GREENHOUSE GAS FLUXES IN A TILLAGE CHRONOSEQUENCE

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INTRODUCTION

- Accumulation of the greenhouse gases carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) in the atmosphere causes a global "greenhouse effect" and leads to accelerated global warming.
- Methane and N_2O have global warming potentials (GWP) 310 and 21 times that of CO_2, respectively.
- Land use change and agricultural activities (e.g. fertilization, livestock, rice production) contribute an estimated 25%, 60-65% and 90% of the total anthropogenic CO_2, N_2O and CH_4 emissions, respectively. Natural forest soils are considered sinks for CH_4.
- No-tillage farming is a method of producing crops without tillage other than the small amount of soil disturbance that occurs at time of planting (Figure 1). No-tillage is used to produce approximately 25% of the corn and 65% of soybean in Ohio. Ohio has the longest continuously maintained no-till plots in the world (48 years).
- As no-tillage is continuously applied to soil it can remove CO_2 from the atmosphere and sequester it in soil as humus. The soil properties also become more like that of a forest soil. The impact of no-tillage on the other greenhouse gases, N_2O and CH_4, is less well understood.

Hypothesis: The greater the number of years crops are grown using continuous no-tillage, the more efficient the soils become in reducing their ability to produce greenhouse gases.

Specific Objective
To create a greenhouse gas inventory for soils with different number of years of continuous no-tillage crop production.

MATERIAL AND METHODS

- **Chronosequence experimental sites:** Six locations, that include Mount Gilead (10 years no-till), Mount Gilead (17 years no-till), Bucyrus (14 years no-till), Centerburg (37 years no-till), Wooster and South Charleston (48 years no-till). We report results from the Wooster site only.
- **Tillage applications:** No-tillage (NT) and moldboard plow tillage (PT) (**Figure 1**). No-tillage uses a systems approach where crops are grown with minimal soil disturbance and the soil is kept covered with crop residue to conserve soil and water. Plow tillage uses a tillage tool to mix the soil with surface trash and stubbles and thereby promote more rapid decomposition.
- **Cropping system:** Continuous corn (NT and PT) and adjacent forested area (reference site).
- **Gas sampling technique:** Static chamber technique using chambers made of polyvinyl rings of 20cm height by 30cm diameter (**Figure 2**). Gas samples (10ml) were taken biweekly during the year.
- **Measurement of gas samples:** Automated gas chromatograph (Varian CP 3800) interfaced with a Combi Pal auto sampler.
- **Soil temperatures and moisture:** Each plot was instrumented with four static chambers, as well as soil temperature and moisture probes.
- **Experimental design:** Randomized block design with minimum of three replicates.

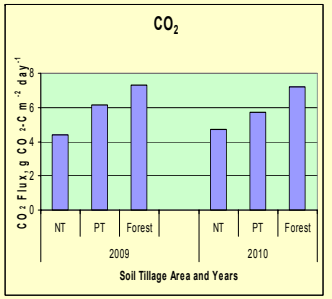
Figure 1A. No-tillage crop production.

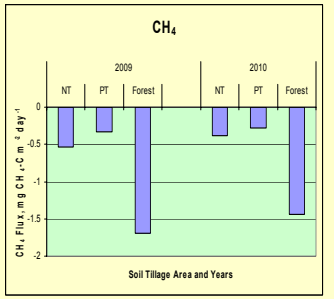
Figure IB. Plow tillage crop production.

Figure 2. Installing the chambers (A), closing the lids to begin gas flux measurement (B), taking a gas sample (C), and storing air sample in a vial until analysis by gas chromatography (D).

RESULTS

- √ The highest CO_2 fluxes from the soil to atmosphere were observed in forest soils and the lowest CO_2 fluxes in no-till soils.
- √ The highest CH_4 fluxes from the soil to the atmosphere were observed in NT soils and the lowest forest fluxes from the adjacent forest.
- √ The highest N_2O fluxes from the soil to the atmosphere were observed from PT soil and the lowest fluxes in no-till soils.
- √ When CO_2, CH_4 and N_2O fluxes from Wooster (Ohio) soils to the atmosphere in 2009 were compared with 2010 data (Figure 3), we conclude the following:
  - CO_2 fluxes were the lowest from NT, and the highest from forest in 2009 and 2010.
  - CH_4 fluxes were the lowest from forest and the highest from PT soil in 2009 and 2010.
  - N_2O fluxes were the lowest from NT soils, the highest from PT soils in 2009 and 2010.





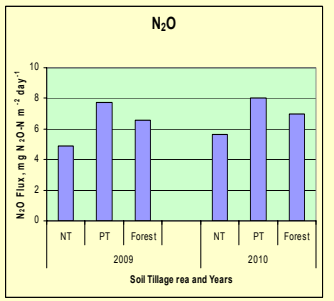


Figure 3. Greenhouse gas fluxes from Wooster soil under continuous corn no-tillage (NT), moldboard plow tillage (PT) and forest in 2009 and 2010.

Table 1. Greenhouse warming potential. The CH_4 and N_2O results **(Figure 3)** were multiplied by 310 and 21, respectively, to calculate the total combined CO_2 equivalence for each management system

Year	Greenhouse Gases (mg m^{-2} day^{-1})	Management System (CO_2 equivalents)		
		NT	PT	Forest
2009	CO_2	4420	6160	7320
	CH_4	-160	-100	-525
	N_2O	110	160	135
Combined Gases		4365	6220	6930
2010	CO_2	4715	5700	7220
	CH_4	-120	-90	-480
	N_2O	115	170	130
Combined Gases		4710	5780	6870
2009-2010	Combined Gases Mean	4540	6000	6900

CONCLUSIONS

- √ Carbon dioxide (CO_2) is the dominant greenhouse gas in the Wooster soil.
- √ Methane (CH_4) was removed by the soil and nitrous oxide (N_2O) was emitted from the soil under all three management systems.
- √ Methane (CH_4) removal was least under forest, intermediate under NT, and least under PT.
- √ Overall; the greatest greenhouse warming potential occurred under forest and the least under NT. This observation based on measurements made for months of July through September (2009) and May through September (2010).

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