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

Jing Hu[1], Fangni Lei[1], Dana M. Miles[2]*, Ardeshir Adeli[2], John P. Brooks[2], Renotta Smith[2], Frances Podrebarac[2], Xiaofei Li[3], Robert Moorhead[1]*

[1]Geosystems Research Institute, Mississippi State University, Mississippi State, MS; [2]Genetics and Sustainable Agriculture Research, USDA-ARS, Mississippi State, MS; [3]Department of Agricultural Economics, Mississippi State University, Mississippi State, MS

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 biogeochemical processes and properties (e.g., labile organic C and enzyme activity, etc.) which are related to carbon dioxide (CO_2) fluxes of the system.

Objectives of this study

- Evaluate the CO_2 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).

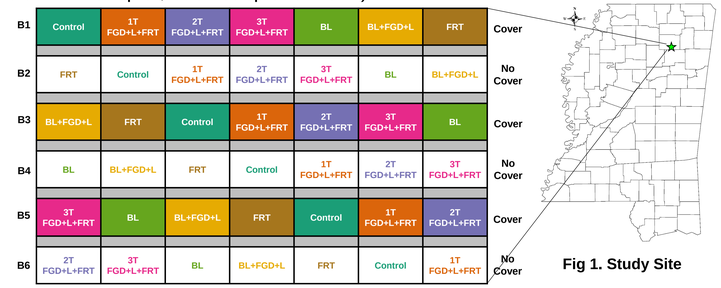

Fig 1. Study Site

- **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 daikon radish + wheat + crimson clover
- **Amendment**: 7 subplots were assigned to different soil amendments
  - **Control**
  - **1T FGD + L**ignite (2:1 ratio) 14 lbs FGD + 7 lbs Lignite/plot **+ FRT**
  - **2T FGD + L**ignite (2:1 ratio) 28 lbs FGD + 14 lbs lignite/plot **+ FRT**
  - **3T FGD + L**ignite (2:1 ratio) 42 lbs FGD + 21 lbs Lignite/plot **+ FRT**
  - **B**roiler **L**itter 83 lbs/plot
  - **B**roiler **L**itter 83 lbs/plot **+** 14 lbs **FGD +**7 lbs **L**ignite
  - **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
- **CO_2**: measured during crop growing season
  - May-August, 2019
  - 5/30, 6/19, 7/9, 8/1, 8/21
  - LiCor 8100A (**Fig 2**)
  - Soil was recorded
- **Soil**: soil samples were collected along gas sampling
  - 0-15 cm
  - enzyme activities (mufG, mufNag, mufP, mufS)

Fig 2. LiCor for CO_2 flux

Results and Discussion

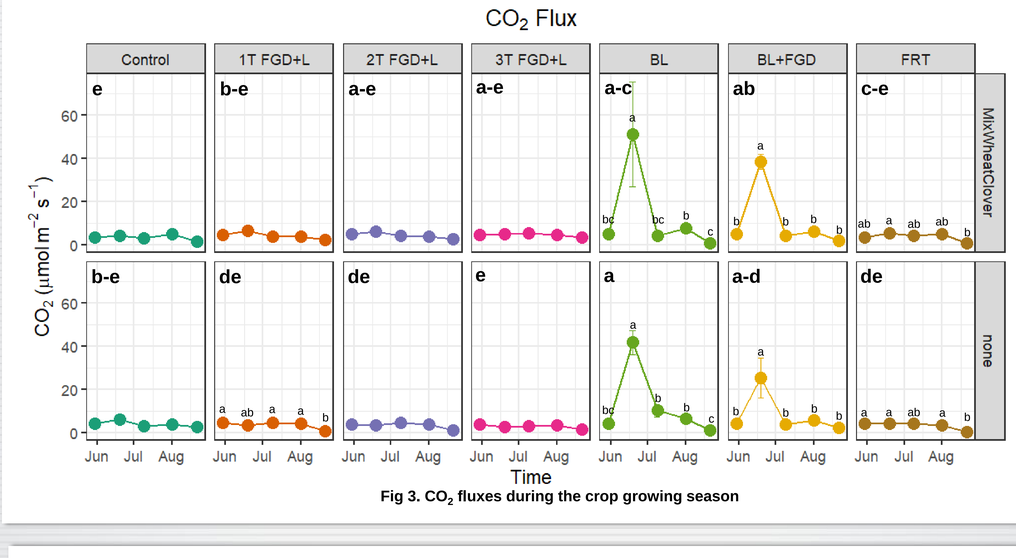

Fig 3. CO_2 fluxes during the crop growing season

• The results of three-way ANOVA show that CO_2 fluxes were significantly affected by soil amendment, time and their interaction (*P < 0.001),* but not by cover crop (**Table 1**).

  • Averagely, significantly higher fluxes were observed on 6/19 while fluxes on 8/21 were significantly lower than other times (*P < 0.05).*

  • Plots subjected to broiler litter (i.e., BL and BL + FGD) amendments had significantly higher flux than others (*P < 0.05).*

• CO_2 fluxes from control plots and plots subjected to amendments of FGD and lignite (FGD + L) did not show significant temporal variation, except for plots with no cover crop and 1T FGD + L (**Fig 3**).

• Peaks of CO_2 flux (25-50 μmol m^{-2} s^{-1}) from BL and BL+FGD plots were observed on 6/19, which are likely due to the proper soil temperature and water content which accelerated soil respiration when abundant labile organic C was provided by broiler litter integration.

Cumulative Fluxes

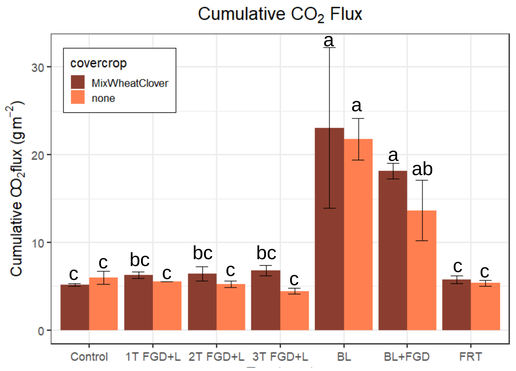

Fig 4. Cumulative fluxes during the growing season

• During 84-day growing season, cumulative CO_2 fluxes ranged from 4 to 40 g CO_2-C m^{-2} (**Fig. 4**).

• Two-way ANOVA revealed that plots with cover crops had slightly higher (*P* = 0.08) cumulative CO_2 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 biological properties. P-values are presented in the table.

	CO_2	Temp	Moisture	mufG	mufNag	mufP	mufS
C	NS	NS	NS	NS	NS	NS	NS
A	*<0.001*	*0.004*	NS	NS	NS	NS	NS
T	*<0.001*	*< 0.001*	*<0.001*	*0.049*	*0.003*	*0.001*	*0.019*
C×A	NS	NS	NS	NS	NS	NS	NS
C×T	NS	NS	NS	NS	NS	NS	NS
A×T	*<0.001*	NS	NS	NS	NS	NS	NS
C×A×T	NS	NS	NS	*0.018*	NS	NS	*0.039*

Temp: temperature; NS – not significant

• 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 CO_2 flux among soil amendments (*P* < 0.001) whereas the difference was not observed for enzyme activities.

• Significant temporal variations (*P* < 0.05) in CO_2 fluxes and enzyme activities are likely attributed to the changes in soil temperature and moisture over time.

Conclusions

• Broiler litter integration increased soil CO_2 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 biogeochemical 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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Corresponding author:

Jing Hu (jingh@gri.msstate.edu)

Dana Miles (dana.miles@usda.gov)