Tillage and Rotation Effects on CO_2, CH_4, and N_2O Emissions from Two Long-Term Sites in Ohio

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Abstract: Soils may be a source or sink of greenhouse gases (CO_2, N_2O, CH_4) that lead to global warming and climate change. While it is known that greenhouse gases are naturally cycled through soil, and are part of the C and N cycles, it is not fully understood what effect crop production practices have on this cycling. The longest, continually maintained no-tillage plots in the world at Wooster (50 years) and Hoytville (48 years) represent two contrasting Ohio soils and were the sites for my study. Greenhouse gas fluxes were measured bi-weekly during the growing season at both sites in plots with rotations of corn after corn (CC) and corn after soybean (CS) in no-tillage (NT) and chisel tillage (MT). For both sites CO_2 emissions from soil were significantly (α =0.1) higher for the CC than the CS rotation following rainfall. However, between rainfall events, there were no differences. For N_2O the MT system resulted in significantly (α =0.1) higher emissions than the NT system with differences in crop rotational effect showing between the sites in the later growing season. Emission fluxes were 3 and 4 times larger for CO_2 emissions than for N_2O and CH_4 respectively at each site with Hoytville being slightly higher in all emissions. Overall, there seemed to be little difference or slightly less greenhouse gas emissions when soils were maintained for long-term under NT compared to MT.

Introduction: Today, agriculture is one of the most active and lucrative industries in the world, providing jobs and sustenance to millions of people all over the world. It is one of the oldest professions, yet one that still has not figured out the best practices to follow in this new and environmentally conscious world. Technological advances allow for more production per acre, greater crop yield, less pest problems, more crop rotation, and less time for fallow fields. These advances were necessary to deal with the ever growing populations that need to be fed but choose to live in urban areas where subsistence food production is not possible. These advances have also had some adverse affects. Agriculture now makes up one of the largest contributors of anthropogenic greenhouse gas (GHG) emissions leading to global warming.

Materials and Methods: Gas chambers were placed in both Wooster and Hoytville sites in early July following planting and samples were taken bi-weekly as well as following rainfall events that were greater than 0.3 inches. Samples were analyzed on a GC at IUPUI for concentrations of CO_2, CH_4 , and N_2O.

Statistics: Sample data was transformed (Ln(X+C)) and an ANOVA with Tukey multiple comparisons was then run for each sample date at the α=0.1 level.

CO_2
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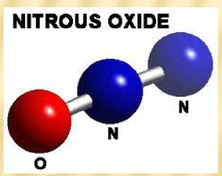

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Results:

Gas	Wooster	Hoytville
CO_2	MT>NT, Following Rainfall: CC>CS and NT>MT	NT>MT, Following Rainfall: CC>CS, NT>MT
CH_4	CS>CC	MT>NT
N_2O	CC>CS, MT>NT	Planting to Late Reproductive: CC>CS, MT>NT Late Reproductive: CS>CC, MT>NT

Bold Lettering signifies the most important factor for determination of gas fluxes.

Greenhouse Gases	Global Warming Potential (Over 100 years period)
Carbon Dioxide (CO_2), naturally occuring in the Earth's atmosphere, is now released in considerable amounts due to increased human activity.	1
Methane (CH_4), a principal component of natural gas, is a relatively potent greenhouse gas.	25
Nitrous Oxide (N_2O) is a colorless non-flammable gas, with a pleasant, slightly sweet odor under room conditions.	298

Source: "The Physical Science Basis, Intergovernmental Panel on Climate Change"

Results:

- CO_2: Between rainfall events tillage plays role in determining emissions. Following rainfall events crop rotation effects help to determine emissions
  - Wooster
    - No Rainfall: NTCS lowest, no difference between other plots
    - Rainfall: MTCS lowest, no difference between MTCC and NTCC for highest
  - Hoytville
    - No Rainfall: NTCC highest, MTCS lowest
    - Rainfall: NTCC highest, no difference between other plots
- CH_4: Little effect from crop production practices. Low emissions overall and overall close to net zero
  - Wooster: MTCS and NTCS highest
  - Hoytville: MTCC and MTCS highest
- N_2O: Tillage played the most important role but crop rotation showed some effect
  - Wooster: MTCC highest, NTCS lowest
  - Hoytville
    - Early Growing Season: MTCC highest, NTCS lowest
    - Late Growing Season: MTCC highest, NTCC lowest.
      - There was a shift in NT with CC becoming lower in emissions than did the CS while MT remained the same
- CO_2 emissions were 3 orders of magnitude larger than N_2O and 4 orders of magnitude larger than CH_4

Discussion: Results of this experiment show that there is no one solution for greenhouse gas emissions. In order to mitigate the greenhouse gas emissions from agricultural fields it is important to understand which gas should be the main focus for mitigation. CO_2 was emitted at larger magnitudes that may out weigh the need to manage for N_2O, even with its higher GWP. For the Wooster site CO_2, CH_4 , and N_2O all appear to be affected by the same practices so one choice can be made for all gases emissions. The Hoytville site appears to come down more to a balancing act. Managing for optimal emissions of all gases can not be achieved so a choice for one gas, or a compromise slightly beneficial for all gases would need to be made. These choices would also need to be based on the expected weather for the coming year, as rainfall plays a role in CO_2 emissions as well as on the expected effect of each gas. Further research is needed to understand the phenomena seen as well as what other factors are involved including the effect of sampling date.

Conclusions: Overall, NT systems produced the same or slightly less emissions than did MT and CS produced slightly less or the same emissions as CC. While our more conservative or modern techniques might not have greatly mitigated emissions, they have not increased emissions and have shown promise towards reducing overall agricultural greenhouse gas emissions.

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