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Biochar Application in Potato Production

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Abstract
Biochar is an organic amendment produced by the process called pyrolysis, which is the burning of biomass in a limited oxygen environment. It can be produced using different biomass types, for example, switch grass, corn residue, or hardwoods. Potential benefits of biochar in cropping systems could include nutrient recycling, soil conditioning, and long-term carbon sequestration. Research in corn and soybean production systems has shown promising results with biochar application, however, research in vegetable cropping systems is lacking.

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Biochar Application in Potato Production

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Introduction

Biochar is an organic amendment produced by the process called pyrolysis, which is the burning of biomass in a limited oxygen environment. It can be produced using different biomass types, for example, switch grass, corn residue, or hardwoods. Potential benefits of biochar in cropping systems could include nutrient recycling, soil conditioning, and long-term carbon sequestration. Research in corn and soybean production systems has shown promising results with biochar application, however, research in vegetable cropping systems is lacking.

In the area of vegetable crops, there are no standards or application strategies (amount, incorporation technique, etc.) that have been developed for the use of biochar. This study investigated the potential use of biochar for commercial potato production. The core objective of the study was to determine an optimal application rate of biochar and evaluate its effects on crop yield.

Materials and Methods

The study was conducted at the ISU Muscatine Island Research and Demonstration Farm, Fruitland, Iowa. Soil type was Fruitfield coarse sand with 0 to 2 percent slope and less than 1.5 percent soil organic matter. The plot was chisel plowed in March and disked in April 2012 and 2013. A pre-plant fertilizer application of 250 and 400 lb/acre of 0-0-60 and 13-13-13, respectively, were made in April for both 2012 and 2013. Four application rates of biochar (0, 2.5, 5.0, or 10.0 ton/acre; 0 ton/acre is referred to as Control) were applied by hand (Figure 1) on April 12, 2012. No biochar was further applied in 2013. Each plot measured 15 ft by 30 ft. Experimental design was a randomized complete block design with four replications.

A mid-season chipping potato (cv. Atlantic) was seeded on April 12, 2012 and April 22, 2013. Each treatment had four rows of potato with the middle two as data rows and the sides as guard rows. Potato seeding was followed by an herbicide spray of Dual II Magnum® (active ingredient A-metolachlor) + Matrix® (active ingredient Rimsulfuron). Insect and disease control was achieved using Mustang Max® (active ingredient zeta-cypermethrin) and Equus® (active ingredient chlorothalonil). On May 11, 2012, urea and ammonium sulfate were broadcast to provide 114 and 15 lb/acre of nitrogen and sulfur. To enhance crop growth, additional nitrogen (20 lb/acre) was applied through overhead irrigation on June 20, 2012. In 2013, urea was applied twice to provide a combined rate of 250 lb/acre. Sulfur was applied at the rate of 20 lb/acre on June 7, 2013. Soil samples were collected in the beginning, mid, and end of the season. Both years in June, data were collected on plant height and width. One of the middle 30-ft-long rows from each treatment was harvested on July 26, 2012 and August 1, 2013. Data was collected as marketable and non-marketable weight and number.

Results and Discussion

At the end of the 2012 growing season, soil pH ranged from 6.1 to 6.4. Biochar has been shown to increase soil pH, although, we did not observe statistically significant differences between treatments (Table 1). There was a general trend of increasing soil pH with increasing biochar rates. Similarly, soil electrolytic conductivity did not show statistically significant differences. In 2013, there were significant differences in soil pH with the control treatment showing lower pH compared with 5 and 10 ton/acre treatments (Table 1). There were no statistically significant differences in pH between control and 2.5 ton/acre, between 2.5 and 5 ton/acre, and also between 5 and 10 ton/acre treatments.

Although there were visible differences in plant growth, there were no statistically significant numerical differences. Plant height and width measured in June in both years did not show any differences (Table 2). Annual data for plant height and width were combined, as there was no interaction between years. In our study we did not find any statistically significant difference for marketable and non-marketable yields (Table 3).

Overall there was considerable increase in potato yield in 2013. One promising trend is the absence of yield reduction for biochar treated plots in both years. Several biochar studies in agronomic crops have shown yield reductions in the first couple of years of biochar use followed by increases in subsequent years. Increases in crop yields have been attributed to better water holding capacity, higher cation exchange capacity, increased nutrient retention, and the ability of biochar to reduce bulk density. Biochar could be a valuable tool for management of soils that are either degraded or have poor nutrient status, however, it would take time to observe significant changes in soil and crop attributes after biochar addition.

Table 1. Effect of biochar on soil pH and electrolytic conductivity at potato harvest (July 26, 2012 and August 1, 2013).

Treatment	Soil pH[1]	Electrolytic conductivity[2] (mS/cm)
	2012	
Control	6.2[2]	0.37
2.5 ton/acre	6.1	0.32
5.0 ton/acre	6.3	0.22
10.0 ton/acre	6.4	0.27
	2013	
Control	5.3 c	0.19
2.5 ton/acre	5.5 bc	1.16
5.0 ton/acre	5.7 ab	0.16
10.0 ton/acre	5.9 a	0.17

[1]Mean separation within columns by Fisher's protected LSD (P≤0.05); means followed by same letter(s) are not significantly different (P≤0.05).
[2]NS=non-significant.

Table 2. Effect of biochar on potato (cv. Atlantic) plant height and width for two years.

Treatment	Plant height[1,2] (cm)	Plant width[1,2] (cm)
Control	45.7	77.3
2.5 ton/acre	46.0	79.5
5.0 ton/acre	46.0	82.3
10.0 ton/acre	47.6	76.7

[1]Plant height and width were collected from eight plants, randomly selected per treatment.
[2]NS=non-significant. Mean separation by Fisher's protected LSD (P≤0.05).

Table 3. Effect of biochar application on potato yield characteristics (2012-2013).[1]

Treatment	Marketable number[2]	Marketable weight[2] (kg)	Non-marketable weight[2] (kg)	
			Scab	Cull
		2012		
Control	93	17.4	15.1	3.1
2.5 ton/acre	106	20.5	15.5	2.9
5.0 ton/acre	87	17.0	19.1	5.3
10.0 ton/acre	90	17.1	17.4	3.1
		2013		
Control	227	31.7	3.1	3.0
2.5 ton/acre	241	33.7	1.7	3.4
5.0 ton/acre	235	32.9	2.5	3.0
10.0 ton/acre	242	36.4	1.8	3.5

[1]Data collected from 30-ft-long rows.
[2]NS=non-significant. Mean separation by Fisher's protected LSD (P≤0.05).