Effects of Cover Crops and Soil Amendments on Carbon Dioxide Fluxes from Corn Cropping Systems in Mississippi

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Introduction

• Integration of cover crops and soil amendments into cultivated systems have been widely applied to increase crop production and improve soil health.
• These practices would affect the soil biochemical processes and properties (e.g., labile organic C and enzyme activity, etc.) which are related to carbon dioxide (CO2) fluxes of the system.

Objectives of this study

• Evaluate the CO2 fluxes from crop production systems with deep-rooted (bio-drilling) cover crops and soil amendments, including flue gas desulfurization (FGD) gypsum and lignite (recalcitrant organic carbon).

Experimental Approaches

• The study site is located in an upland soil at the Mississippi Agricultural and Forestry Experiment Station near Pontotoc, MS (Fig. 1).
• Experiment design is a split-plot randomized block design (started in 2019, 6 block × 7 subplot; each subplot 3 × 9 m).

- Cover crop: 6 blocks were assigned to cover crop and no cover crop
- Winter cover crop planted soon after the main crop is harvested
- mixture of dill, radish, wheat and crimson clover

• Amendment: 7 subplots were assigned to different soil amendments
- Control
- 1T FGD + Lignite (21:1 ratio) 14 lbs FGD + 7 lbs Lignite/plot + FRT
- 2T FGD + Lignite (21:1 ratio) 28 lbs FGD + 14 lbs Lignite/plot + FRT
- 3T FGD + Lignite (21:1 ratio) 42 lbs FGD + 21 lbs Lignite/plot + FRT
- Broiler Litter 83 lbs/plot
- Broiler Litter 83 lbs/plot + 14 lbs FGD + 7 lbs Lignite
- FRT (UAN) 50 lbs/acre at planting and 100 lbs/acre at V6 corn growth stage
- injected into the soil 10 cm away from the plant and 5 cm deep using liquid fertilizer applicator

- CO2 measured during crop growing season
- May-August, 2019
- Soil and water samples collected at 0-15 cm
- Soil and water samples collected for CO2

Results and Discussion

CO2 Flux

- During 84-day growing season, cumulative CO2 fluxes ranged from 4 to 40 g CO2-C m2 (Fig. 4).
- Two-way ANOVA revealed that plots with cover crop had slightly higher (P = 0.08) cumulative CO2 fluxes than those with no cover crop.
- Cumulative fluxes from plots subjected to broiler litter amendment (BL and BL+FGD) were significantly higher than other plots (P < 0.001), which is possibly caused by the high content of labile organic C and inorganic N and P in the broiler litter.

Soil Properties

Table 1. Effects of cover crop (C), soil amendments (A), time (T) and their interactions on soil physical and biophysical properties. P-values are presented in the table.

<table>
<thead>
<tr>
<th>CO2</th>
<th>Temp</th>
<th>Moisture</th>
<th>mufG</th>
<th>mufNag</th>
<th>mufP</th>
<th>mufS</th>
</tr>
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<tbody>
<tr>
<td>C</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>A</td>
<td>&lt;0.001</td>
<td>0.004</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>T</td>
<td>&lt;0.001</td>
<td>0.001</td>
<td>0.001</td>
<td>0.019</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>C×A</td>
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<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
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</tr>
<tr>
<td>C×T</td>
<td>NS</td>
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<td>NS</td>
<td>NS</td>
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</tr>
<tr>
<td>A×T</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
</tbody>
</table>

- Winter cover crops were planted in the studied plots in early 2019. Given the short period of implementation, no significant differences between plots with and without cover crops were observed on the parameters measured in our study (Table 1).
- Soil respiration was more sensitive to the soil amendments than the microbial enzyme activity, as indicated by significant differences of CO2 flux among soil amendments (P = 0.001)
- Significant temporal variations (P < 0.05) in CO2 fluxes and enzyme activities are likely attributed to the changes in soil temperature and moisture over time.

Conclusions

- Broiler litter integration increased soil CO2 fluxes with significantly higher fluxes observed in the middle of June, leading to the cumulative fluxes approximately 3.5 times higher than control and other soil amendments.
- The effects of cover crops on soil physical and biological properties were not observed in our study, which is likely due to the short-term implementation.
- The ongoing long-term study (in total 6 years) at this site would provide insights on changes in effects of cover crop and soil amendment on soil biochemical properties and greenhouse gas fluxes over time.
- Flux measurements out of the growing season should be included in future studies in order to provide us a better understanding of annual greenhouse gas and C budget.

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Fig. 1. Study Site

Fig. 2. LCUr for CO2 flux

Fig. 3. CO2 fluxes during the crop growing season

Fig. 4. Cumulative fluxes during the growing season

Fig. 5. Cumulative CO2 flux

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