Land management and Greenhouse Gases Emission From Agricultural Ecosystem

David A.N. Ussiri and Rattan Lal
Carbon Management and Sequestration Center, School of Natural Resources, The Ohio State University, 2021 Coffey Rd, Columbus, OH 43210. Fax: 614/292-7432

INTRODUCTION

Accumulation of radiatively active gases in the atmosphere could alter the earth’s atmospheric energy balance, and has been linked to warming trends in global climate (Smith 1997). Carbon dioxide (CO₂), CH₄ and N₂O are greenhouse gases mainly affected by agricultural activities. Decomposition of organic compounds by heterotrophic soil organisms and respiration by autotrophic organisms especially plant roots and rhizomes are the main sources of CO₂ evolving from aerobic soils. Methane is produced as a result of anaerobic mineralization of SOM in soils, while N₂O. Soils generally harbor both methanogens and methanotrophs. Methane emissions occur when methanogens activity dominate, while soils oxidize CH₄ under aerobic conditions. Carbon dioxide is by far the most abundant greenhouse gas (GHG), however, CH₄ and N₂O are important atmospheric trace gases due to longer residence time in atmosphere, resulting in global warming potential 21 and 310 times that of CO₂ (Houghton et al., 1996). In addition, N₂O and CH₄ play role in ozone depletion, and are of global environmental significance. Several management practices, including no-tillage and residue management have been proposed as strategies to increase SOC, mitigating atmospheric GHG increases and restoring soil quality in agricultural land.

Objectives: The objective of this research was to evaluate the effects of long term tillage practices on soil organic carbon distribution and CO₂, CH₄ and N₂O emissions.

MATERIALS AND METHODS

This experiment was conducted at Western Branch Research Farm of the Ohio Agricultural Research and Development Center (OARDC) near South Charleston, Ohio (39°45’N, 83°36’W). Soils are predominantly silt-loam of the Crosby (fine, mixed, mesic Aeric Ochraqualf) and Brookston series (fine-loamy, mixed mesic typic Argiaquolls), with 15% sand, 65% silt and 20% clay (van Doren et al., 1976). Gas chambers were installed in a long-term tillage plots (established in 1962) with no till (NT), chisel till (CT) and moldboard plow (MP) treatments and maintained under corn. Three gas chambers were installed in each plot in May, and closed soil chamber method was used to obtain air samples (Plate 1). The sampling chamber consisted of a 15 cm diameter and 25 cm long PVC pipe. The chambers remained in place for the entire cropping season except for temporary removal during farm operations. Sampling was conducted approximately twice per month. At each sampling, soil temperatures were also recorded at 5, 10 and 20 cm depth. The sampling time was 60 minutes, between 11.00 to 15.00 hrs. Gas samples were stored into crimp-sealed bottles (10 ml) evacuated to < 0.05 kPa, and analyzed by gas chromatograph fitted with thermal conductivity detector (TCD), flame ionization detector (FID) and electron capture detector (ECD) for CO₂, CH₄ and N₂O detections, respectively.

Soil samples were collected in June, prior fertilizer application. These were air-dried, ground and sieved to pass 60 mesh ( 250 · m sieve), and analyzed for C, N concentration and ¹³C by Elemental CN analyzer (Elementar, Germany) and Isotope ratio mass spectrometer (GV Instruments, UK, respectively.

RESULTS

• Soil temperatures at 5 cm soil depth ranged from 14.6 to 30.9°C during the growing season. Highest temperatures were observed in the MP plots, while the lowest temperatures were in the NT plots.

• Carbon dioxide emission varied within the growing season, with highest emissions occurring in July, with low emissions in May-June and September-October.

• CO₂ emission was strongly correlated with soil temperatures of the top 10 cm depth (R² = 0.68).

• The CT plots were the sinks for CH₄ for most of the growing season, while NT plots were CH₄ source.

• Both SOC and N concentration was significantly higher in the surface soils of NT plots but no significant difference in 15-30 cm.

• NT and CT soils in the 15-30 cm depth were significantly depleted in ¹³C than MP, while NT soils of the 0-15 cm were slightly enriched in ¹³C.

CONCLUSIONS

NT stored more C in the soils, however, most of the stored SOC was held near the surface (0-15 cm). The concentration of SOC in the 15-30 cm depth was similar in all tillage methods. The SOC from lower depths of NT plots were depleted in ¹³C, indicating slow rates of SOM mineralization and longer residence time for SOC in NT than CT and MP plots. Tillage method affected both CO₂ and methane emissions. The NT plots released more CO₂ than MP and CT during the active growing period. NT plots were the source while CT plots were sinks for CH₄ in most of the growth season.

Table 1. Tillage effects on SOC, total N concentration and ¹³C distribution in the top 30 cm depth.

<table>
<thead>
<tr>
<th>Sampling Date</th>
<th>Soil Depth</th>
<th>CT</th>
<th>NT</th>
<th>MP</th>
</tr>
</thead>
<tbody>
<tr>
<td>15-30</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0-15</td>
<td>1.83±0.04</td>
<td>2.19±0.39</td>
<td>2.07±0.31</td>
<td>1.98±0.20</td>
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<td>15-30</td>
<td>0.79±0.10</td>
<td>1.09±0.15</td>
<td>0.94±0.04</td>
<td>1.17±0.23</td>
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<tr>
<td>0-15</td>
<td>1.15±0.04</td>
<td>1.19±0.06</td>
<td>1.18±0.01</td>
<td>1.30±0.07</td>
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<tr>
<td>15-30</td>
<td>-17.5±0.63</td>
<td>-16.7±0.63</td>
<td>-16.3±0.62</td>
<td>4.6±0.63</td>
</tr>
</tbody>
</table>

References

