Designing relevant biochars as soil amendments using lignocellulosic and manure-based feedstocks

By: J. Novak, K.B. Cantrell, D.W. Watts, W.J. Busscher and M.G. Johnson

ABSTRACT

Purpose: Biochars are a soil amendment produced from lignocellulosic and manure feedstocks. Not all biochars are viable soil amendments because of differences in their physical and chemical properties. Biochar could deliver more effective service as a soil amendment if its chemistry were designed prior to pyrolysis. In this study, we demonstrate how biochars can be designed with relevant properties as successful soil amendments through feedstock selection, pyrolysis conditions, and particle size choices.

Materials and methods: Biochars were produced by pyrolysis of parent lignocellulosic (peanut hull, pecan shells, switchgrass, pine chips, and hardwood wastes), and manure (poultry litter), and blends of these feedstocks at temperatures ranging from 250 to 700°C. Additionally, blended feedstocks were made into pellets prior to pyrolysis at 350°C. Dust sized biochar was obtained through grinding of pelletized biochars. The biochars were evaluated as fertility amendments in a Norfolk soil during two different pot incubation experiments.

Results and discussion: Poultry litter biochars were alkaline and enriched in N and P, whereas biochar from lignocellulosic feedstocks exhibited mixed pH and nutrient contents. Blending PL with PC resulted in lower biochar pH values and nutrient contents. In pot experiment 1, all biochars significantly ($P < 0.05$) raised soil pH, soil organic carbon (SOC), cation exchange capacity (CEC), and Mehlich 1 extractable P and K. Poultry litter biochar added at 20 g kg-1 resulted in excessive soil P concentrations (393 to 714 mg kg-1) and leachate enriched with dissolved phosphorus (DP, 22 to 70 mg L-1). In pot experiment 2, blended and pelletized PL with PC feedstock reduced soil pH and extractable soil P and K concentrations compared to pot experiment 1. Water leachate DP concentrations were significantly ($P < 0.05$) reduced by pelletized biochar blends.

Conclusions: Short-term laboratory pot experiments revealed that biochars can have different impacts at modifying soil quality characteristics. Keying on these results allowed for creating designer biochars to address specific soil quality limitations. In the process of manufacturing designer biochars, first, it is important to know what soil quality characteristics are in need of change. Second, choices between feedstocks, blends of these feedstocks, and their accompanying particle sizes can be made prior to pyrolysis to create biochars tailored for addressing specific soil quality improvements. Utilization of these principles should allow for effective service of the designed biochar as a soil amendment while minimizing unwanted ex facto soil quality changes and environmental effects.