. Across chamber placements all 2012 treatments where corn was grown had the highest CO_2 emissions, whereas in 2013 the lowest, except C and CSWc treatments placed BR.

Averaged within all treatments, soils were a minor CH_4 sink where 2012 was significantly greater. In 2013, positive CH_4 emissions were recorded under C, CSWs, and CSWw treatments in both chamber placements.

Conclusions

- These results provide an important understanding on how different weather conditions might affect GHG emissions from agricultural soils.

- These results will help develop best-management recommendations for minimizing GHG emissions from corn-based systems.

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