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INFLUENCE OF BIOCHAR ON GROWTH AND MINERAL CONCENTRATIONS OF PEPPER

Zeliha Küçükyumuk, İbrahim Erdal, Ali Coşkan, Meliha Göktaş, Esra Sırça
Suleyman Demirel University, Isparta, Turkey

Abstract

Biochar can get from every biomass material and carbonization of the total mass of organisms. Determining the most suitable dose of the biochar to increase nutrient concentrations of pepper and also determine whether used with chemical fertilizers or not was the aim of the study. In this study, biochar was used either with or without chemical fertilizers. Biochar was applied as 0, 10, 20, 40 t·ha-1 into two liter pots containing two kilogram of soil. N-P-K was applied as 100 mg·kg-1 N, 100mg kg-1 P and 125 mg·kg-1 K respectively. Leaf N, P, K, Fe, Mn, Cu, and Zn concentrations, soil pH, EC and organic material and plant dry weight were determined in the study. As a result, while biochar combined with chemical fertilizers, the soil pH and organic material increased, soil EC decreased, plant N, P, K, Fe, Mn and dry weight increased. Soil P and K concentrations also increased with the applications. From the results of the study, biochar could be used with chemical fertilizers to increase yield and concentrations of nutrients of pepper.

Key words: biochar, growth, pepper, nutrition

INTRODUCTION

Biochar can be obtained from any kinds of biomass material and gained from carbonization of the total mass of organisms. Biochar can reach soil fertility by holding carbon (Dharmakeerthi *et al*., 2012). Reducing agricultural waste is another advantage of biochar. Since soil needs organic wastes to prevent environmental problems, biochar applications are getting important.

In the international literature was showed that biochar had important effects on high plant available nutrient concentrations (Glaser *et al.*, 2002; Lehmann *et al*., 2003; Liang *et al*., 2006; Asai *et al*., 2009; Park *et al*., 2011). Biochar had some important plant nutrients that influence yield. Nutrient concentrations and yield were increased by biochar application increased doses in combination with other commercial fertilizers (Dharmakeerthi *et al*., 2012). Organic and inorganic refuses could be amended (Uchimiya *et al*., 2010). Adsorption of heavy metals were effective with biochar applications (Liu and Zhang, 2009). The yield and nutrient concentrations increment with biochar were determined by some researchers (Asai *et al*., 2009; van Zwieten *et al*., 2010; Zhang *et al*., 2010). It has reported that total C in biochars was higher while biochars made from wood (Park *et al*., 2011). While biochar and basic fertilizers applied together to soils, significant fertility increments were found (Glaser *et al.*, 2002; Steiner *et al.*, 2007).

The aim of this study was to determine the suitable doses of the biochar to increase nutrient concentrations of peppers and also to determine whether to be used with chemical fertilizers or not.

MATERIALS AND METHODS

This study was conducted at Soil Science and Plant Nutrition Department climate cabin. In this study, "Ucburun" variety pepper and the biochar produced from wood debris was used. The oven was adjusted to 300^{0}C and gas production started at 350^{0}C. The gas lighted with a lighter to evaluate the process. Finally the temperature reached to 400^{0}C and the final combustion temperature was 400^{0}C. The biochar production was carried out over a period of 120 min. 100 g of biochar was produced from 400 g of wood debris. Biochar was used either applied with and without NPK fertilizers. As basal fertilization, N-P-K was given as 100 mg·kg^{-1} N, 120 mg·kg^{-1} P and 150 mg·kg^{-1} K from NH_4NO_3 and KH_2PO_4, respectively.

Biochar was applied as Bio_0 (0), Bio_1 (10), Bio_2 (20), Bio_3 (40) t·ha^{-1} into two kilograms soil containing pots. Biochar was given to the root area before planting the seedlings. Plants were irrigated manually. In the experiment, there were 8 treatments in total with 4 replicates in a completely randomized plot design. The soil used in this study were; pH 7.2 (1:2.5 water); organic matter 2.9% (Jackson, 1973); $CaCO_3$ 16%; 0.5 M $NaHCO_3$ – extractable P 30 kg·ha^{-1}; NH_4OAC-exchangeable K 550 kg·ha^{-1} (Olsen *et al.*, 1954; Knudsen *et al.*, 1982).

Eleven weeks after planting, plant shoots (above ground part of the plants) were harvested. Plant samples were washed with tap water and distilled water. Then they were dried at 65°C until were reached to stable weights and dry weights of plants were weighed. In order to determine nutrient analyses, samples were grounded. Kjeldahl method was used for determining total Nitrogen. In order to determine P, K, Fe, Zn, Mn and Cu concentrations, 0.4 g of grounded samples were wet digested in microwave (CEM Mars X-press) at 180°C. K, Fe, Zn, Mn and Cu concentrations were analyzed using atomic absorption spectrophotometer according to Kacar and Inal (2008) and phosphorus concentrations were analyzed by vanadate-molybdate colorimetric method. Soil organic matter was measured according to Walkley and Black (1947), soil pH and EC (soil:water-ratio 1:2.5) was also measured using EC meter and pH meter. DTPA extractable Fe, Cu, Mn and Zn analyses were done as described by Lindsay and Norwell (1978).

Statistical evaluations of the values were made using SAS program.

RESULTS AND DISCUSSIONS

In Table 1, the effects of biochar on N, P and K concentrations were given. Biochar combined with chemical fertilization increased plant N concentrations significantly ($p<0.01$). In previous studies biochar treatment were influenced from N transformations in soil (Clough and Condron, 2010; Taghizadeh-Toosi *et al.*, 2012). Statistical analyses showed that different doses of biochar significantly affected P concentration of peppers. Compared to control conditions (0.15%) biochar increased the P concentrations of plants. In a study researchers mentioned that biochar can enhance the availability of macro-nutrients such as N and P (Atkinson *et al*., 2010). As seen in Table 1, K concentrations were not affected from biochar treatments statistically.

As seen in Table 2, micro nutrients except Fe were not affected from biochar treatments. Biochar with NPK fertilizers increased plant Fe concentrations. While plants had 84 $mg \cdot kg^{-1}$ without NPK fertilizers, this value increased to 110 $mg \cdot kg^{-1}$ with NPK applications. Plants Zn, Cu and Mn concentrations were not affected by biochar treatments. Manganese concentrations increased with NPK fertilization from 120 $mg \cdot kg^{-1}$ to 132 $mg \cdot kg^{-1}$ but this increment was not significant.

As shown in Table 3, biochar treatment with and without NPK fertilizers increased plant dry weights. When using biochar with NPK fertilization, the plants dry weights ranged from 3.10 g to 3.54 g. Studies confirmed that biochar applications led to increases in plant growth (Lehmann *et al*., 2003; Rondon *et al*., 2007; Asai *et al*., 2009; Blackwell *et al*., 2009).

Table 1.Effects of biochar on N, P and K concentrations (%) on peppers

		Treatments		
		NPK(-)	NPK(+)	Mean
N	Bio_0	4.23	4.23	4.23
	Bio_1	3.04	4.27	3.66
	Bio_2	3.37	4.40	3.88
	Bio_3	3.41	4.25	3.83
	Mean	3.27B*	4.28A	
		NPK(-)	NPK(+)	Mean
P	Bio_0	0.15	0.15	0.15b**
	Bio_1	0.17	0.25	0.21a
	Bio_2	0.19	0.22	0.20a
	Bio_3	0.17	0.20	0.19ab
	Mean	0.17	0.21	
		NPK(-)	NPK(+)	Mean
K	Bio_0	3.75	3.75	3.75
	Bio_1	3.75	3.83	3.79
	Bio_2	3.85	3.83	3.83
	Bio_3	3.62	3.93	3.78
	Mean	3.74	3.84	

*shows the difference between NPK treatments ($P<0.01$).
**shows the difference between biochar rates ($P<0.01$).

Table 2. Effects of biochar on plant Zn, Fe, Mn and Cu concentrations ($mg \cdot kg^{-1}$)

		Treatments		
		NPK(-)	NPK(+)	Mean
Zn	Bio_0	16	16	16
	Bio_1	15	15	15
	Bio_2	16	15	16
	Bio_3	15	16	16
	Mean	15	15	

		Treatments		
		NPK(-)	NPK(+)	Mean
Fe	Bio_0	114	114	114
	Bio_1	88	104	96
	Bio_2	82	111	96
	Bio_3	84	111	97
	Mean	84B*	110A	
Mn		NPK(-)	NPK(+)	Mean
	Bio_0	127	127	127
	Bio_1	122	141	132
	Bio_2	122	133	128
	Bio_3	116	125	121
	Mean	120	132	
Cu		NPK(-)	NPK(+)	Mean
	Bio_0	10	10	10
	Bio_1	9	9	9
	Bio_2	9	9	9
	Bio_3	10	10	10
	Mean	9	10	

*shows the difference between NPK treatments ($P<0.01$).

Table 3. Effect of biochar on dry weight (g) of pepper

		Treatments		
		NPK(-)	NPK(+)	Mean
Dry weight	Bio_0	2.72Ba*	2.72Ba	2.72
	Bio_1	2.72Bb	3.95Aa	3.34
	Bio_2	2.52Bb	3.86Aa	3.20
	Bio_3	3.43Aa	3.75Aa	3.59
	Mean	2.85	3.57	

*Capital letters show the difference between biochar doses, small letters show the difference between NPK applications ($P<0.01$).

Soil pH decreased with biochar applications. In a study by Dharmakeerthi *et al*. (2012) determined that the reason of soil pH decreases might be release of protons NH_4 during nitrification process in sulphate of ammonia addition. The organic material of the soil significantly ($P<0.01$) increased with addition of biochar. Also biochar with chemical fertilizers increased soil organic material from 2.97 % to 3.07 % (Table 4). The increase of soil organic matter may be due to the increase of soil N concentrations (Schouten *et al*., 2012; Wang *et al*., 2012).

Table 4. Effects of biochar on soil pH, EC and Organic Material (OM)

		Treatments		
		NPK(-)	NPK(+)	Mean
pH(1:2,5)	Bio_0	7.24	7.24	7.24b**
	Bio_1	7.43	7.44	7.44a
	Bio_2	7.45	7.43	7.44a
	Bio_3	7.45	7.47	7.46a
	Mean	7.44	7.39	
		NPK(-)	NPK(+)	Mean
EC(µs)	Bio_0	522	522	522
	Bio_1	279	473	376
	Bio_2	332	469	401
	Bio_3	309	515	412
	Mean	307B*	495A	
		NPK(-)	NPK(+)	Mean
OM(%)	Bio_0	2.95	2.95	2.95
	Bio_1	2.95	3.08	3.01
	Bio_2	2.96	3.10	3.03
	Bio_3	3.00	3.17	3.09
	Mean	2.97B	3.07A	

*shows the difference between NPK treatments ($P<0.01$).
**shows the difference between biochar rates ($p<0.01$).

Table 5 indicates the effect of biochar on micro element concentrations. Soil Zn concentrations were not affected from biochar treatments. Biochar with NPK fertilization decreased soil Fe and Mn concentrations and were found significant ($P<0.01$). Soil Fe concentrations decreased from 3.3 mg·kg^{-1} to 3.1 mg·kg^{-1}; Mn concentrations decreased from 5.2 mg·kg^{-1} to 4.7 mg·kg^{-1}. When biochar was applied to soil, soil Fe and Mn concentrations increased compared to control conditions. Biochar with and without NPK fertilization decreased soil Cu concentrations and soil Cu concentrations on biochar treatment were found significant ($p<0.01$). In a study (Park *et al*., 2011) researchers studied effect of biochar and they found that biochar treatment decreased soil Cu concentrations.

Reduce of Cu concentrations can be explained with soluble C increment effects immobilization of Cu in plants.

Table 5. Effect of biochar on soil Zn, Fe, Mn and Cu concentrations

Treatments				
		NPK (-)	NPK (+)	Mean
Zn ($mg \cdot kg^{-1}$)	Bio_0	0.38	0.38	0.38
	Bio_1	0.34	0.35	0.35
	Bio_2	0.39	0.38	0.39
	Bio_3	0.34	0.38	0.36
	Mean	0.36	0.37	
		NPK (-)	NPK (+)	Mean
Fe ($mg \cdot kg^{-1}$)	Bio_0	3.0	3.0	3.0b**
	Bio_1	3.5	3.2	3.4a
	Bio_2	3.2	3.1	3.1ab
	Bio_3	3.1	3.1	3.1ab
	Mean	3.3A*	3.1B	
		NPK (-)	NPK (+)	Mean
Mn ($mg \cdot kg^{-1}$)	Bio_0	4.1	4.1	4.1c
	Bio_1	4.9	4.5	4.7b
	Bio_2	5.0	4.9	5.0ab
	Bio_3	5.7	5.1	5.4a
	Mean	5.2	4.7	
		NPK (-)	NPK (+)	Mean
Cu ($mg \cdot kg^{-1}$)	Bio_0	0.91	0.91	0.91ab
	Bio_1	0.95	0.89	0.92a
	Bio_2	0.93	0.89	0.91ab
	Bio_3	0.91	0.87	0.89b
	Mean	0.93A	0.89B	

*shows the difference between NPK treatments ($P<0.01$).
**shows the difference between biochar rates ($p<0.01$).

CONCLUSIONS

From the results of the study, all biochar doses used in this study could be applied with chemical fertilizers to increase yield and concentrations of nutrients of pepper plants. Application of biochar to pepper plants can be an environmental approach when used with commercial fertilizers. The results indicated that biochar application was effective in metal immobilization. The results from the study need to be developed under field conditions.

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Corresponding author: Zeliha Küçükyumuk, PhD
Prof. Dr İbrahim Erdal,
Prof. Dr Ali Coşkan,
Meliha Göktaş,
Esra Sırça
Department of Soil Science and Plant Nutrition,
Agricultural Faculty,
Suleyman Demirel University, 32260,
Isparta, Turkey
zelihakucukyumuk@sdu.edu.tr

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