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Progressing from Terra Preta de Índios to the Whole World

Microbial Ecology of Biochar-Amended Soil

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Introduction

Soil biota are critical for soil function; thus, understanding how biochar added to soil may affect soil ecology is important for ensuring that soil quality is maintained. The size distribution of pores in properly prepared biochar provides a habitat for many microorganisms, where they are protected from predation and desiccation and where their diverse carbon (C), energy and mineral nutrient needs are met. We examined soil microbial biomass C; basal respiration; the metabolic quotient (qCO_2); C, nitrogen and phosphorus exoenzyme locations and activities; microbial community composition; and, the identity of dominant fungi colonizing biochar in a NY soil amended with 0, 1, 12 or 30 t biochar ha^{-1}.

Results and Discussion

Results echo those obtained in studies on the terra preta soils of the Brazilian Amazon. Biochar-amended soils had higher microbial biomass C, but lower basal respiration, which resulted in lower values for qCO_2. These results indicate a substantial increase in microbial carbon use efficiency, the existence of an alternative soil sink for CO_2 (such as the carbonate cycle), or some combination of these. Biochar-amended soils had higher activities of aminopeptidase and phosphatase, relative to β-D-glucosidase or β-D-cellobiase, which indicates a low demand for C substrate relative to cellular needs for N or P. The opposite was true for unamended soils, where C mineralizing enzymes were most active. These results suggest that the changes observed in qCO_2 in biochar-amended soils may be linked to increased microbial C use efficiency. Alternatively, the functioning of C-mineralizing enzymes may be impaired by how they become adsorbed to the biochar.

Biological molecules adsorb strongly to biochar. This compromises recoveries of target molecules in many of the assays commonly used to measure microbial characteristics of soils. In enzyme assays that depended on recovering fluorescent products formed when the substrates, MUF-P and MUF-G, were cleaved by their target enzymes, adsorption of liberated fluorophores increased with increasing levels of biochar added to soils. A unique approach was used to derive the kinetic coefficients needed to measure enzyme activities in biochar-amended soils. Adsorption isotherms were derived for each rate of biochar applied. These were fitted to the Freundlich Equation, which was then used to model the kinetics of each of four enzymes tested. and using the resulting modeled values derived to do so was developed (Jin et al., submitted). All other assays based on soil extractions needed to be similarly examined and modeled so that more robust data could be derived. The bacterial and fungal community compositions s were affected strongly by adding biochar to the NY soil. Community divergence increased with increasing rates of biochar applied. Sequenced fungal internal transcribed spacer (ITS) amplicons indicated a shift from septate fungi in the *Basidiomycetes* and *Ascomycetes* to coenocytic fungi in the *Zygomycetes* and *Glomeromycota* (arbuscular mycorrhizal fungi, AMF).

Enhanced germination of AMF spores in contact with biochar has been observed in other studies. Here, we suggest that the adsorption of essential nutrients on biochar allows these fungi to colonize, produce exoenzymes and meet their mineral nutrient needs. The recalcitrance of biochar suggests that the septate fungi may not be able to meet their C needs from biochar and thus are not encouraged to colonize.

Conclusions

Overall, our data suggest that profound changes in soil microbial communities are occurring in biochar-amended soils that apparently lead to tighter cycling and reduced system loss of both nutrients and carbon (as CO_2). Biochar clearly influences the diversity of microbes colonizing its surface, their activities and their abundance, with a net result of the conservation of resources within the soil system.