# Impact of Biochar and Fertility Management on Potato Production

**RFR-A1750**

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## Introduction

Biochar, a charcoal created from organic materials burned at high temperatures and low oxygen environment, when added as a soil amendment, has been shown to increase soil fertility, water holding capacity, greenhouse gas reduction, and carbon sequestration. Biochar as a biorenewable resource has the potential to positively impact several key areas of our production systems such as soil organic matter and quality, water quality, crop growth, yield, and productivity.

Adding biochar to a soil is an irreversible decision, so understanding its long-term impacts is essential for growers to make informed decisions. In the United States, most biochar research has been conducted in warmer regions. Little has been published on how biochar will affect crop production in northern climate zones such as the Midwest, especially in horticultural crops. In addition, long-term effects of biochar and its interaction with fertility programs such as compost and synthetic fertilizers have not been studied. Not much information is available on biochar types, quality, and appropriate field application rates in vegetable cropping systems. This study builds on a previous experiment that was set up in 2012 with different biochar application rates on a sandy soil in Fruitland, Iowa. The objective of this study was to investigate interactions among biochar and two soil fertility programs to optimize the application rate and evaluate the effect of biochar on potato production.

## Materials and Methods

The study was conducted at the 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. Four rates of biochar (0, 2.5, 5.0, or 10.0 tons/acre; 0 tons/acre, referred to as Control) were applied and incorporated April 5, 2012. Each plot measured 15 ft x 30 ft. Several crops such as potato, sweet corn, sweet potato, and cabbage were grown from 2012 to 2016. In 2017, each biochar plot was split into two and assigned to one of the fertility treatments: urea or compost. Individual plots were 7.5 ft x 30 ft. On April 21, 2017, dairy manure-based compost was spread and incorporated to provide 120 lb N/acre. Urea was applied in three equal splits to provide a total of 120 lb N/acre. Urea was broadcast and incorporated April 21, May 26, and June 23, 2017. Experimental design was a randomized complete split block design with four replications.

A mid-season chipping potato (cv. Atlantic) was planted April 25, 2017. Each treatment had two rows of potato. Rows were spaced 40 in. apart and potatoes within rows were spaced 8 in. apart. Potato seeding was followed by a herbicide application of Dual II Magnum® (active ingredient A-metolachlor) + Lorox® [active ingredient Linuron 3-(3, 4-dichlorophenyl)-1- methoxy-1-methylurea)] May 3, 2017. Insecticide Fanfare® (active ingredient bifenthrin) was sprayed June 22, 2017, followed by Mustang Max® (active ingredient zeta-cypermethrin) July 14, 2017. Fungicide Inspire® (active ingredient

Difenoconazole) was sprayed July 14 to manage diseases. Soil samples were collected at the beginning, middle, and end of the season. Crop was irrigated using central pivot irrigation. Potato was harvested August 4, 2017, and data collected on marketable and non-marketable tubers. Ten potatoes were randomly collected from each treatment to record hollow heart. Specific gravity also was collected.

## Results and Discussion

At the beginning of the growing season, soil pH ranged from 6.7 to 6.9 (Table 1). Biochar has been shown to increase soil pH, although we did not observe statistically significant differences between treatments. There was a general trend of increasing soil pH with increasing biochar rate. Similarly, soil electrical conductivity did not show statistically significant differences and ranged from 0.13 to 0.16. Biochar application increased soil organic matter from 1.57 percent (Control) to 2.02 percent (10 tons/acre biochar treatment). There were no differences in soil phosphorus, potassium, calcium, or magnesium concentrations between biochar application rates.

There was no interaction between biochar rates and fertilization treatment. There were no significant differences in total potato weight between biochar application rates (Table 2). The source of fertility significantly affected total weight with urea treatment showing higher total weight. Similar effects were observed in A-grade tuber number and weight with urea significantly increasing number and weight as compared with compost treatment.

There were no significant differences in number or weight of B-grade tubers between biochar application rates or fertility treatments. Tuber quality was not affected by biochar application rates, however, fertility program did have a significant effect. Numbers and weights of tubers with scab were higher in the urea treatment when compared with compost (Table 3). Incidence of hollow heart was minimal with no significant differences between biochar or fertility treatments.

The effect of biochar on vegetable crop yields are not widely available, however, data is available for field crops. A number of studies have shown yield reductions in the initial years after biochar incorporations followed by increases in subsequent years. We did not find any increase in number or weight of A-grade or B-grade tubers with the use of biochar.

This study is being conducted in year five after biochar incorporation (2012), therefore, there is a possibility that differences may appear in later years. Several studies have shown improvement in soil water holding capacity, higher cation exchange capacity, increased nutrient retention, and reduction in soil bulk density with biochar use. In this study, biochar has been in the soil only for the last five years, which is too early to speculate effects of biochar on soil properties, crop growth, and yield. Biochar could be a valuable tool for management of soils that are either degraded or have poor nutrient status. It may 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 the time of potato planting.** †

| Treatment | Soil pH$^{NS}$ | Electrical conductivity (mS/cm)$^{NS}$ | Organic matter (%) | Phosphorus (ppm)$^{NS}$ | Potassium (ppm)$^{NS}$ | Calcium (ppm)$^{NS}$ | Magnesium (ppm)$^{NS}$ |
|---|---|---|---|---|---|---|---|
| Control | 6.7 | 0.13 | 1.57 b | 138 | 184 | 907 | 132 |
| 2.5 tons/ac | 6.7 | 0.14 | 1.62 ab | 128 | 190 | 793 | 124 |
| 5.0 tons/ac | 6.8 | 0.13 | 1.70 ab | 128 | 172 | 863 | 124 |
| 10.0 tons/ac | 6.9 | 0.16 | 2.02 a | 138 | 238 | 918 | 127 |

$^{NS}$Non-significant.

†Mean separation within columns; means followed by same letter(s) are not significantly different ($P \leq 0.05$).

**Table 2. Effect of biochar on potato Atlantic yield characteristics. Data collected from 30-ft long row. Plant spacing within row is 8 in.**†

| Treatment | Total weight (kg) | A-grade | | B-grade | |
|---|---|---|---|---|---|
| | | Number | Weight (kg) | Number | Weight (kg) |
| Biochar rate | | | | | |
| Control | 23.5$^{NS}$ | 106$^{NS}$ | 14.8$^{NS}$ | 19$^{NS}$ | 0.9$^{NS}$ |
| 2.5 tons/ac | 23.6 | 103 | 14.1 | 19 | 0.9 |
| 5.0 tons/ac | 25.2 | 115 | 16.7 | 16 | 0.7 |
| 10.0 tons/ac | 24.8 | 112 | 17.0 | 24 | 2.0 |
| Fertility | | | | | |
| Compost | 19.5 b | 89 b | 12.0 b | 18$^{NS}$ | 0.8$^{NS}$ |
| Urea | 29.1 a | 129 a | 18.8 b | 21 | 1.4 |

$^{NS}$Non-significant.

†Mean separation within columns; means followed by same letter(s) are not significantly different ($P \leq 0.05$).

A-grade = tuber size not less than 1-7/8 in. diameter; B-grade = tuber size not less than 1-1/2 in. diameter.

**Table 3. Effect of biochar on potato Atlantic tuber quality. Data collected from 30-ft long row. Plant spacing within row is 8 in.**†

| Treatment | Scab | | Hollow heart number | Specific gravity |
|---|---|---|---|---|
| | Number | Weight (kg) | | |
| Biochar rate | | | | |
| Control | 63$^{NS}$ | 7.2$^{NS}$ | 0.6$^{NS}$ | 1.076 $^{NS}$ |
| 2.5 tons/ac | 68 | 8.1 | 0.9 | 1.077 |
| 5.0 tons/ac | 65 | 7.8 | 0.6 | 1.076 |
| 10.0 tons/ac | 63 | 6.8 | 1.2 | 1.076 |
| Fertility | | | | |
| Compost | 55 b | 6.1 b | 0.7$^{NS}$ | 1.076$^{NS}$ |
| Urea | 74 a | 8.8 a | 1.0 | 1.077 |

$^{NS}$Non-significant.

†Mean separation within columns; means followed by same letter(s) are not significantly different ($P \leq 0.05$).