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Biochar as a Soil Amendment for Vegetable Production

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Abstract

Environmental concerns and the price of fossil fuels have encouraged research on technologies to utilize biomass in energy production. Some technologies being investigated for their potential to provide energy involve a process known as pyrolysis. One of the byproducts of pyrolysis is called biochar. Biochar has shown potential to improve plant and soil health on several unproductive soils around the world. Much of the research on the use of biochar in Iowa soils has been focused around agronomic crops with little research into how it may affect vegetable production systems.

Objectives of this study were to investigate the effects of using biochar as a soil amendment on bell pepper (Capsicum annuum L. Paladin) production in Iowa. The study investigated biochar's effects on plant growth, yield, and soil nutrient retention.

Keywords

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Disciplines

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Biochar as a Soil Amendment for Vegetable Production

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Introduction

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Objectives of this study were to investigate the effects of using biochar as a soil amendment on bell pepper (*Capsicum annuum* L. Paladin) production in Iowa. The study investigated biochar's effects on plant growth, yield, and soil nutrient retention.

Materials and Methods

Study was conducted at the ISU Horticulture Research Station, Ames, Iowa. Soil type was Clarion loam, moderately eroded, with 5 to 9 percent slope. Biochar treatments (Struemph Charcoal Company, Belle, MO) included four rates: 0, 5, 10, and 20 tons/acre. In May 2012, biochar was hand applied at set rates to 20 by 20 ft plots. Soon after application, biochar was tilled into the top 6 in. The experiment was set up as a split plot design with biochar rate as the main plot and plastic mulch treatment as sub plots. Within each biochar treatment, two 20 ft long raised beds were shaped, one with black plastic, and the other without plastic. Pepper plants were then transplanted in double rows on each bed. Drip irrigation was set up and the frequency of irrigation was determined using tensiometer (Irrometer Company, Riverside, CA). Data variables collected were marketable and non-marketable fruit weight and numbers, plant height, leaf chlorophyll content, and plant dry weight. Chlorophyll content was measured using a SPAD 502 Plus Chlorophyll Meter. Lysimeters were also set up at a depth of 2 ft in each treatment to monitor water quality. Water samples were sent to the Iowa State University Soil and Plant Analysis Laboratory.

Results and Discussion

No treatment differences were observed for marketable or nonmarketable fruit numbers or nonmarketable weight. There were no statistically significant differences in marketable weights within plastic mulch or no-plastic mulch treatments, however, differences existed between 0 tons/acre no-plastic treatment and biochar rates of 10 or 20 tons/acre in the plastic mulch treatment. A decreasing trend in marketable yield and marketable number is seen as the biochar application rate increases within the plastic mulch treatment. Plant height, chlorophyll content, or dry weight did not show statistically significant differences (Table 2). Nitrate leaching (Figure 1) decreased with the progress of the growing season. Plots with higher biochar rates (10 and 20 tons/acre) consistently showed lesser amount of nitrate leaching for four sampling dates between July and August 2012, however, those reductions were not visible in the final four sampling dates (Figure 1).

The lack of response to biochar mulch treatments was anticipated as research has shown biochar to decrease nutrient availability in certain soils during the first year of biochar application. Nutrient tie up may be responsible for the decreasing trend in marketable yield, and marketable number mentioned previously. The increased production of the peppers grown without plastic mulch was not anticipated but is likely due to the relatively high temperatures over much of the growing season. Black plastic mulch is used to increase soil temperature early in the season, and may have had detrimental effects on production due to the abnormally high temperatures seen this summer. The early season decrease in leaching from plots with higher levels of biochar is likely due to nitrates being adsorbed to the surface of the biochar particles, and the decrease in nitrate leaching seen late in the season could be due to the increased uptake of nitrates by larger plants.

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Table 1. Marketable and nonmarketable yield and number of peppers grown in different biochar and plastic mulch treatments at ISU Horticulture Research Station.[Z]

		Fruit yield per plot (kg)		Fruit number per plot	
Plastic treatment	Biochar (tons/acre)	Marketable[y]	Nonmarketable[NS]	Marketable[NS]	Nonmarketable[NS]
Black plastic	0	22.2 abc	9.4	178	123
	5	20.9 abc	8.1	166	101
	10	19.8 bc	8.0	155	96
	20	18.9 c	9.0	151	110
No plastic	0	27.0 a	9.3	192	103
	5	24.6 abc	9.0	178	106
	10	25.1 abc	10.0	187	114
	20	25.5 ab	7.4	192	87

[Z]Means are an average of four treatment replicates.
[y]Means within column followed by the same letter are not significantly different from one another (α=0.05, Fisher's protected t-test).
[NS]Means within column are not significantly different from one another (α=0.05, Fisher's protected t-test).

Table 2. Average plant height, dry weight, and chlorophyll content of pepper plants grown in different biochar and plastic mulch treatments at ISU Horticulture Research Station.[z]

Cover	Biochar (tons/acre)	Height[NS] (cm)	Biomass[y] (g)	SPAD[y]
Plastic	0	50.5	94.1 b	59.2 abcd
	5	49.1	96.4 ab	57.5 cd
	10	47.6	98.4 ab	58.0 bcd
	20	50.6	105.3 ab	56.2 d
No plastic	0	53.4	118.5 a	63.7 a
	5	51.1	104.1 ab	62.2 abc
	10	51.7	105.8 ab	61.8 abcd
	20	52.9	108.8 ab	59.9 abcd

[Z]Means are an average of four treatment replicates.
[y]Two plants from each treatment were collected at the end of the growing season. Means within column followed by the same letter are not significantly different from one another (α=0.05, Fisher's protected t-test).
[NS]Means within column are not significantly different from one another (α=0.05, Fisher's protected t-test).

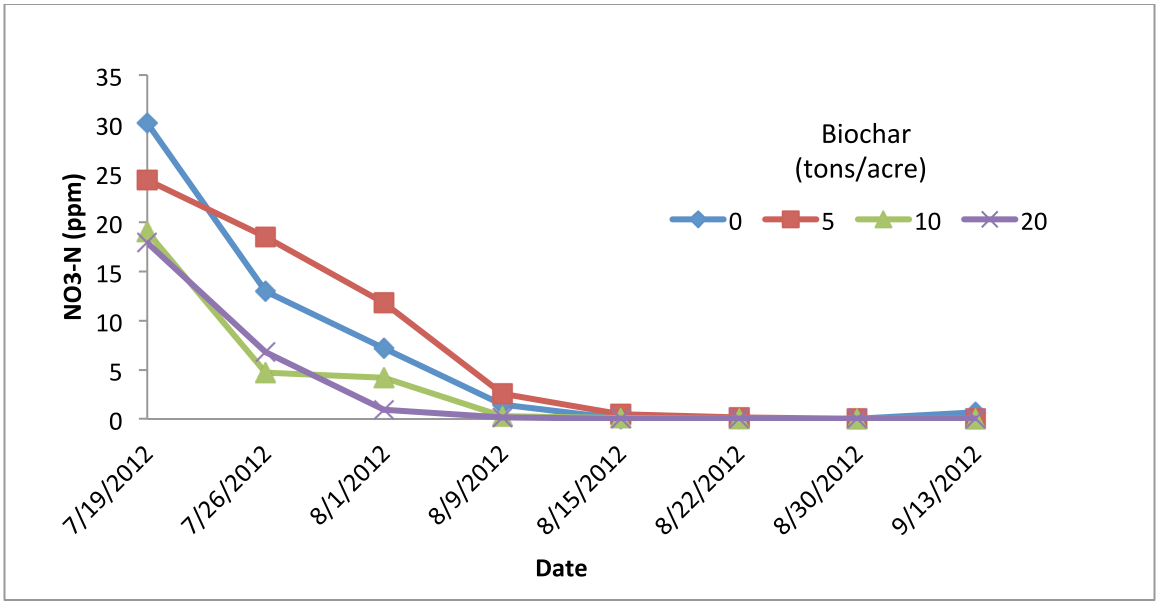

Figure 1. Levels of nitrate in leachate collected at 2-ft depth near the pepper plants in no-plastic biochar treatments.