INFLUENCE OF BIOCHAR AND FERTILIZERS ON THE GROWTH AND YIELD OF TOMATO

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Abstract

Biochar, a stable organic amendment, can increase water and nutrient retention capacity of soil and thus may influence crop yield. The influence of biochar and chemical fertilizers on tomato yield was investigated through a pot culture experiment. There were six treatments viz., T_0: Control (no fertilizer or biochar use), T_1: 100% recommended dose of NPK fertilizer, T_2: 100% recommended dose of biochar, T_3: 75% biochar + 25% NPK fertilizers, T_4: 50% biochar + 50% NPK fertilizers, and T_5: 25% biochar + 75% NPK fertilizers. The recommended dose of N, P and K was 120, 60 and 60 kg ha^{-1}, respectively. Biochar was used at 2 t ha^{-1}. Biochar contained 22.5% organic carbon, 0.028% N, 32.48 mg kg^{-1} P and 11.85 meq 100^{-1} g soil K. The variety was BARI Hybrid Tomato-4 (summer variety). The growth and yield parameters such as plant height, number of fruits $plant^{-1}$, individual fruit weight, fruit diameter and fruit weight $plant^{-1}$ were significantly influenced by the different treatments. Treatment T_4 (50% biochar + 50% NPK fertilizer) recorded the maximum yield of tomato. Biochar application resulted in a notable increase in NPK concentration of tomato fruits. Use of 50% NPK fertilizer with biochar 2 t ha^{-1} positively influenced soil properties except pH.

Keywords: Biochar amendment, NPK fertilizers, Soil properties, Tomato, Yield

1. Introduction

Tomato *(Solanum lycopersicum)*, one of the most widely cultivated and economically significant vegetables globally, provides vitamins A, C, potassium, and antioxidants. The increasing demand for high-quality tomatoes has driven farmers to seek effective methods to enhance fruit yield and quality. Traditionally, use of chemical fertilizers plays a pivotal role in achieving higher crop yield by supplying readily available nutrients to plants. Studies have demonstrated that fertilizers can significantly boost tomato growth and yield by ensuring an adequate supply of N, P and K (Bekbayeva *et al.* 2021; Bentamra *et al.* 2023). Nevertheless, an excess use of fertilizers can result in negative environmental consequences, such as soil

acidification, nutrient leaching, and contamination of water bodies (Yijie *et al.* 2022). In contrast, biochar, a stable, carbon-rich product obtained from the pyrolysis of organic materials under limited oxygen conditions, has brought attention as a sustainable soil amendment. Biochar has tremendous positive effect on water and nutrient retention capacity of soil and promoting beneficial microbial activity (Lehmann and Joseph *et al.* 2009). Research indicates that biochar can also mitigate greenhouse gas emissions and sequester carbon, contributing to climate change mitigation (Laird *et al.* 2009). The synergistic use of biochar and fertilizers presents a promising approach to sustainable crop production. Numerous studies have investigated the efficacy of biochar in addition with inorganic fertilizers on various crops, showing positive outcomes in terms of yield and soil condition (Bai *et al.* 2022; Wu *et al.* 2023). Biochar may increase fruit yield and quality of tomato by increasing nutrient uptake. (Abid *et al.* 2017). An application of biochar to soil resulted in remarkable increase in photosynthetic pigments, fruit yield and quality of tomato (Vaccari *et al.* 2015). This research aims to explore the combined effects of biochar and chemical NPK fertilizers with the principle of integrated nutrient management on the growth and yield of tomato. The findings could offer valuable guidance to the farmers and agricultural practitioners striving for sustainable intensification of tomato cultivation.

2. Materials and Methods

This experiment was conducted in the shade house of the Department of Soil Science of Hajee Mohammad Danesh Science and Technology University (HSTU), Dinajpur during February to June 2023. The soil (0-15 cm depth) under study was collected from the HSTU study field, cleared of all debris and dried in a plastic sheet in the sun. Initial soil sample was analyzed for some physical and chemical properties. Analysis was done in the laboratory of the Department of Soil Science, HSTU, Dinajpur. The soil was sandy loam with pH 6.7 (soil: water ratio 1:2.5), Walkley and Black organic carbon 0.498%, total N (Kjeldahl N) 0.021%, Bray P 24.9 mg kg^{-1}, NH4OAc exchangeable K 7.59 me% and $CaCl_2$ extractable S 12.1 mg kg^{-1}, respectively.

The experiment consisted of six treatments with three replications, pots arranged in a completely randomized design (CRD). The treatments were T_0 = Control (No fertilizer of biochar use), T_1 = 100% recommended dose of fertilizers (RDF), T_2 = 100% Biochar (2 t ha^{-1}), T_3 = 75% biochar + 25% RDF, T_4 = 50% biochar + 50% RDF, T_5 = 25% biochar + 75% RDF. The recommended dose of N, P and K was 20, 60 and 60 kg ha^{-1}, respectively (FRG, 2018). Nutrient composition of biochar is depicted in Table 1.

Table 1. Nutrient composition of biochar used in the experiment

Properties	Value	Extraction methods
Organic Carbon (%)	22.5	Wet oxidation method.
Total N (%)	0.028	Micro-Kjeldahl method
Available P (ppm)	32.48	Olsen method
Exchangeable K (meq/100g soil)	11.85	NH4OAC extraction method

Total number of pots was 18. An amount of 10 kg soil was filled into each plastic pot. High yielding summer variety BARI Hybrid Tomato-4 was used as planting material.

The crop was harvested when it attained maturity. Data on the growth and yield parameters were recorded. Those parameters included plant height (cm), number of branches plant^{-1}, number of flowers plant^{-1}, number of fruits per plant, individual fruit weight (g), fruit diameter (cm), fruit length (cm), and total fruit weight (g). Post-harvest soil samples from each pot were analyzed for pH, organic carbon, total N, available P, exchangeable K and available S contents.

The data were analyzed statistically by the use of Statistix 10 software. One-way analysis of variance (ANOVA), followed by Duncan's Multiple Range Test (DMRT) was performed to determine significant differences between the treatments. Values with $p < 0.05$ were considered as statistically significant.

3. Results and Discussion

3.1 Effects of biochar and fertilizers on the growth and yield parameters of tomato

All the plant parameters significantly varied due to different biochar and fertilizer treatments (Table 2), Treatment T_4 (50% biochar + 50% NPK fertilizers) produced the tallest tomato plant (69.2 cm) and the maximum number of branches plant^{-1} (13) and T_0 treatment (control) produced the smallest plant (27 cm) and the minimum number of branches plant^{-1} (8). Use biochar might have influenced the soil's water holding and nutrient retention capacity which in turn had enhanced plant height and branches per plant (Suthar *et al.*, 2018; Agbna *et al.*, 2017). The maximum number of fruits plant^{-1} (6.00) was found in treatment T_4 which is statistically similar with T_5 treatment and the lowest result (2.00) was noted for treatment T_0. In treatment T_4 individual fruit weight (160.7 g) was the maximum and in treatment T_0 it was the minimal (61.4 g). Biswas *et al.* (2017) reported that biochar worked positively in case of number of flowers and fruits plant^{-1} and individual fruit weight. Treatment variations were not significant in fruit diameter Similar research findings were reported by Pathak *et al.* (2020) and Nabaei *et al.* (2021) when biochar was added to pots for

tomato production. The main parameter i.e. total fruit weight plant^{-1} (189.3 g) was the highest in treatment T_4 and the lowest (150.7 g) in treatments T_0 (control). Biochar when applied alone or in combination with fertilizers showed better performances in increasing total fruit weight plant^{-1} (Guo *et al*, 2021).

3.2 Effects of biochar and fertilizers on post-harvest soil properties

Soil pH and total N after crop harvest did not exhibit any significant variation (Table 3) due to the addition of different doses of biochar in different treatments ($p < 0.01$). The organic carbon (OC) content significantly varied with the different ($p < 0.01$) the treatments. The highest percentage of OC (0.60%) was found in T_4 treatment and the lowest (0.41%) in control treatment which was statistically similar with the T_1 treatment (0.58%). Available P, exchangeable K or available S content was significantly different ($p<0.01$) with the different treatments. The greatest amount of available P (95.1 mg kg^{-1}, exchangeable K (12.4 meq100^{-1} g soil) and that of available S (17.8 mg kg^{-1}) content were observed in T_4 treatment and the lowest value of P i.e. 38.7 mg kg^{-1}, K (6.86 meq100^{-1} g soil) and available S (11.1 mg kg^{-1}) were noticed in T_0 treatment. Aslam *et al.* (2014) found that the incorporation of biochar significantly contributed to increased P content in soil. Biochar application significantly contributed to the highest content of exchangeable K and available S (Salem *et al.* 2019).

Table 2. Effects of biochar and fertilizers on the growth and yield of tomato

Treatments	Plant height (cm)	No. of branches plant^{-1}	No. of fruits plant^{-1}	Individual fruit weight plant^{-1} (g)	Fruit diameter (cm)	Total fruit weight plant^{-1} (g)
T_0	27.0 d	8 d	2 d	61.4 e	3.43	150.7 e
T_1	55.7 bc	10 c	4 bc	120.7 c	3.50	167.1 d
T_2	65.7 abc	11 bc	3 cd	154.5 b	3.75	177.0 b
T_3	54.7 c	12 ab	5 ab	118.1 d	3.53	178.1 b
T_4	69.2 a	13 a	6 a	160.7 a	3.73	189.3 a
T_5	67.0 ab	11 bc	5 ab	153.6 b	3.73	168.8 c
CV (%)	12.1	9.2	17.0	1.23	7.23	2.81
S.E. (±)	5.57	0.81	0.57	1.28	0.21	3.89

T_0 = Control (No fertilizer or biochar use), T_1 = 100% RDF NPK, T_2 = 100% 10 t ha^{-1} biochar, T_3 = 75% biochar + 25% NPK fertilizer, T_4 = 50% biochar + 50% NPK fertilizer, T_5 = 25% biochar + 75% NPK fertilizer.

Table 3. Chemical properties of post-harvest soils

Treatments	pH	Total N (%)	OC (%)	Available P (mg kg^{-1})	Exch. K (me%)	Available S (mg kg^{-1})
T_0	5.7	0.012	0.41 d	38.8f	6.9e	11.1e
T_1	6.0	0.021	0.58 ab	85.8b	10.2b	16.4c
T_2	6.1	0.014	0.57 b	67.7c	7.7d	14.8d
T_3	5.6	0.021	0.48 c	46.2e	7.8c	16.9b
T_4	6.2	0.021	0.60 a	95.1a	12.4a	17.8a
T_5	6.3	0.014	0.57 b	61.6d	10.2b	14.4d
CV (%)	7.57	12.54	3.21	2.29	12.09	1.59
S.E. (±)	0.36	0.01	0.03	1.2	0. 81	0.19

T_0 = Control (No fertilizer or biochar use), T_1 = 100% RDF NPK, T_2 = 100% 10 t ha^{-1} biochar, T_3 = 75% biochar + 25% NPK fertilizer, T_4 = 50% biochar + 50% NPK fertilizer, T_5 = 25% biochar + 75% NPK fertilizer.

4. Conclusions

The findings of the study clarified that biochar has tremendous influence on the growth, yield and yield contributing attributes of tomato along with soil properties. The effect of combined application of biochar and fertilizers was better than that of their single application. The overall result showed that combined application of 50% biochar + 50% NPK fertilizer demonstrated the maximum yield of tomato. It appeared that application of biochar significantly increased organic matter, total N, available P, exchangeable K and available S content in the soil. However, such biochar study needs to be done under field conditions.

Conflicts of Interest

The authors declare no conflicts of interest regarding publication of this paper.

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