Journal of Agroforestry and Environment

Volume 16, Issue 2, 2023

Journal DOI: https://doi.org/10.55706/jae
Journal homepage: www.jagroforenviron.com

Effect of Fruit Peel Biochar on Growth and Yield of Tomato (*Solanum lycopersicon* Mill.) and Country Bean (*Lablab purpureus*) in Acidic Soil of Sylhet, Bangladesh

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Received: 12/06/2023
Accepted: 28/08/2023
Available online: 31/08/2023

Abstract: The potential of biochar as a soil conditioner has been approved by scientists worldwide due to its large surface area, high water retention capacity, slow nutrient releasing nature and liming ability; and it might also help to get desirable crop yield in problem soil like acidic soil. Hence, an experimental field trial was operated at the research field of the Department of Agroforestry and Environmental Science, Sylhet Agricultural University, Sylhet to evaluate the performance of banana peel biochar (BB) and orange peel biochar (OB) in the growth and yield of tomato (*Solanum lycopersicon* Mill.) and country bean (*Lablab purpureus*) under acidic soil conditions. In case of tomato, plant height (PH), number of leaves plant^{-1} (NLP), leaf length (LL), and stem diameter (SD) in treatments having different levels of biochar were significantly higher than the control. The maximum PH (72.20 cm), NLP (21), LL (35.66 cm), SD (9.05 cm), and total leaf chlorophyll content (TLCC) (50.56 µmol m^{-2}) of tomato were found in T_7 (3% OB w/w + CF) followed by T_4 (3% BB w/w + CF) whereas in country bean, the PH (373 cm), NLP (34), branch number (BN) (3), and TLCC (36.65 µmol m^{-2}) were also recorded in T_7 followed by T_4. The root length (RL) (43.5 cm) and fresh root weight (FRW) (14 g) of country bean were the maximum at T_7, followed by T_5 (1% OB w/w + CF). According to the results, positive effects of BB and OB application were observed on all the yield parameters of country bean and tomato. The number of pod plant^{-1} (NPP) (384), individual pod weight (IPW) (5.78 g), total pod weight plant^{-1} (TPWP) (2220 g), and pod length (PL) (10.57 cm) of country bean were also found to be highest in T_7, followed by the T_4. Similarly, the highest NFP (37), IFW (55 g), and TFWP (1980 g) of tomato were noted in T_7, followed by T_4. After the cultivation of country bean and tomato, a significant increase in the soil pH was noticed at T_3 (2% BB w/w + CF), T_4, T_6 (2% OB w/w + CF) and T_7 in respect of the control. Therefore, the findings of the study suggest that both BB and OB could have a positive impact on growth and yield components of tomato and country bean by altering soil pH of acidic soil.

Keywords: Fruit peel biochar; Soil conditioner; *Solanum lycopersicon* Mill.; *Lablab purpureus*; Acidic soil.

INTRODUCTION

The economy of Bangladesh is predominantly agriculture-based and sole contribution of crop sector is about 12% of the entire GDP (BBS, 2014). Bangladesh is an extremely populous country having 165.16 million people and the growth rate of population is rising alarmingly. The local production is not sufficient to support this huge population and thus food shortage has become a common issue of the country. To counter this problem, actions should be taken to escalate the total production of food. Soil is one of the basic natural resources for crop production. For ensuring high yield and quality of crops, it is must to maintain soil reaction (pH) and nutrients in proper amounts and in balance. But, acidity of soil is a big challenge for Bangladesh because of its negative role on soil health and productivity. More than 30% of total arable land in Bangladesh is acidic (Sumner and Noble, 2003). In Bangladesh, soils having varying acidity range (pH <4.5-6.5) cover 0.25 million ha, 3.70 million ha and 2.74 million ha, respectively (BARC, 2012). Particularly, soil acidity in greater Sylhet ranges from 4.9-6.1 (Hossain and Sattar, 2002). Acidic soils are characterized by having less availability of P, Ca, and Mg, poor water holding capacity, low CEC and high exchangeable Fe and Al. In most cases, soil pH ranging from 6-7 is optimum for adequate availability of nutrients in soils (BARC, 2012). Acidic soil can significantly pose negative impact on crop production and it is documented that productivity of soil decreases 50-75% under soil pH <4.5 whereas 25-50% under soil pH 4.5-5.5 (Zahid *et. al*., 2020). Liming is a widely used strategy to alleviate soil acidity constraints and maintain crop growth and yield in acid soils. Several study and experimental trials (Goulding, 2016; Holland *et al*., 2019; Hijbeek *et al*., 2021) established the positive effect of liming and recommended application of suitable type of lime according to its availability, texture of soil, the extent of soil acidity, soil nutrient status and crop type. Liming increases soil pH, enhances availability of Ca, Mg, P, N, and Mo; reduces solubility of Fe, Mn and Al (Goulding, 2016), boosts nitrification and N-mineralization (Fuentes *et al*., 2006), enriches microbial population (Liao *et al*., 2020; Mahmud & Chong, 2022) and thus, favours production factors resulting in desirable crop production. Although liming is a very common solution for correcting soil acidity, it requires much money at the starting of crop cultivation, which is tuff to manage for the marginal farmers to enjoy the output of liming. Furthermore, over dose of lime application can reduce the of micronutrient availability (Murphy and Sims, 2012). In this context, organic amendment like biochar might be a worthy choice for neutralizing soil acidity, since it has an alkalizing ability and it can potentially raise pH of soil (Randolph *et al*., 2017; Xu *et al*. 2016). Biochar is a carbonaceous solid material produced through the thermochemical transformation of organic ingredients in anaerobic or less oxygen ambiance (Magnusson, 2015; Guo, 2020**.** Henceforth, biochar is generally prepared in an environmentally friendly process by converting organic residues into soil conditioner (Albuquerque *et al*., 2014). Empirically, biochar has properties to trap inorganic N, organic substances, different nutrient elements (Wang *et al*., 2015), develop the soil water retention ability (FAO, 2010) and it improves microbial activity in soil (Pokharel *et al*., 2018). Moreover, pyrolizing organic biomass to obtain biochar may avoid emissions of greenhouse gases to the air, which is released due to their insincere disposal (Gwenzi *et al*., 2016). The technology of biochar has multiple potentials in overcoming many challenges such as efficient biomass management, fostering renewable energy, crop productivity, and mitigating climate change.

There are numerous types of biochar, categorized based on the raw materials (agricultural wastes, forest residues, organic wastes materials) from which it is made. Fruit wastes contribute a healthy share to the total solid waste generation in any country and thereby deserve sincere attention regarding management options (Lam *et al*., 2018). Food industries produce around 3.5 million tons of banana peel annually worldwide (Housagul *et al*., 2014), where major contribution come from India, China, Philippines and Brazil (FAO, 2014). During processing of citrus fruits, about 50–60% of the fruit mass is discarded as fruit residues (Ozturk *et al*., 2019). Normally, fruit wastes are managed by open dumping, incinerating and composting that create environmental issues due to CH_4 and CO_2 emission (Lam *et al*., 2018). Bangladesh also producing fruit wastes in huge amount every year, which could be a potential option for producing biochar and might be a good alternative of lime to maintain suitable soil pH for ensuring better production of non-acid loving crops in acidic soil. In this context, it is very important to check the consequence of fruit waste biochar usage on crop growth and yield under acidic soil condition of Sylhet region in Bangladesh.

Tomato (*Solanum lycopersicon* Mill.), member of solanaceae family and Country bean (*Lablab purpureus*), member of Fabaceae family are two important vegetable crops in Bangladesh. Tomato is rich in vitamins A, C and E; and antioxidant element lycopen (Rashid, 1993). In Bangladesh, tomato is being cultivated in 6.81% agricultural land, giving average yield of 5451 kg $acre^{-1}$ and cumulative production of 368000 tons. (BBS, 2016), which is clearly very poor than other countries like USA (65.2 t ha^{-1}), Japan (52.8 t ha^{-1}), China (30.3 t ha^{-1}) and India (15.6 t ha^{-1}) (FAO, 2008). Dry seed of country bean contains 20-30% protein (Mia, 1989). Besides, it contains vitamin A, vitamin C, riboflavin and minerals like Mg, Ca, P, K, Fe, S and Na (Jukanti *et al.*, 2012). It occupies a unique position as vegetable among the legume crops and during 2018-2019, 144050 metric tons country beans were grown from 51578 acres of land area (BBS, 2019). Taking into account the above facts, a field experiment was done with the following goals to observe the influence of fruit peel biochar on the growth and yield of tomato and country bean in acidic soil.

i) To quantify the impacts of banana peel and orange peel biochar on the growth and yield attributes of tomato and country bean.

ii) To evaluate the influence of the two biochar on pH of the soil.

MATERIALS AND METHODS

Experimental site and climatic features

The experiment was operated at the research field and laboratory of the Department of Agroforestry and Environmental Science, Sylhet Agricultural University, Sylhet. Being under sub-tropical zone, this territory

DOI: https://doi.org/10.55706/jae1624

experiences heavy precipitation ranging from 246-968 mm month^{-1} and high average temperature > 30°C during May - September whereas from October-April low precipitation occurs within the range from 0-22 mm month^{-1} and mean temperature remains < 28°C.

Biochar preparation

To prepare banana peel biochar (BB) and orange peel biochar (OB), raw materials were collected from fruit markets of Sylhet city. Collected banana peel and Orange peel were brought to the lab, dried in open air for 07 days, then dried using an oven at 68±2 ^{0}C for 48 hours, and pyrolised for producing biochar using a traditional kiln. Biochars were pulverized and sieved at 2 mm for further use in chemical analysis and field experiment. Some basic characteristics of soil, BB and OB were determined (Table 1).

Experimental design for growing tomato and country bean

Both tomato and country bean were grown separately under the following eight (08) treatments maintaining Randomized Complete Block Design (RCBD) with three replicates.

(1) T_0 = CK,
(2) T_1 = CF,
(3) T_2 = BB1 + CF (1% BB w/w + CF),
(4) T_3 = BB2 + CF (2% BB w/w + CF),
(5) T_4 = BB3 + CF (3% BB w/w + CF),
(6) T_5 = OB1 + CF (1% OB w/w + CF),
(7) T_6 = OB2 + CF (2% OB w/w + CF) and
(8) T_7 = OB3 + CF (3% OB w/w + CF)

Here,
CK = Control, no amendment
CF = Chemical fertilizers
BB = Banana peel biochar, and
OB = Orange peel biochar

The treatments are denoted as T_0, T_1, T_2, T_3, T_4, T_5, T_6 and T_7.

Seeds of BARI hybrid Tomato 4 (summer variety) were sown in seedbed on 6 April 2022 and 30 days old seedlings were shifted in the well-prepared plots at a spacing of 40 cm × 30 cm between rows and plants, respectively. Six seedlings were transplanted in each plot and finally four healthy seedlings were allowed to grow till the end. On the other hand, seeds of SAU Country Bean-1 (summer variety) were sown directly in the well-prepared plots on 6 April 2022 at a spacing of 1.5 m × 1.0 m between rows and plants, respectively. Three seeds were sown in each of four pits of every plot and finally four healthy seedlings in each plot were allowed to grow till the end. Before sowing, seed treatment was done with Vitavex at the rate of 2g kg^{-1} seed.

Table 1. Basic characteristics of soil, BB and OB.

Material	pH	Total organic carbon (%)	Available N (%)	Available P (ppm)	Available K (me/100g)	Available S (ppm)
Soil	5.2	1.25	0.11	37.36	0.16	24.49
BB	10.62	60.45	-	-	-	-
OB	9.50	71.84	-	-	-	-

For growing tomato and country bean, chemical fertilizers were applied following doses prescribed by BARC (2018) and biochars (BB and OB) were applied in selected treatments at required doses. Mulching, weeding, irrigation etc. were done as and when necessary. Polythene sheds were prepared to protect the seedlings of tomato from heavy rainfall. Approximately 90 days after transplanting and 130 days after seed sowing, tomato and country bean plants were uprooted, respectively and subsequently taken to the lab for estimation of growth and yield attributes.

Plant data collection and soil sample analysis

Different growth and yield indexes of tomato and country bean were recorded very carefully during growing period and harvesting time. Total leaf chlorophyll content (µmol m^{-2}) in both crops was also assessed. Weighing the fresh weights of fruit and root was done by using digital balance, while total leaf chlorophyll content (µmol m^{-2}) was detected using chlorophyll meter (SPAD-502). pH of Soil samples (1:5 H_2O w/v) and biochars (1:10 H_2O w/v) was obtained using pH meter. Total organic carbon (%) was quantified according to the method followed by Ahmod, et al. (2023).

Statistical Analyses

All experimental data were analyzed using GraphPad Prism software (version 8.00, La Jolla, CA, USA). One-way ANOVA were used to evaluate the effects of the treatments. The mean differences were adjusted by the Tukey's HSD test at 5% level of significance.

RESULTS AND DISCUSSIONS

Effect of fruit peel biochar application on the morphological characters of tomato

The influence of different treatments on the morphological characteristics of tomato is presented in Table 2. The plant height (PH), stem diameter (SD), number of leaves plant^{-1} (NLP) and leaf length (LL) of tomato plants were significantly higher in the BB and OB treated plots than that of the control plot whereas the branch number (BN) and total leaf chlorophyll content (TLCC) did not show any significant difference. The highest PH (72.20 cm), NLP (21), LL (35.66 cm), SD (9.05 cm), and TLCC (50.56 µmol m^{-2}) of tomato were found in T_7 (3% OB w/w + CF) followed by T_4 (3% BB w/w + CF). On the contrary, the lowest PH (52 cm), NLP (12), LL (20 cm), SD (3.80 cm), BN (1), and TLCC (43 µmol m^{-2}) of tomato were recorded in T_0 (CK) followed by T_1 (CF). Sial *et al*. (2019) also applied fruit peel biochar to observe their performance in crop growth and he reported enhancement in soil pH, PH and TLCC in wheat. Parallel to the discoveries of our study, Calcan *et al*. (2022) also noticed a significant positive effect of vine pruning residue biochar on some morphological characteristics of tomato including PH, SD, NLP, and volume of root in soil having strong acidity.

Table 2. Effects of different kinds of fruit peel biochars on the morphological characters of tomato.

*Treatments	Plant height (PH) (cm)	Number of leaves plant^{-1} (NLP)	Leaf length (LL) (cm)	Stem diameter (SD) (cm)	Branch number (BN)	Total leaf chlorophyll scontent (TLCC) (µmol m^{-2})
T_0	52.00^{b}	12^{d}	20.00^{d}	3.8^{d}	1^{a}	43.00^{a}
T_1	66.69^{a}	15^{cd}	26.66^{c}	6.11^{cd}	1^{a}	43.50^{a}
T_2	68.00^{a}	17^{bc}	29.79^{bc}	6.24^{bc}	2^{a}	44.11^{a}
T_3	68.96^{a}	18^{abc}	32.67^{ab}	8.30^{abc}	1^{a}	46.33^{a}
T_4	71.35^{a}	20^{ab}	34.00^{ab}	8.60^{ab}	2^{a}	46.48^{a}
T_5	70.00^{a}	18^{abc}	30.50^{bc}	6.90^{abc}	1^{a}	45.00^{a}
T_6	70.10^{a}	20^{ab}	33.25^{ab}	8.38^{abc}	1^{a}	47.00^{a}
T_7	72.20^{a}	21^{a}	35.66^{a}	9.05^{a}	2^{a}	50.56^{a}

*T_0= CK, (Control, no amendment), T_1= CF (Chemical fertilizers), T_2= 1% banana peel biochar (BB) w/w + CF, T_3= 2% BB w/w + CF, $T_{4=}$ 3% BB w/w + CF, T_5= 1% orange peel biochar (OB) w/w + CF, T_6= 2% OB w/w + CF; T_7= 3% OB w/w + CF. Values bearing the same letters are statistically similar.

Influence of fruit peel biochar application on the yield and yield contributing traits of tomato

Table 3 presents the impact of different fruit biochars application on the yield and yield contributing characteristics of tomato. The number of fruit plant^{-1} (NFP) and individual fruit weight (IFW) of tomato was found to be significantly higher at T_7 (3% OB w/w + CF) and T_4 (3% BB w/w + CF) compared to T_0 (control). But the total fruit weight plant^{-1} (TFWP) was significantly greater in all the biochar treated plots in relation to the control. The highest NFP (37), IFW (55 g), and TFWP (1980 g) of tomato were recorded in T_7 followed by T_4 whereas the smallest values of these traits were measured in T_0 followed by T_1. Results of the current experiment are in line with the observations of EI Namas, (2020) where average fruit weight (gm) of tomato and total yield plant^{-1} significantly increased in BC2 (0.4 wt.% biochar) and BC3 (0.6 wt.% biochar) treatments relative to the control (BC0).

Table 3. Influence of different types of fruit peel biochars on the yield and yield contributing traits of tomato.

*Treatments	No. of fruit plant^{-1} (NFP)	Individual fruit weight (IFW) (g)	Total fruit weight plant^{-1} (TFWP) (g)
T_0	22^{b}	36^{b}	900^{f}
T_1	28^{ab}	42^{ab}	1176^{ef}
T_2	32^{ab}	40^{ab}	1280de
T_3	34^{ab}	46^{ab}	1564^{bcd}
T_4	36^{a}	52^{a}	1900^{ab}
T_5	33^{ab}	41^{ab}	1353^{cde}
T_6	35^{a}	48^{ab}	1680^{abc}
T_7	37^{a}	55^{a}	1980^{a}

*T_0= CK, (Control, no amendment), T_1= CF (Chemical fertilizers), T_2= 1% banana peel biochar (BB) w/w + CF, T_3= 2% BB w/w + CF, $T_{4=}$ 3% BB w/w + CF, T_5= 1% orange peel biochar (OB) w/w + CF, T_6= 2% OB w/w + CF; T_7= 3% OB w/w + CF. Values bearing the same letters are statistically similar.

Effects of fruit peel biochar application on the morphological parameters of country bean

The effects of applied fruit biochar on the morphological parameters of the country bean are shown in Table 4. The PH, BN, root length (RL), and fresh root weight (FRW) of country beans were significantly higher in the BB and OB treated plots compared to the control plot. But there was no significant variation in the NLP, and TLCC of country beans at different fruit biochars treated plots compared to T_0. The highest PH (373 cm), NLP (34), BN (3), and TLCC (36.65 µmol m^{-2}) of country bean were recorded in T_7 (3% OB w/w + CF) followed by T_4 (3% BB w/w + CF). The RL (43.5 cm) and FRW (14 g) of country bean were also highest at $T_{7,}$

DOI: https://doi.org/10.55706/jae1624

followed by T_5 (1% OB w/w + CF). Similar to the tomato, the lowest values in all indexes of country bean were also found in T_0 followed by the T_1. These results are in great harmony with the results of Egamberdieva *et al.* (2020).

Table 4. Effects of different fruit peel biochars on the morphological parameters of country bean.

*Treatments	Plant height (PH) (cm)	Number of leaves plant^{-1} (NLP)	Branch number (BN)	Root length (RL) (cm)	Fresh root weight (FRW) (g)	Total leaf chlorophyll content (TLCC) (μmol m^{-2})
T_0	207.15^{e}	27^{a}	2^{b}	14^{d}	4^{e}	34.10^{a}
T_1	240.33^{de}	28^{a}	2^{b}	16.33^{d}	3.66^{e}	35.71^{a}
T_2	269.66^{cd}	30^{a}	2^{b}	33^{bc}	8^{cd}	35.75^{a}
T_3	302.17^{bc}	32^{a}	3^{a}	38^{abc}	5.33^{de}	35.81^{a}
T_4	350.00^{ab}	33^{a}	3^{a}	31^{c}	10.33^{bc}	36.35^{a}
T_5	270.16^{cd}	31^{a}	3^{a}	47^{a}	12^{ab}	35.80^{a}
T_6	312.08^{bc}	33^{a}	2^{b}	41.66^{ab}	11^{abc}	36.01^{a}
T_7	373.00^{a}	34^{a}	3^{a}	43.5^{a}	14^{a}	36.65^{a}

*T_0= CK, (Control, no amendment), T_1= CF (Chemical fertilizers), T_2= 1% banana peel biochar (BB) w/w + CF, T_3= 2% BB w/w + CF, T_4= 3% BB w/w + CF, T_5= 1% orange peel biochar (OB) w/w + CF, T_6= 2% OB w/w + CF; T_7= 3% OB w/w + CF. Values bearing the same letters are statistically similar.

Impact of fruit peel biochar application on the yield and yield contributing characters of country bean

The effects of BB and OB application on the country bean yield and yield contributing characteristics are given in Table 5. The no. of pod plant^{-1} (NPP), individual pod weight (IPW), and total pod weight plant^{-1} (TPWP) of country beans were found to be significantly greater in the BB and OB treated plots compared to T_0 whereas non- significant difference was shown in the pod length (PL), and the number of seed pod^{-1} (NSP). The highest NPP (384), IPW (5.78 g), TPWP (2220 g), and PL (10.57 cm) of country bean were recorded in T_7 followed by T_4 whereas the minimum values were noted in T_0 followed by T_1. The NSP was higher (4) in all biochar treatments (except T_5) in comparison to both T_0 and T_1. In a study, Prapagdee, S. and Tawinteung, N. (2017) shown that 5% (w/w) cassava stem biochar significantly enhanced soil fertility and plant growth of *Vigna radiata* L. whereas growth of bean and yield of pod significantly increased with 10% (w/w) biochar, which agree well with our observations.

Table 5. Impact of different types of fruit peel biochars on the yield and yield contributing characters of country bean.

*Treatments	No. of pod plant^{-1} (NPP)	Individual pod weight (IPW) (g)	Total pod weight plant^{-1} (TPWP) (g)	Pod length (PL) (cm)	No. of Seed pod^{-1} (NSP)
T_0	300^{e}	4.10^{d}	1233^{d}	8.00^{a}	3^{a}
T_1	333^{d}	4.20^{cd}	1400^{cd}	8.58^{a}	3^{a}
T_2	337^{cd}	4.67^{bcd}	1675^{bcd}	9.23^{a}	4^{a}
T_3	358^{bc}	5.10^{abc}	1710^{abcd}	9.73^{a}	4^{a}
T_4	375^{ab}	5.76^{a}	2160^{ab}	10.20^{a}	4^{a}
T_5	357^{bc}	4.72^{bcd}	1686^{bcd}	9.22^{a}	3^{a}
T_6	365^{ab}	5.13^{ab}	1875^{abc}	10.00^{a}	4^{a}
T_7	384^{a}	5.78^{a}	2220^{a}	10.57^{a}	4^{a}

*T_0= CK, (Control, no amendment), T_1= CF (Chemical fertilizers), T_2= 1% banana peel biochar (BB) w/w + CF, T_3= 2% BB w/w + CF, T_4= 3% BB w/w + CF, T_5= 1% orange peel biochar (OB) w/w + CF, T_6= 2% OB w/w + CF; T_7= 3% OB w/w + CF. Values bearing the same letters are statistically similar.

Effect of fruit peel biochar application on soil pH

The soil pH of the experimental plots was determined to identify the effect of fruit peel biochar use on the acidic soil of the Sylhet region. Before cultivating country bean and tomato, the pH of soil was 5.2. After the cultivation of country bean and tomato, no significant increase was recorded in the soil pH at T_3 (2% BB w/w + CF), T_4 (3% BB w/w + CF), T_6 (2% OB w/w + CF) and T_7 (3% OB w/w + CF) in comparison to T_0 (Table 6). But a non-significant increase was observed in soil pH compared to T_1 (CF), T_2 (1% BB w/w + CF) and T_5 (1% OB w/w + CF). The highest soil pH was found when 3% of orange peel biochar along with chemical fertilizer dose was applied to the soil under country bean and tomato cultivation, followed by the application of 3%

DOI: https://doi.org/10.55706/jae1624

of banana peel biochar along with control fertilizer dose (Table 6). Usually, biochars are basic in nature and they have the capacity to neutralize soil acidity. Many scientists previously established the potential of various kinds of biochars to raise soil pH to varying extent (Dai *et al*., 2014; Smebye *et al*., 2016 and Si *et al*., 2018). Particularly, Sial, *et al*. (2019) showed that banana and orange peel biochar non-significantly increased soil pH in different levels of biochar treatments in wheat growth.

Table 6. Impact of different fruit peel biochars on soil pH.

*Treatments	Soil pH	
	Country bean	Tomato
T_0	5.20^{d}	5.20^{d}
T_1	5.30^{d}	5.27^{d}
T_2	5.43^{cd}	5.40^{cd}
T_3	5.80^{b}	5.73^{b}
T_4	5.90^{ab}	5.87^{ab}
T_5	5.40^{cd}	5.43^{cd}
T_6	5.67^{bc}	5.70^{bc}
T_7	6.10^{a}	6.03^{a}

*T_0= CK, (Control, no amendment), T_1= CF (Chemical fertilizers), T_2= 1% banana peel biochar (BB) w/w + CF, T_3= 2% BB w/w + CF, T_4= 3% BB w/w + CF, T_5= 1% orange peel biochar (OB) w/w + CF, T_6= 2% OB w/w + CF; T_7= 3% OB w/w + CF. Values bearing the same letters are statistically similar.

CONCLUSION

After the experiment it was revealed that both banana and orange peel biochar showed better growth and yield in tomato and country bean; furthermore, treatments with increasing rates of biochar (particularly T_4 and T_7) gave better performances in both tomato and country bean. These results might contribute to enlarge the prospects of biochar application in safe crop production both in normal and less fertile soils, which will ultimately be helpful in the development of sustainable technology for crop production. In the other way, this study might encourage the government policy makers to take initiative to put the organic wastes into the circular economy, which will also prevent the respective environmental pollution. However, considering the experimental results further field trial at large scale should be conducted and biochar from different feedstocks should be tested for crop production.

Acknowledgement

The authors extend their sincere thanks and appreciation to the “Ministry of Science and Technology, Bangladesh (MoST)” and “Sylhet Agricultural University Research System (SAURES)” for providing research funds.

Conflict of Interest

There are no conflicts of interest declared by the authors.

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DOI: https://doi.org/10.55706/jae1624