Effect of Biochar on Carrot Production

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Introduction

Environmental and economic factors are encouraging research into biofuel technologies. One such technology is gaining interest because of its potential to utilize waste streams as well as low quality biomass difficult to process into ethanol. This technology is known as pyrolysis. Pyrolysis is the burning of biomass in a low oxygen environment. Biochar is a byproduct of the pyrolysis process. Biochar has shown potential to improve plant growth in marginal soils. Little research has looked at the effect of growing root crops in soils amended with biochar, or on how biochar might affect the post-harvest quality of root crops like carrots.

Objectives of this study were to investigate the effects of using biochar as a soil amendment for carrot (*Daucus carota* L., var. *sativus* Huffm.) production in Iowa. The study investigated biochar's effects on plant growth, yield, and post-harvest quality.

Materials and Methods

Research was conducted at the ISU Horticulture Research Station, Ames, Iowa, in two types of soil—Clarion loam, moderately eroded, with 5 to 9 percent slope; and a highly modified sand and pea gravel plot formerly used for turf grass research. Biochar treatments included four rates: 0, 5, 10, and 20 ton/acre. In May 2012, biochar was applied at set rates to 20 ft × 20 ft plots. Soon after application, biochar was tilled into the top 6 in. The experimental design was a randomized complete block design with four replications. Carrots were direct seeded using Jang JP 1 precision seeder (Jang Automation, Korea). Each treatment consisted of two beds of carrots. Each bed consisted of three rows 12 in. apart. Carrot seeds were spaced 1.5 in. within rows. Carrots were harvested after the first frost in the fall. Data were collected on marketable number and weight, non-marketable number and weight, and total soluble solids (Brix° value). Total soluble solid estimation was conducted on two sets of carrot samples, stored for one and eight weeks after harvest.

Results and Discussion

No treatment differences were seen for marketable carrot weight or numbers in the loam or sand plots (Tables 1 and 2). Non-marketable carrot weight was not different between 0, 10, or 20 ton/acre treatments in either loam or sand; however, there was a decrease in non-marketable carrot weight in the 5 ton/acre treatment in the loam soil. Even though there were no statistically significant differences between treatments, there was a positive effect on marketable carrot weights in the 5 ton/acre treatment. There was a decrease in number of forked carrots as the rate of biochar increased. The 20 ton/acre treatment significantly decreased the number of forked carrots in both sandy and loamy soil (Table 2). Similar trend was observed in forked carrot weights in the sandy soil. There were, however, no treatment differences in forked carrot weights in the loam soil (Table 1). Decreases in the number of forked carrots may have important implications for carrots grown in heavier loam as well as nutrient-poor sandy soils. A decrease in the number of forked carrots in the loamy soil could possibly be due to a decrease in bulk density brought about by the addition of biochar. As biochar is a low density material, large additions may help to increase air and water infiltration. The decreases in forking in sandy soils could be due to either a change in nutrient availability, or a decrease in disease or abiotic stresses. These findings have important implications as biochar may help decrease numbers of forked carrots in soils considered marginal for carrot production. There were no differences in total soluble solids (Brix˚value) between treatments in either of the sampling dates (Figure 1). Brix˚values were higher for the samples analyzed eight weeks after harvest, however this difference was not significant. This slight increase is likely due to loss of water in the carrot during the extra seven weeks of storage.

Acknowledgements

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Table 1. Yield characteristics of carrots grown on loamy soil.

Biochar (ton/acre)	Weight (kg)			Number		
	Marketable[x]	Non-marketable[z,y]	Forked[x]	Marketable[x]	Non-marketable[y]	Forked[y]
0	12.8	15.8 a	13.1	96	86 a	68 a
5	15.4	13.5 b	11.4	111	73 ab	59 ab
10	13.2	15.3 ab	13.2	93	77 ab	62 ab
20	14.2	14.0 ab	12.1	94	66 b	58 b

[z]Sum of two categories of non-marketable roots: size/shape and aster yellows.
[y]Means within a column followed by the same letter are not significantly different from each other (α=0.05, Fisher's protected LSD).
[x]Not statistically significant (α=0.05).

Table 2. Yield characteristics of carrots grown on sandy soil.

Biochar (ton/acre)	Weight (kg)			Number		
	Marketable[x]	Non-marketable[z,x]	Forked[y]	Marketable[x]	Non-marketable[y]	Forked[y]
0	5.6	7.0	6.3 a	51	37 ab	28 ab
5	6.4	6.9	6.1 ab	58	42 a	32 a
10	5.0	5.8	4.5 ab	46	31 b	20 bc
20	5.5	5.4	4.3 b	47	29 b	19 c

[z]Sum of two categories of non-marketable roots: size/shape and aster yellows.
[y]Means within a column followed by the same letter are not significantly different from each other (α=0.05, Fisher's protected LSD).
[x]Not statistically significant (α=0.05).

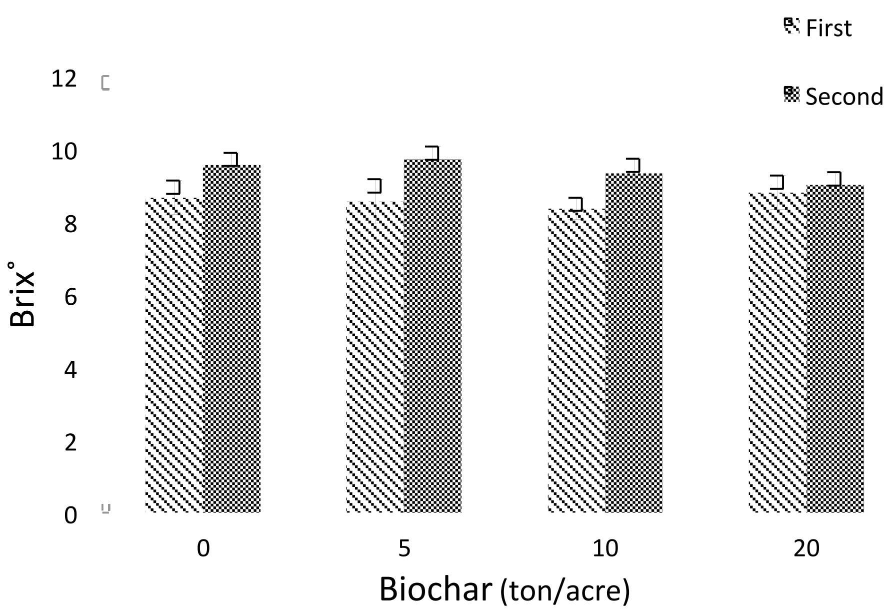

Figure 1. Average carrot juice Brix° (total soluble solids) measured one week (first) and eight weeks (second) after harvest. Means were not significantly different from one another (α=0.05).