Impacts of Biochar and Compost on Vegetable Production

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Introduction

Biochar is a material that has various uses, including as a soil amendment. Biochar is biomass which, by thermal decomposition, has been broken down through a process called pyrolysis. This procedure increases surface area, cation exchange capacity, and porosity of the biochar, among other benefits. These characteristics of biochar are beneficial to plants as the increased cation exchange capacity and surface area allows for storage sites of nutrients, which can be taken up by plant roots. Increased pore space created from the addition of biochar gives greater nutrient availability and enhanced water retention, allowing for greater plant growth.

The importance of this project rests in the potential of biochar to serve as a "holding container" for nutrients from which plants can draw. By adding biochar to the soil, it may be possible to decrease the impacts of nutrient leaching, utilizing biochar's high surface area and cation exchange capacity rates. Therefore, it is possible that as these nutrients become more readily available to plants over time due to the presence of biochar, fertilizer application rate could be decreased. Less use of fertilizer implies a lower economic impact of input costs to growers and decreased nutrient leaching could mean healthier waterways. Increases in nutrient retention could allow for greater plant growth and productivity, and could positively influence soil fertility and health.

The objective of this study was to test impacts of varying biochar application rates with or without additional compost. Literature suggests there could exist a drag on nutrient availability to plants the first year of biochar application. Compost as an additional treatment in this study will help researchers understand if a drag exists, and if compost application can mitigate that issue by enhancing plant health and soil fertility. Research has been done on midwestern soils using application rates higher than rates chosen for this study. This study investigates the viability of smaller application rates of 500 lb/acre, 1,000 lb/acre, and 2,000 lb/acre on midwestern soils. With the addition of compost to each respective rate, the study will further investigate how soil microbial communities are impacted by biochar plus compost additions, and if there are significant impacts on overall soil fertility, plant health, and yields.

Materials and Methods

The study used a split plot randomized complete block design with four replications. The whole plot factor was biochar rate (0, 500, 1,000, 2,000 lb/acre), and the subplot included compost treatment (no-compost or compost). Compost treatments received 9,680 lb/acre of compost, which was broadcasted and incorporated. The biochar and compost were applied June 8, 2020. The biochar was spread by hand for the 500 and 1,000 lb/acre rate, and with a variable rate drop spreader for the 2,000 lb/acre treatment. The compost was hand spread as well. Both applications were incorporated through tillage. Raised beds with black plastic mulch and drip irrigation were set up. Each subplot consisted of four 20-ft long beds of pepper (Red Knight) with the outer two beds serving as the guard row. Beds were spaced 5.5 ft center-to-center and comprised of two rows of pepper spaced 15 in. apart. Plant spacing within row was 18 in. Pepper was seeded in 72-celled trays April 24 at the ISU Horticulture Greenhouse. Transplants were hardened off starting June 2, and transplanted June 12.

During the growing season, based on soil test results, crop was fertigated with Nutriculture® 20-20-20 and Calcint® 15.5-0-0. Crop was sprayed once with Bt (Dipel Pro), twice with neem oil (Trilogy), and once with Esfenvalerate (Asana) to manage cucumber and flea beetles. Pepper was harvested seven times over the growing period. A few harvests, including the first, were lost due to the derecho weather event August 10, 2020. After this event, we cleared the field of all damaged peppers and began a regular harvest schedule August 21, 2020. After harvest, peppers were graded into marketable and non-marketable categories. Marketable peppers included fruits that had blocky shape, large size, and lack of blemishes, cuts, or bruises. Non-marketable category included fruits exhibiting blossom end rot, sun scald, small sized, and frost damage.

Results and Discussions

Overall, yields were low due to the negative impact of derecho on crop growth. There were no significant differences in marketable fruit number or weight between biochar rates or the compost treatment. The higher biochar application rate of 2,000 lb/acre had slightly higher marketable fruit number and weight than other treatments, but it was not statistically significant. Similarly, compost treatment also exhibited slightly higher marketable fruit weight, but there was no statistical significance. Biochar application did not have any affect on number of fruits exhibiting blossom end rot or sunscald. Treatments that received compost had higher number of fruits with sunscald as compared with no-compost treatment. The 2,000 lb/acre biochar treatment also had higher number of fruits damaged by frost. This could be attributed to higher number of marketable fruits in that treatment at the time of the last harvest that was affected by a frost event.

Overall, we did not observe any benefit of biochar on crop growth or yield, however, there was no yield drag either. Studies have reported reduced yield in vegetable crops planted soon after biochar incorporation primarily due to nitrogen immobilization. Given the first year of the study, it is positive there was no yield drag. Soil data still is being analyzed for effect of biochar and compost on soil nutrient concentrations and microbial population diversity and biomass.

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Table 1. Average pepper marketable and non-marketable yield at the ISU Horticulture Research Station, Ames IA. Yield data reported from 22 plants in each treatment.

	Marketable		Blossom end rot		Sunscald		Small size		Frost damage	
Treatment	**Number**	**Weight (kg)**	**Number**	**Weight (kg)**	**Number**	**Weight (kg)**	**Number**	**Weight (kg)**	**Number**	**Weight (kg)**
Biochar[z]										
No-biochar	74	18.4	4.4	0.7	14	2.7	34	5.0	4 b[y]	0.6 b
500	73	18.1	4.0	0.6	12	2.8	34	4.6	5 b	0.7 b
1,000	78	18.9	5.7	1.0	12	2.6	29	4.3	6 b	0.9 b
2,000	81	19.9	3.8	0.7	13	2.8	29	3.7	10 a	1.6 a
Significance	*0.5638*	*0.7569*	*0.2884*	*0.4642*	*0.8645*	*0.9757*	*0.5012*	*0.3875*	*0.0008*	*0.0016*
Compost[x]										
No-compost	73	17.9	4.8	0.8	11 b	2.3 b	32	4.4	7	1.1
Compost	80	19.7	4.2	0.7	14 a	3.1 a	31	4.4	5	0.8
Significance	*0.1371*	*0.1971*	*0.4097*	*0.7192*	*0.0454*	*0.0455*	*0.6729*	*0.9412*	*0.0581*	*0.1234*

[x]Compost application @ 9,680 lb/acre.

[y]Mean separation within columns and treatments using Fisher's protected t-test; means followed by same letter(s) are not significantly different ($P \leq 0.05$).

[z]Biochar rates in expressed lb/acre.