Biochar and Managed Perennial Ecosystems: Testing for Synergy in Ecosystem Function and Biodiversity

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Introduction

Biochar is a carbon-rich material that is similar to charcoal. It is produced when biomass is burned in the absence of oxygen, a process otherwise known as pyrolysis. Pyrolysis and the production of biochar are currently being promoted as a means to both produce domestic fuel (bio-oil) while concurrently producing a co-product that increases crop yield and sequesters carbon in the soil (biochar). Although there may be many potential benefits in the application of biochar to agricultural soils, such as enhanced soil fertility and improved soil water status, there are no studies of higher-order ecological and ecosystem effects of biochar and its potential synergistic interactions (either positive or negative) on complex perennial systems. The goal of this field experiment was to determine how biochar and manure addition directly affected ecosystem structure and function in perennial systems, specifically soil nutrients, water, plants, and soil organisms.

Materials and Methods

In April 2011, we established five experimental blocks each containing six 4-m^2 plots (30 total plots). Within each replicate block we randomly assigned plots to one of six treatments: factorial combinations of two nutrient addition levels (0 and 4.5 kg manure m^{-2}) and three biochar levels (0, 1% and 3% of soil volume). A diverse seed mixture of 30 tall grass prairie species was planted following plot set up. In March 2012, the plots were burned to remove excess vegetation litter.

Results and Discussion

In the third year of this restoration, the native prairie species, including Canadian wild rye, side oats grama, black-eyed Susan, and big blue stem, began to dominate the site (Figure 1). There also was an increase in the number of plant species (richness) from the first two years of this study, but unlike previous years, there was no effect of the biochar and manure treatments on plant species richness (Table 1).

Biochar and manure interacted to affect the biomass of the planted species. In the no-manure treatments, biochar had no effect on the biomass of planted species. However, planted species biomass in the manure treatments was greatest in 3 percent biochar treatment. In the control biochar treatment (0%), manure significantly reduced planted species biomass. We found no effect of biochar or manure on total plant biomass.

The soil microbial community, as characterized by phospholipid fatty acids, was uniform across the various treatments (Figure 2). Yet the activity of soil enzymes produced by the microbial community was affected by both manure and biochar (data not shown), suggesting the microbes were influenced by these inputs. We will continue to monitor both above- and below-ground community development and nutrient levels for the next two years to determine how biochar may affect non-agricultural communities.

Acknowledgements

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Table 1. Mean (± standard error) plant community and soil parameters with biochar and manure treatments, year 3.

	Control			Manure (4.5 kg m^{-2})		
	0%	1%	3%	0%	1%	3%
Species richness	11.0 ± 0.7	13.2 ± 2.1	12.8 ± 1.2	11.0 ± 0.8	14.6 ± 1.1	12.0 ± 0.6
Planted biomass (g m^{-2})	145.61 ± 45	129.01 ± 50	178.47 ± 52	78.74 ± 34	113.53 ± 43	215.55 ± 61
Total aboveground biomass (g m^{-2})	612.75 ± 31	739.97 ± 126	583.81 ± 84	656.06 ± 172	901.85 ± 368	662.35 ± 57
Belowground biomass (g m^{-2} to 10 cm)	352.92 ± 96	321.72 ± 52	192.02 ± 36	148.70 ± 30	202.36 ± 53	415.08 ± 139
Total soil carbon (g kg^{-1} soil)	42.12 ± 5.3	54.59 ± 2.8	78.85 ± 6.2	45.45 ± 1.2	58.08 ± 7.2	67.41 ± 5.8

Figure 1. Vegetation in experimental biochar plots, June 2013.

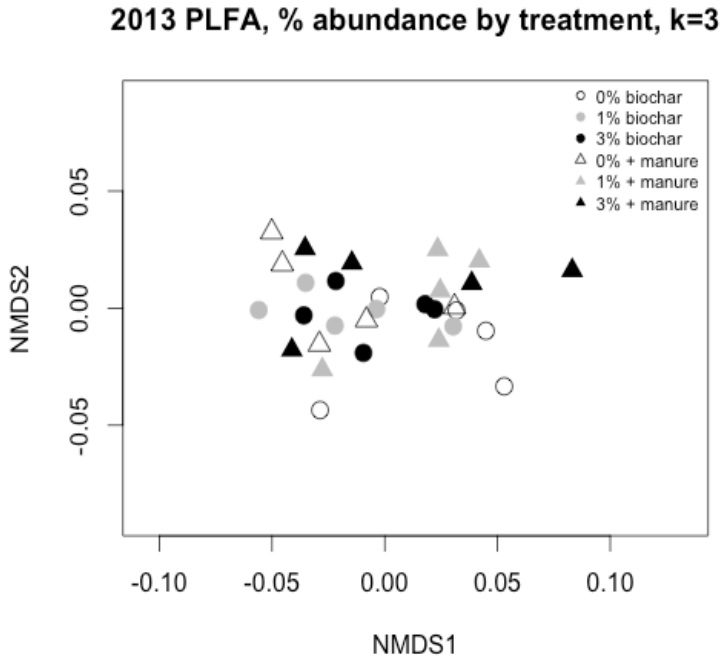

Figure 2. Soil microbial community (as measured by phospholipid fatty acids) differentiation in the biochar and manure treatments, year 3.