Impacts of biochar on nitrogen cycling microbial communities and nitrous oxide emissions

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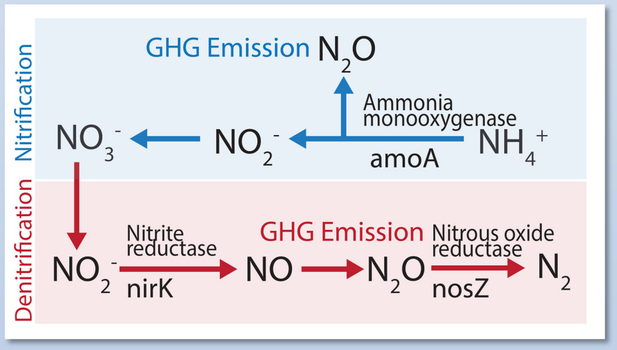
Introduction

- 80% of anthropogenic N_2O emissions are estimated to come from agricultural soil management
- Biochar can influence microbial processes and N_2O emissions, yet mechanisms remain unclear
- Lab microcosms indicate biochar influences denitrification- and nitrification-mediated N_2O production, however few field experiments have quantified relationships over growing season

Objectives

- Determine seasonal N_2O emissions from a maize field in response to biochar and N fertilizer application
- Evaluate relationships between biochar-induced changes in microbial processes, soil inorganic N availability, and N_2O emissions



Hypothesis

- Biochar will alter microbial community function by decreasing denitrification activity to a greater extent than increasing nitrification activity
- Biochar will decrease total N_2O emissions over the course of a season

Methods

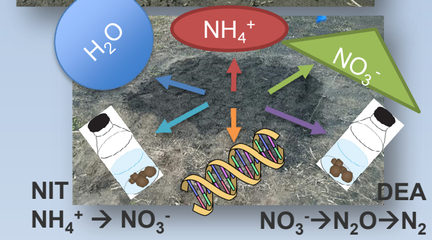
Four treatments:

1. Control
2. 100 Mg ha^{-1} biochar
3. 269 kg N ha^{-1} (UAN fertilizer broadcast)
4. 100 Mg ha^{-1} biochar + 269 kg N ha^{-1}

Field N_2O fluxes measured using static flux chambers

Soil samples assayed for inorganic N, moisture, and potential enzyme activity.

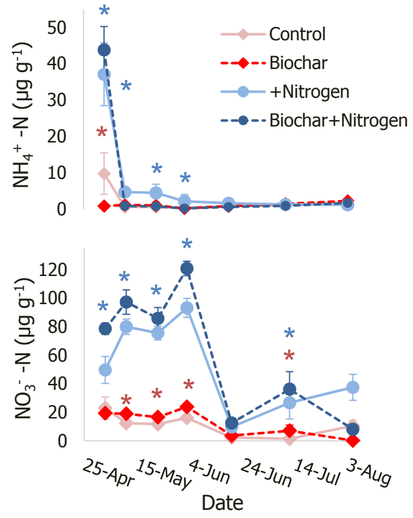
DNA extracted to determine functional gene copy number using qPCR.



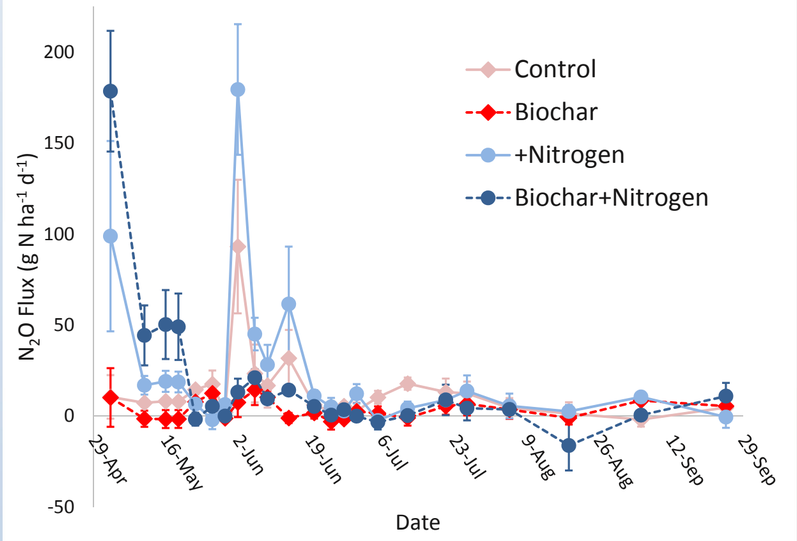
Results

*Significant differences between biochar & non-biochar treatments, $p < 0.05$ (Fertilized, Unfertilized)

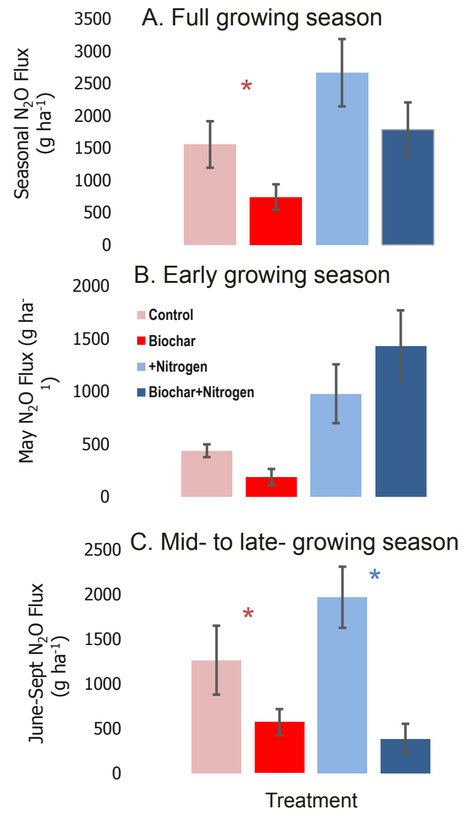
1. Soil nitrate was higher in biochar plots and ammonium lower in fertilized biochar plots for majority of season.



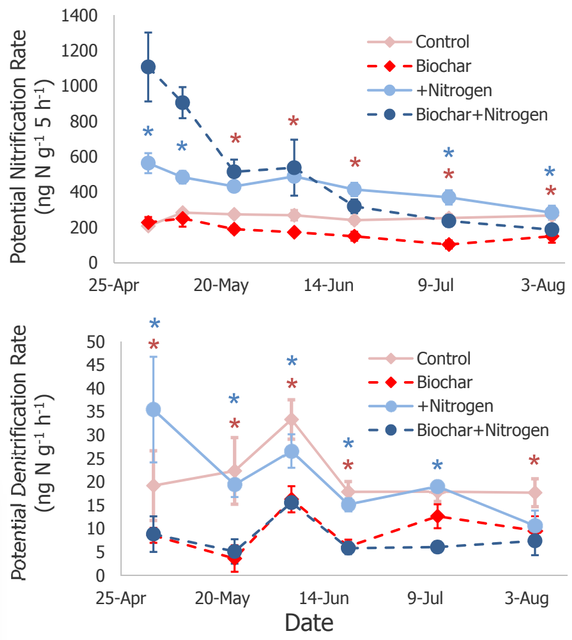
2. Daily N_2O fluxes exhibited complex dynamics in response to biochar over the growing season. Biochar treatments remained low after May, while non-biochar treatments continued to fluctuate.



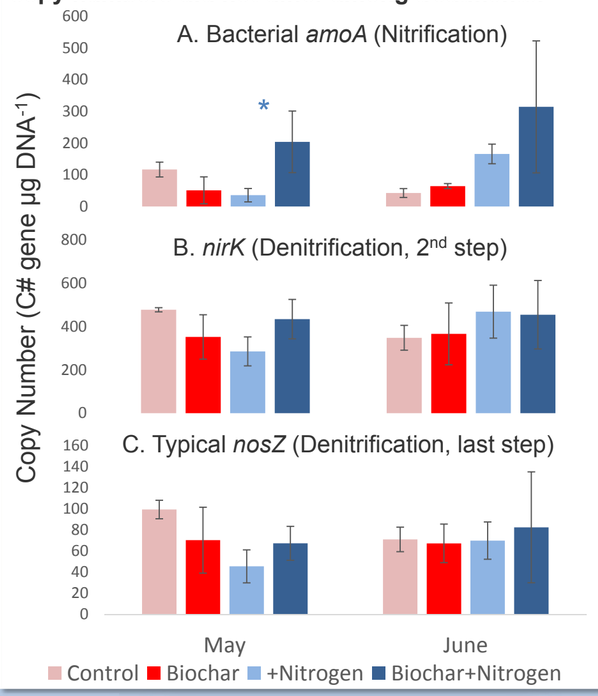
3. Cumulative N_2O fluxes for June-Sept were lower with biochar, leading to significant full season differences in unfertilized treatments.



4. Potential nitrification rates were higher for fertilized biochar plots early in the growing season, whereas potential denitrification rates were lower in biochar treatments throughout the season.



5. Nitrification gene copy numbers were greatest in fertilized biochar plots, while denitrification gene copy numbers did not differ among treatments.



Biochar Properties

Source	Yellow pine pyrolyzed at 550C
Bulk Density	0.224 g/cm^3
Organic Carbon	80.8% total mass
Total Nitrogen	0.63% total mass
C:N	128.3
Hydrogen/Carbon (H:C)	0.33 molar ratio (0.7 Max)
Total Ash	9.6% total mass
pH value	9.89
Surface Area Correlation	459 m^2/g dry

Conclusions

1. In unfertilized plots, biochar was associated with reduced N_2O emissions over the entire growing season.
2. In fertilized plots, biochar led to reduced N_2O emissions only later in the season.
3. Early in the season, fertilized biochar treatments showed higher rates of potential nitrification and greater copy numbers of the nitrification associated functional gene *amoA*.
4. Potential nitrification rates for biochar treatments were more sensitive to N availability than non-biochar treatments.
5. Biochar treatments exhibited lower rates of potential denitrification despite no significant differences in copy number of denitrification-related functional genes.
6. Effect of commercially available biochar on field N_2O emissions and microbial activity differed depending on N addition, with biochar mitigating N_2O emissions for some portion of the growing season in both unfertilized and fertilized treatments.

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