Assessing the Interactions between CO2 and Microbial Activity in a Mississippi Corn Field Using the DNDC Model and Experiment Data

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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 biogeochemical processes, leading to variations in crop yield and changes in soil properties.

Objectives of this study

- To improve the understanding of the interactions among fertilizer, microbial activity, soil health, and crop yield via the incorporation of an agro-ecosystem numerical model.
- Corn crop management under different fertilization and cover-crop application scenarios are explored to help identify the best practice for long-term sustainable agricultural system.

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).

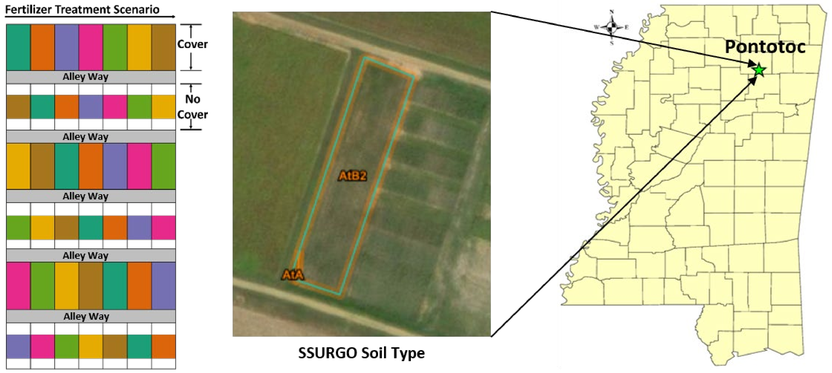

Fig 1. Study Site in Pontotoc County, Mississippi. Left panel is the experiment design plot showing the location of blocks with different cover crop and fertilization applications.

Cover crop: 6 blocks were assigned with 3 cover-crops and 3 no-cover-crops
- winter cover crops were planted after the main crop was harvested in October 2018
- cover crop consisted of a mixture of daikon radish, wheat, and crimson clover

Amendment: 7 subplots were assigned for each block with different soil amendments applied to soil surface prior to planting corn. FRT was injected into the soil 10 cm away from the plant and 5 cm deep using liquid fertilizer applicator.

- **CTL:** control scenario with no fertilization
- **1T:** FGD + Lignite (2:1 ratio) 14 lbs FGD + 7 lbs Lignite/plot + FRT
- **2T:** FGD + Lignite (2:1 ratio) 28 lbs FGD + 14 lbs lignite/plot + FRT
- **3T:** FGD + Lignite (2:1 ratio) 42 lbs FGD + 21 lbs Lignite/plot + FRT
- **BL:** Broiler Litter 83 lbs/plot
- **BL+FGD+L:** Broiler Litter 83 lbs/plot + 14 lbs FGD +7 lbs Lignite
- **FRT:** FRT (UAN) 50 lbs/acre at planting & 150 lbs/acre at V6 growth stage

DNDC Model

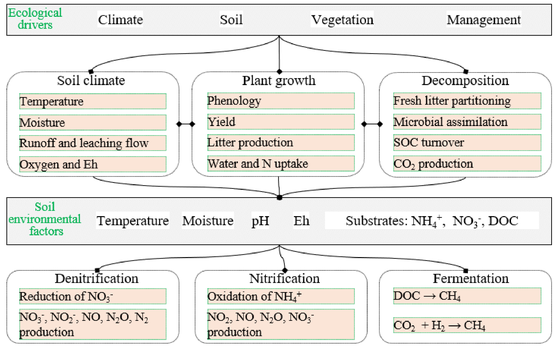

Fig 2. DeNitrification-DeComposition (DNDC) model structure.

Meteorological Input: daily precipitation, daily maximum air temperature, daily minimum air temperature data records in 2019 were obtained from the Pontotoc Experimental Station, MS.

Soil Data: soil type information was obtained from the USDA SSURGO map. The main soil type was silt loam.

Results and Discussion

Model Simulated Soil N/C Storage Change

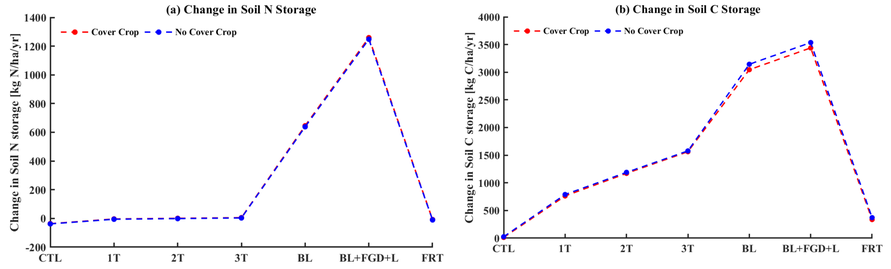

Fig 3. DNDC model simulated changes in soil (a) N and (b) C storage.

- Fertilization applications generally lead to increased N and C storage in the soil when comparing all fertilization cases (i.e., 1T, 2T, 3T, BL, BL+FGD+L, and FRT) with the control case (i.e., CTL).
- Broiler litter can significantly increase the N and C storage in the soil system which is expected as broiler litter contains high fractions of total N and C nutrients.
- Cover crop has limited impacts on the changes of soil N storage. Instead, the cover crop increases the total amount of crop in the fields thus increasing soil O_2 levels which can enhance the microbial activity. Therefore, more carbon is likely to leave the soil system through microbial respiration.

Biomass and Yield Comparison

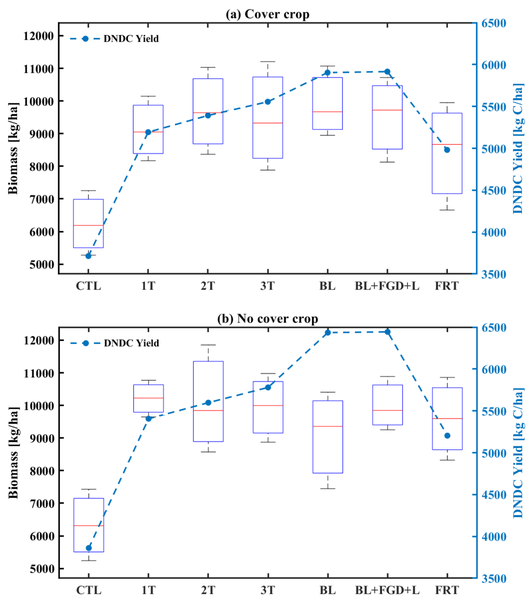

Fig 4. Comparison between ground-based biomass measurement and DNDC model simulated crop yield for different fertilization and cover crop treatment scenarios.

- In Figure 4, the biomass measurements are compared with the DNDC model simulated yield for each treatment scenario in 2019.
- Variations in biomass measurements are found for each scenario with 3 replicates.
- Generally consistent trends are found in both biomass measurements and model simulated yield across different fertilization applications and cover crop management. Cover crop does not strongly impact the biomass.
- Increased biomass and yield are observed with applied fertilization, particularly yield increases significantly from the CTL scenario to 1T scenario for both cover-crop and no-cover-crop cases.
- Differences in biomass are modest among all fertilization applications. The changes of biomass in BL and BL+FGD+D cases are small as compared to other cases. However, DNDC model simulated yield increases significantly when broiler litter is applied in either BL or BL+FGD+L cases. Excessive nutrients in broiler litter may not be well utilized by cash crop and cover crop as indicated by biomass trends in Fig 4. Instead, DNDC model lacks a module to simulate this effect and therefore model predicts higher yields when broiler litter is applied.

Conclusions

- Fertilization applications can generally increase both soil N and C storage. The effect of cover crops on soil N storage is marginal. On the contrary, cover crops can slightly decrease soil C storage.
- Consistent trends in biomass measurements and DNDC yield simulations are found except for the cases with broiler litter applications. DNDC model predicts increases in yield with broiler litter which is not found in biomass measurements.
- The ongoing long-term study (in total 5 years) at this site would provide insights of the impacts of different cover crop and fertilization factors on crop yield and soil health.
- Further model parameterization schemes can be applied for a better model simulation.

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