Carbon-Nitrogen Mineralization in Highly Weathered Coastal Plain Ultisols: Effect of Switchgrass Biochars with Supplemental Nitrogen

Gilbert C. Sigua*, Jeff M. Novak, Don W. Watts, Ariel A. Szogi and Paul Shumaker

USDA-ARS, Coastal Plains Soil, Water and Plant Research Center, Florence, South Carolina, USA 29501

*gilbert.sigua@ars.usda.gov

ABSTRACT

- Switchgrass biochars (SG) and switchgrass residues (USG) had contrasting effects on nitrogen (N) mineralization in highly weathered Ultisols of Coastal Plains region.
- Cumulative and net CO_2-C evolution was increased by the additions of SG and USG especially when supplemented with N.
- Soils treated with 250SG had the least amount of total inorganic nitrogen (TIN) while the greatest amount of TIN was observed from the control+N.
- Results suggest that application of SG in the short term may cause N immobilization resulting in the reduction of TIN.
- Our research demonstrates that care has to be taken when applying biochar because it could affect crop growth and productivity as a result of potential N immobilization.

BACKGROUND AND OBJECTIVE

- Research has shown organic residues (e.g. switchgrass residues) added to soils to improve soil organic carbon content and fertility of highly weathered Ultisols in the southeastern Coastal Plain region, but made minimum gains because materials decompose easily due to the region's warm climate and abundant rainfall.
- There is still a need to pursue additional research that will improve our understanding on the impact of soil fertility enhancement because the effect could vary greatly between sources, i.e., switchgrass residues (USG) vs. switchgrass biochars (SG).
- We hypothesized that SG with supplemental N would deliver more positive effects on carbon and N mineralization than USG.
- The objective of this study was to evaluate the effects of USG and SG, with or without supplemental inorganic N fertilizer on carbon and N mineralization in highly weathered Coastal Plains Ultisols.

MATERIALS AND METHODS

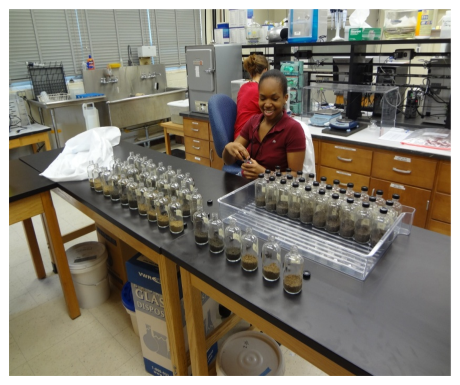
- Soils and Biochar Production – A Norfolk soil (fine loamy, kaolinitic, thermic) collected from the Clemson University Pee Dee Research, Darlington, South Carolina was used in the study.
- Switchgrass (*P. varigatum* L.) feedstock used in the study was obtained by harvesting switchgrass at the Clemson University Pee Dee Research and Education Center. Feedstock was process before pyrolysis by air-drying and grinding to pass a 6-mm sieve.

Pyrolysis, USDA-ARS, Florence, SC

- Pyrolytic runs of the raw switchgrass residues were performed at 250°C and 500°C under a continual stream of N_2 gas: Lindburg electric box furnace equipped with a gas tight retort (Model 51662; Lindburg/ MPH, Riverside, MI).
- All biochars and uncharred switchgrass were ground to pass a 0.42-mm sieve using a Wiley mini Mill, further sieved to pass a 0.25-mm sieve.

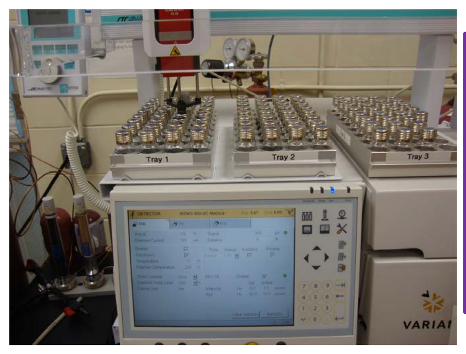
- Experimental treatments consisted of the control (CONT) soil, soil with nitrogen (N) (CONT+N), uncharred switchgrass at 250°C (250SG), switchgrass with N at 250°C (250SG+N), switchgrass at 500°C (500SG) and switchgrass with N at 500°C (500SG+N).

- Application Rate: 8 g/400 g soil (~40 tons SG and USG or about 2%) based on 112 kg/ha corn yield goal; 100 kg N/ha using ammonium nitrate (37% N).



- The soil:biochar treatments were prepared by weighing 400 g of dried Norfolk soil; 10% w/w or 40 g DI/400 g soil; 3 reps/treatment.

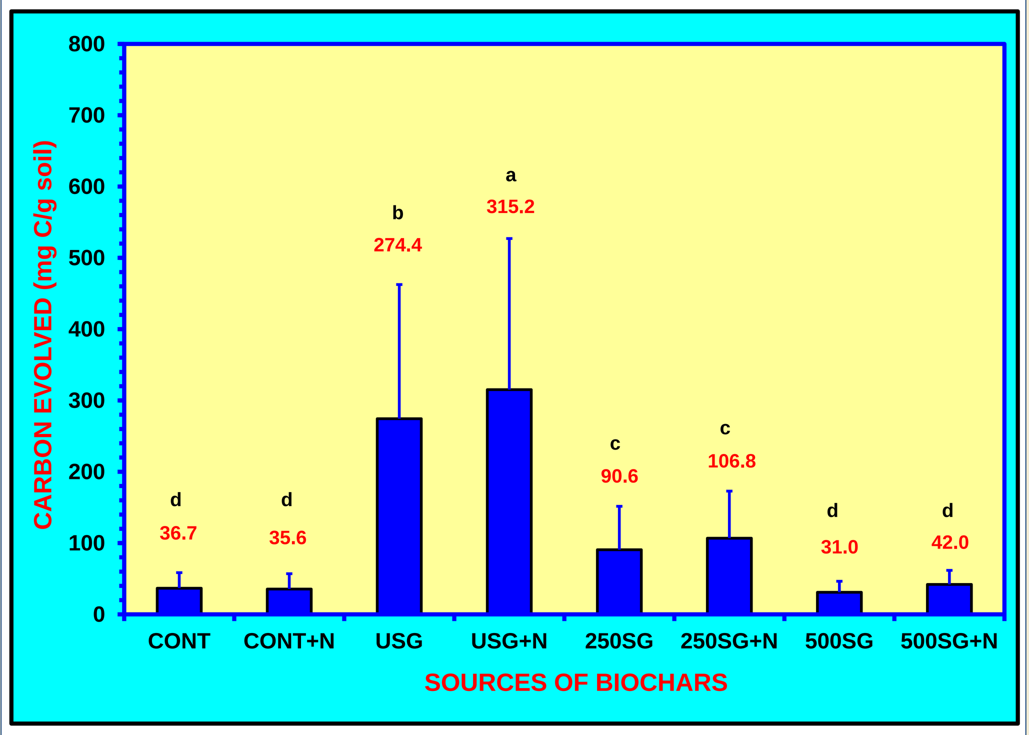
- Prior to headspace gas sampling, head pressure was measured and then pressurized with 5 mL He. Headspace CO_2 sample then injected into a 10-mL vial for measurements.



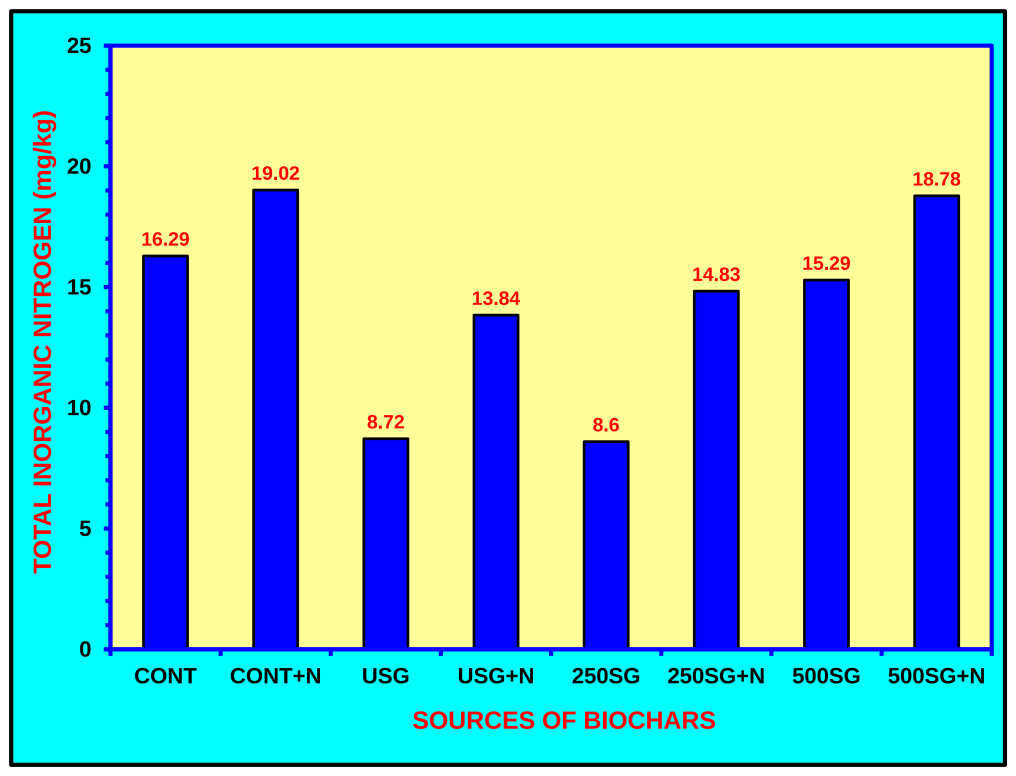
- The headspace vials were then placed into an automatic injector of a Variant GC for CO_2 concentration.

- At the end of incubation period, soil samples were analyzed for total inorganic N (NH_4-N + NO_3-N) with 2N KCl; using N Autoanalyzer.

RESULTS AND DISCUSSION

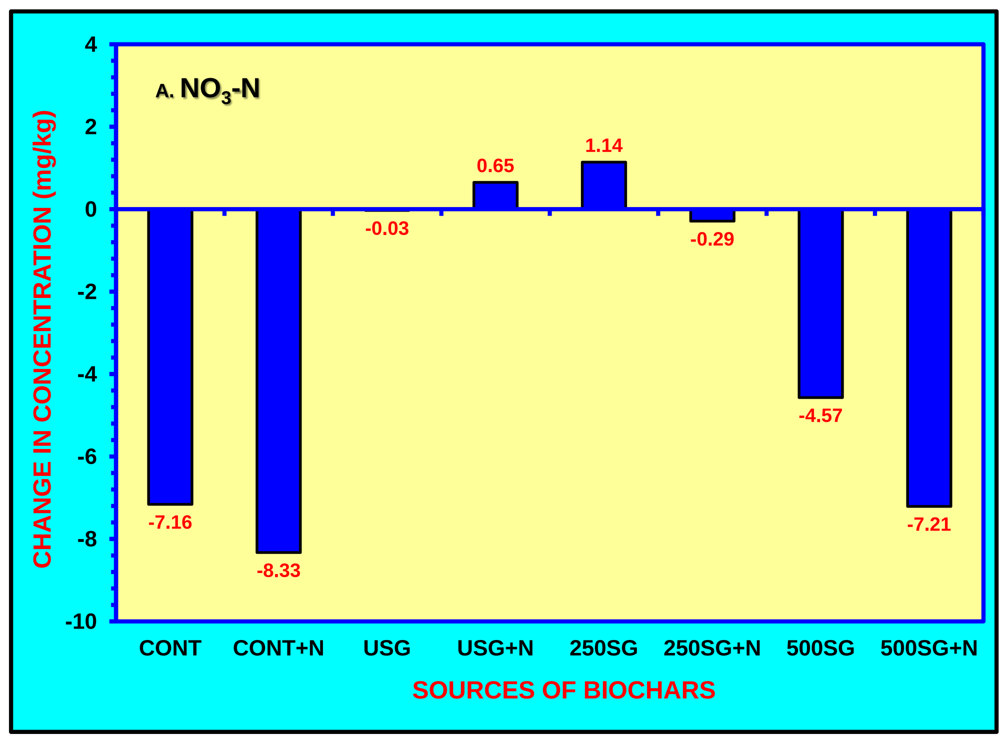


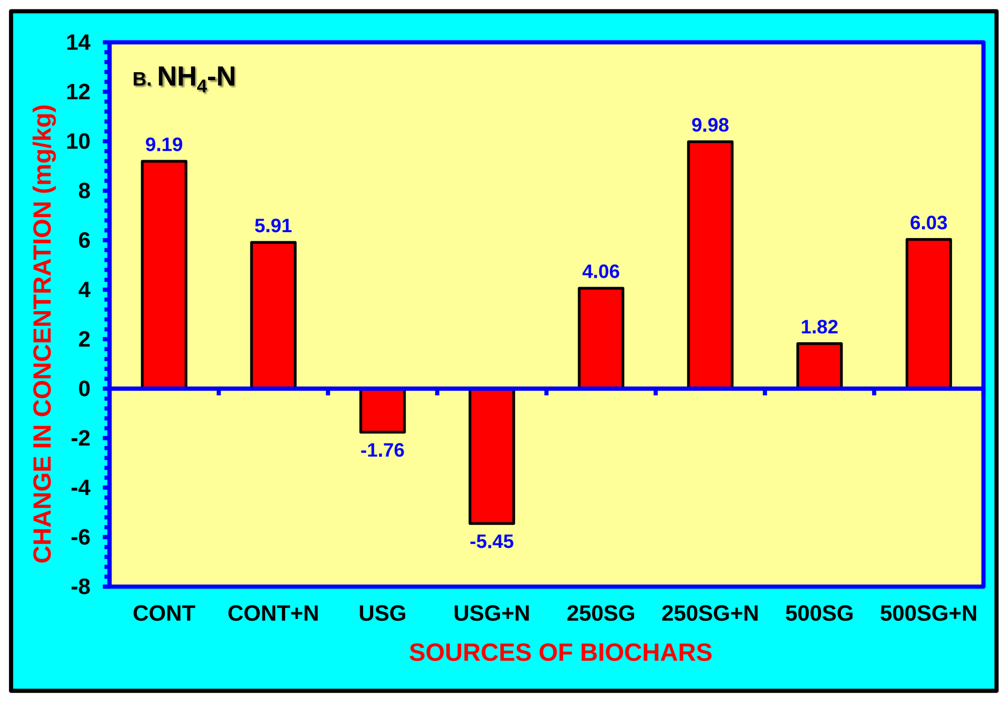
- Net CO_2-C evolution was significantly affected by USG and SG with or without N.
- Soils with USG+N had the greatest net CO_2-C evolved while soils with 500SG had the least amount of CO_2-C evolved.
- The net amount CO_2-C evolved between soils treated with 250SG and 250SG+N did not vary from each other.
- Net CO_2-C evolved from soils with 500SG, 500SG+N, CONT and CONT+N were comparable among each other.



- TIN varied widely ($p<0.0001$) among soils amended with USG and SG.
- Of the soils amended with SG and/or USG with or without N, soils with 250SG had the least amount of TIN.
- Overall, the concentration of TIN were significantly enhanced in soils treated with supplemental N.

Changes in TIN mineralized from USG and SG with or without N





- Overall, soils amended with USG, USG+N, 250SG, 250SG+N, 500SG and 500SG+N had negative concentration of TIN while control+N had positive TIN.
- Results of our study suggest that application of USG and SG with our without N in the short-term caused N immobilization resulting in the reduction of NH_4-N + NO_3-N could be related to the mineralization-immobilization turnover ratio (MIT).

SUMMARY AND CONCLUSION

- Switchgrass biochars and switchgrass residues had contrasting effects on N mineralization in a highly weathered Ultisols of Coastal Plains region.
- Results suggest that application of SG in the short term may cause N immobilization resulting in the reduction of TIN.
- To avoid negative effect on N availability, consider applying biochars some months before main crop season.

REFERENCES

Sigua, G.C., Stone, K.C., Hunt, P.G., Cantrell, K.B. and Novak, J.M. 2015. Increasing biomass of winter wheat using sorghum biochars. Agron Sustainable Development. J. 35:739-748.

Sigua, G.C., J.M. Novak, D.W. Watts, A.A. Szogi and P.D. Shumaker. 2016. Impact of switchgrass biochars with supplemental nitrogen on carbon-mineralization in highly weathered Coastal Plain Ultisols. Chemosphere 145: 135-141.