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Effect of cover crops on nitrous oxide emissions, nitrogen availability and carbon accumulation in organic versus conventionally managed systems

Baas, D.G.[1], Mutch D.R.[1], Robertson G.P.[2], Millar, N.[2] and Miller, S.R.[3]

[1]Michigan State University Extension, 612 E. Main Street, Centreville, MI 49032

[2]Michigan State University, W.K. Kellogg Biological Station, 3700 E. Gull Lake Drive, Hickory Corners, MI 46060

[3]Michigan State University, Agriculture, Resource and Food Economics, 446 W. Circle Drive, Rm 88, East Lansing, MI 8824

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ABSTRACT We propose a study to investigate the effects of various cover crops, specifically their residue quality and termination time, on nitrous oxide (N_2O) emissions, nitrogen (N) availability patterns and carbon (C) accumulation in major Midwest field crop systems under organic and conventional management.

Our goals are:

1. to determine the potential of cover crops as management options for improving N synchrony with cash crops,
2. evaluate the impact of cover crops on N_2O emissions, and
3. improve farmer knowledge of cover crop utilization in relation to N utilization efficiency (NUE) and economic potential through decision tools and communications.

Over three field seasons we will conduct in situ measurements of N_2O fluxes, soil N availability and C concentrations, and relate these to field operations and crop quality parameters at certified organic and conventionally managed plots at the same site.

We will use these data to:

1. improve extension tools by providing information on the greenhouse gas (GHG) impacts and NUE of using cover crops,
2. evaluate economic costs associated with transitioning between conventional and organic systems
3. identify opportunities for including cover crop management in offset methodologies for environmental markets, and
4. expose data for use by others to test and refine process-based, field-scale GHG simulation models.

This research will address USDA ORG 2011 program priorities for documenting and understanding the effects of organic practices on GHG emissions and improved technologies and metrics to document and optimize the environmental services and climate change mitigation ability of organic farming systems.

METHODS

The research design is a randomized split-split-block (RSSB) design with four replications for a corn-soybean-wheat rotation (Figure 1) under conventional and organic management practices.

Treatments:

1. Corn
   a. Cereal rye cover crop
   b. No cover crop/no-till (conventional only)
   c. No cover crop
2. Soybeans
   a. Wheat cover/cash crop
   b. No cover crop/no-till (conventional only)
   c. No cover crop
3. Wheat
   a. Frost-seed red clover cover crop
   b. Oilseed radish cover crop
   c. Annual ryegrass cover crop
   d. No cover crop

Management:

The certified organic site and conventional site are located at the Michigan State University W.K. Kellogg Biological Station and managed independently according to the practices typical for each in Michigan using timing based on the growing season (Figure 2).

- Organic: Organic certified or non-GMO seed, organic fertilizers and rotary hoe/cultivation for weed control
- Conventional: GMO seed, synthetic fertilizers and herbicides for weed control

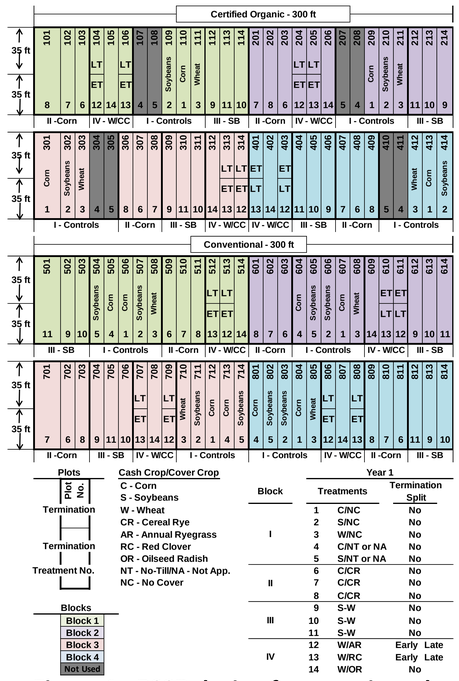

Figure 1. RSSB design for organic and conventional research plots.

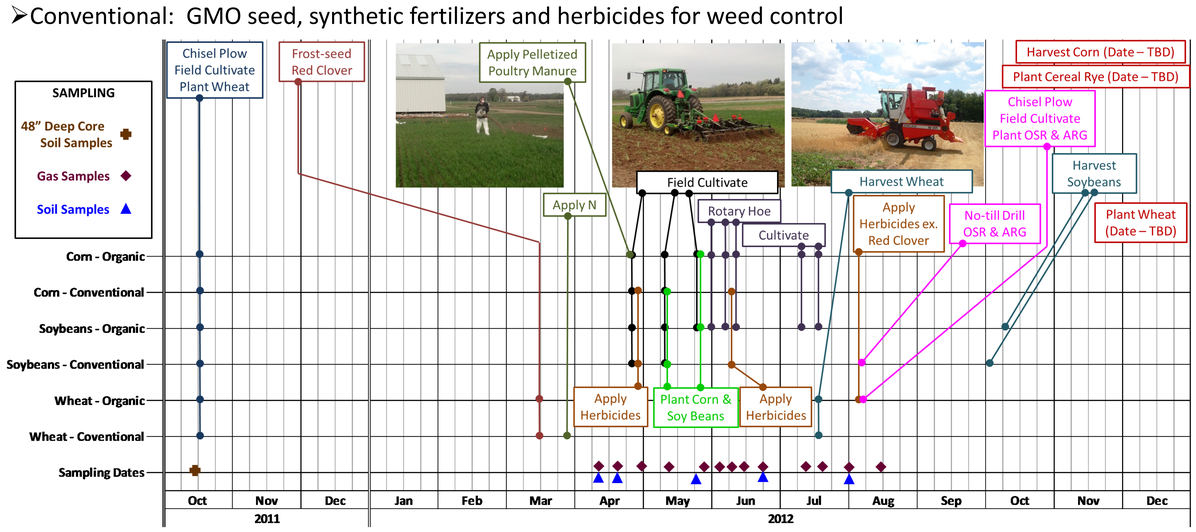

Figure 2. Year one management practices, timing and sampling dates.

METHODS

Systems approach dictates sampling by common practice. Sampling for N_2O is performed on all plots when soil disturbance occurs due to a field operation on any plot and periodically between operations. Soil sampling is performed periodically throughout the study, and plant sampling at grain harvest and spring/fall for cover crops.

Soil sampling (Figure 2) and analysis:

- N, P and the major exchangeable cations (Mehlich III and NH_4OAc extractions)
- Soil pH (1:1 soil:water slurry)
- Total C and N (elemental analyzer)
- Inorganic N (NH_4^+ and NO_3^-; analysis of KCl extractions)
- Cellulose and lignin fractions (fiber Analyzer)

Plant sampling and analysis:

- Total C and N (elemental analyzer)
- Cellulose and lignin fractions (fiber Analyzer)
- Grain yield
- Plant biomass (Figure 3)

In situ gas sampling (Figure 2) and analysis

- N_2O, CH_4 and CO_2 collected using a two-part chamber system with a vented, non-steady state enclosure configuration (Figure 4)
- Gas samples are analyzed for N_2O, CH_4 and CO_2 (gas chromatograph; Figure 5)

Figure 3. Wheat biomass sampling.

Figure 4. In situ gas sampling.

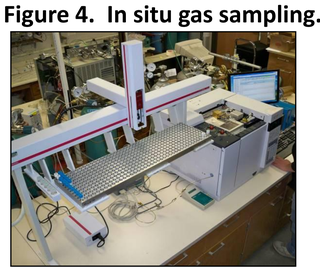

Figure 5. Gas chromatograph.

PRELIMINARY RESULTS

For year one (2012) of the study, cover crop treatments were established August 8, 2012 and cover crop effects will be measured going forward. Preliminary results compare management (organic vs conventional), fertilization methods (UAN vs poultry manure), weed control (herbicides vs rotary hoe/cultivation) and tillage (conventional tilled vs conventional no till).

Conclusions:

- N_2O emissions are greatest under Organic management in May-June, and under Conventional management in July-August (Figure 6)
- N_2O emissions increase following input of organic N (poultry manure) and synthetic N (UAN) fertilizers (Figure 6)
- N_2O emissions are influenced by irrigation and field cultivation (Figure 6)
- N_2O emissions are highest in the corn treatments (Figures 7 and 8)
- N_2O emissions are lower under no-till corn (Figure 8)

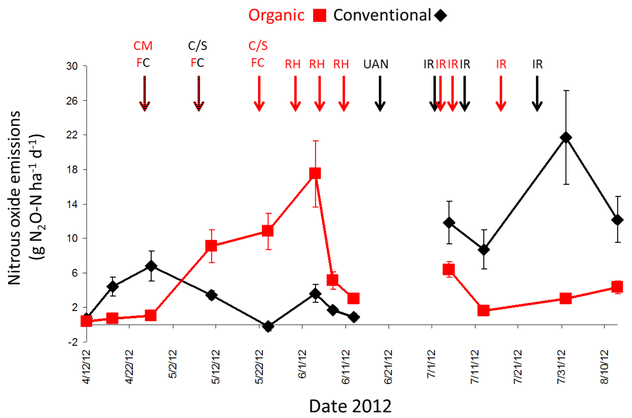

Figure 6. Average daily N_2O emissions by management practice.

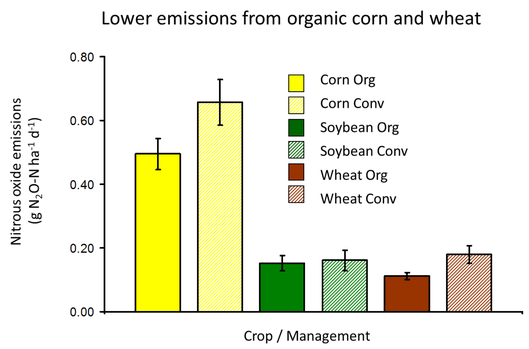

Figure 7. Average daily N_2O emissions by management practice and crop.

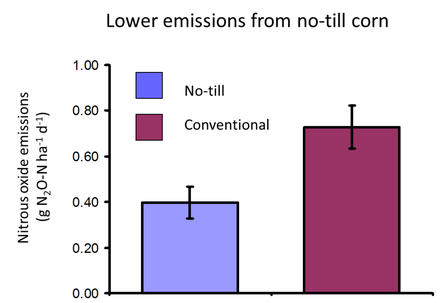

Figure 8. Average daily N_2O emissions for conventional managed corn with tillage and no till.

FUTURE WORK

Complete year one wheat planting, corn harvest, cereal rye cover crop after corn planting and fall gas, soil and plant biomass sampling. For years two and three:

- Continue rotation/cover crop studies
- Soil C studies
- N mineralization studies
  - Residue quality
  - Termination date
- Economic studies

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