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Effect of Biochar on Growth and Yield of Yard long bean (*Vigna unguiculata*) Under Salinity Stress

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Abstract: One of the most popular vegetables worldwide is the yard long bean. Salinity is a significant environmental problem that causes lower yields in vegetable crop. Application of biochar is a crucial manure management practice that can be used to increase yard long bean production under saline conditions. An experiment was conducted at the research field of the Noakhali Science and Technology University, Noakhali-3814, Bangladesh during the period from 1st March to 2nd June of 2022 to determine the potential of biochar on the growth and yield performance of yard long bean (*Vigna unguiculata* subsp. *sesquipedalis*) under salinity stress. The experiment consisted three treatments with two levels of biochar and each replicated three times following randomized complete block design. The treatment combinations were T_0= no biochar + Recommended doses of chemical fertilizer (RDF), T_1= biochar (3 t ha^{-1}) + RDF, T_2= biochar (6 t ha^{-1}) + RDF respectively. The tallest plant height (33.33 cm), minimum days of flowering (29.33 days), highest chlorophyll content (63.43), maximum number of leaf (61.43) and pod (56.33) per plant, highest pod weight (17.70 g), pod length (31.77 cm), pod diameter (0.98 cm), maximum number of seeds (13.67) per pod and also yield hectare (5.49 t) were found from T_2 = biochar (6 t ha^{-1}) + RDF under the soil with 0.1 M salinity stress, whereas lowest data was found from control T_0= no biochar + RDF under the soil with 0.1 M salinity stress . The findings of experiment indicated that the application of biochar at the level of 6 t ha^{-1}+ RDF enhanced the growth and yield performance of yard long bean under salinity stress.

Keywords: Yard long bean; Biochar; Salinity; Growth; Yield.

INTRODUCTION

In Bangladesh, India, Indonesia, the Philippines, and Sri Lanka, yard long bean (*Vigna unguiculata* subsp. *sesquipedalis*) is a common vegetable crop (Ullah *et al.*, 2011). There are numerous other names for yard long bean, including asparagus bean, chinese long bean, pea bean, string bean, snake bean, snake pea, snap pea, bodi, and borboti. (Bhagavati *et al.*, 2019). It is a member of the Fabaceae family and is also a crucial summer vegetable in Bangladesh (Haque *et al.*, 2021). Yard long bean is an excellent nutritive vegetable containing a good amount of crude protein and also good source of vitamins and minerals (Ano and Ubochi, 2008). In Bangladesh, it has dwarf and tall climbing varieties. During the summer, when there are fewer vegetables available, it has significant commercial value. It works as a ground cover and enriches the soil by fixing nitrogen (Haque *et al.*, 2021; Singh *et al.*, 1997). Yard long bean propensity for rapid growth has made it a necessary part of sustainable agriculture on tropical marginal soils (Yuvaraj *et al.*, 2020). In Bangladesh, yard long bean is an important vegetable, however, in addition to contributing to the nation's economy, vegetables are vital agricultural products for human life (Ali *et al.*, 2023b; Ali *et al.*, 2022a).

Salinity is a global issue that is getting severe and has reduced crop productivity and global food production (Misu *et al.*, 2023: Khatun *et al.*, 2023: Fischer *et al.*, 2017). About 1.056 million hectares of the 1.689 million hectares (30% of the net cultivable land of coastal areas are negatively affected by varied levels of soil salinity in Bangladesh (Kanwal *et al.*, 2018). High levels of Na and

chloride are frequently indicative of high salinity (Hussien Ibrahim *et al.,* 2020). When the concentration of salt in the soil exceeds the crop's tolerance levels, it hinders the growth of the crop. Even if there may be sufficient water in the root zone, salt limits plant growth since it can be harmful to plants and inhibits their ability to absorb water (Payo *et al.,* 2017). Not only plant growth but also stomatal conductivity, leaf water potential, photosynthetic rate, root length, and shoot biomass, number of grain yield per plant all decrease in response to salinity (Kanwal *et al.,* 2018; Shamsi and Kobraee, 2013). To get high yields for vegetable crop cultivation most farmers in Bangladesh use inorganic fertilizers (Ali *et al.,* 2023a; Ali *et al.,* 2022b) but inorganic fertilizers has positive and negative impacts in soil. Soil amendment with biochar has been proposed as a way to boost long-term production and nutrient availability (Sarong and Orge, 2015; Sohi *et al.,* 2010). Biochar, a fine-grained carbon-rich charcoal produced by the pyrolysis of biomass in a low-oxygen environment that increase soil fertility (Liu *et al.,* 2016; Zhang *et al.,* 2019; Wang and Wang, 2019). It is regarded as having a high cation-exchange capacity and being naturally alkaline (Lehmann *et al.,* 2011). Generally, it has several positive effects on soil properties as it promotes microbe's growth, reproduction and reducing soil nutrient loss, lowering the incidence of pests and diseases. In recent years, biochar has drawn a lot of attention because of its distinctive quality of high salt adsorption that makes it a good soil supplement (Puja, 2021)**.**

Its large surface area momentarily binds the Na^+ to lessen the plant's uptake of it and improved the supply of K^+, Ca^{2+},and Mg^{2+} in the soil solution (Zhang *et al.,* 2019). Biochar helps increase salt leaching, lowering the EC of the soil solution which contribute to its great capacity for reducing the detrimental effects of saline stress (Parkash and Singh, 2020). There is no much research about the effect of biochar amendments on growth and development of yard long beans dwarf variety under salinity stress. Therefore, this experiment reviewed for the first time about biochar effects on yard long beans dwarf variety under salinity stress. The study was conducted to find out the effect of biochar on growth, different morphological parameters and yield performance of yard long bean under saline soil.

MATERIALS AND METHODS

Experimental site, soil and climate

The experiment was conducted at the research field of the Noakhali Science and Technology University, Noakhali, Bangladesh during the period from 1st March of 2022 to 2nd June 2022 in agro-ecological region of the Young Meghna Estuarine Floodplain (AEZ-18) (Figure 1). The experiment site was almost level land having sandy loam soil, moderately alkaline with pH value 7.5.

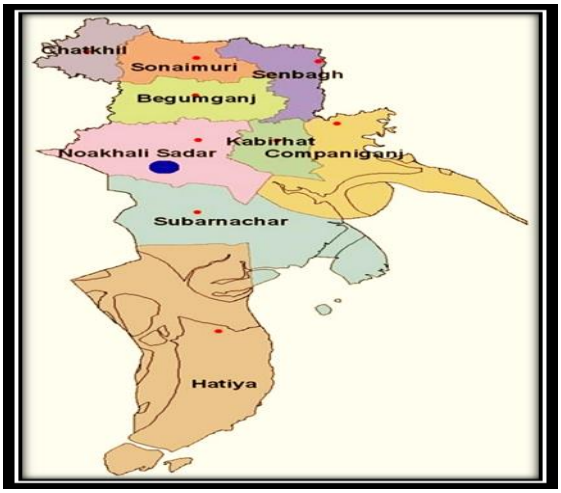

Figure 1. Location of the study area in the map (Source: Bangladesh.gov.bd)

Experimental treatments and design

The single factor experiment was laid out following Randomized Complete Block Design (RCBD) comprising three treatments with three replications. The treatments were T_0 = no biochar + Recommended doses of chemical fertilizer (RDF), T_1 = biochar (3 t ha^{-1}) + RDF, T_2 = biochar (6 t ha^{-1}) + RDF respectively. An area of 12 m^2 was divided into three equal blocks. Each block was divided in to 3 plots where 3 treatments were allotted at random. Thus, there were 9 (3x3) unit plots altogether in the experiment field. The size of the plot was 1mx1m. The distance between blocks and between plots were kept 0.50 m and 0.50 m respectively.

Seed collection

Stickless (Variety) of yard long bean obtained from Seed Bazar Nursery, Ulipur Upazila, Kurigram District, Rangpur division. "Stickless" is an unusual dwarf variety. It also called "Khato Barabti" in Bangladesh.

Land preparation

The field which was selected to conduct the experiment was opened with a power tiller. Later on, the land was ploughing and cross ploughing. Thereafter, the land was ploughed to obtain good tilth, which was necessary to get better yield. All the weeds and stubbles were removed from the experimental field.

Biochar application

Full amount of biochar was applied during final land preparation.

Recommendation dose of chemical fertilizers and fertilizers application

Recommendation dose of chemical fertilizer for yard long bean cultivation show in Table 1. The entire amount of TSP and half of MoP were applied during final land preparation and rest half dose of MoP was applied as top

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dress after 25 days of sowing. The entire amount of urea was applied in three split doses.

Table1: Recommendation dose of chemical fertilizers (BARC)

Fertilizer	Quantity (kg/ha)
Urea	250 kg
TSP	225 kg
MoP	185 kg

Seed sowing

Seeds of yard long bean were sown on each plot of the experiment field by line sowing method. The seeds were covered with light soil later. After emergence of seedling, 12 plants were left on each plot and the rest were removed from the plot for uniform space. Plant to plant distance 25 cm and row to row distance 25 cm.

Application of Salt

5.844g of NaCl dissolve in 1 liter of water and made 0.1 M NaCl solution. For evenly distribution of 9 research plots (each are 1mx1m) 0.1 M NaCl solution with 105.192g of NaCl dissolve in 18 liter of water and this salt solution were applied 10 days after seed germination for observing plant growth, development and yield under this rate of salinity stress.

Intercultural operation

After seed sowing, each plot was covered with banana leaves for conserve soil moisture and helps to germination of seed. Seedlings emergence was completed within 7 days. Then light watering to the individual seedlings was provided for 3-4 days to overcome water deficit condition and after establishment of the seedings, watering was done when necessary. 15-16 days after germination, straw was placed around the plants as mulching materials. Weeding was done three times in plots for clean cultivation. De-topping (removal of apical portion /meristem of plants which promotes the emergence of lateral branches) was done for three times because it is very essential for this short height variety. Docord10EC (Cypermethrin) @ 1.25 ml/liter was sprayed to control leaf minor at the stage of seedling.

Collection of data

Data were collected on plant height, days of flowering, number of leaves per plant, chlorophyll content (measured by SPAD-502PLus chlorophyll meter), number of pods per plant, individual pod length, individual pod weight, pod diameter, number of seeds per pod and pod yield per hectare from six plants being randomly selected from each treatment.

Statistical analysis

The recorded data on the different parameter of the study were analyzed statistically by using Microsoft Office and Excel 2016. Analysis of variance of different parameters was performed by the "F" test and "T" test at 1% level of significance.

RESULT AND DISCUSSION

Plant height

Plant height of yard long bean was significantly influenced by different levels of biochar dose (Table 2). Plant height varies from 24.67 cm to 33.33 cm. The longest (33.33 cm) plant was recorded from T_2 = biochar (6 t ha^{-1}) + RDF, while the shortest (24.67 cm) plant was recorded from T_0 = no biochar + RDF. Also (28.67 cm) plant was recorded from T_1 = biochar (3 t ha^{-1}) + RDF. The application of biochar considerably raised the height of the rice plant (Chen *et al.,* 2021). Additionally, Cong *et al.* (2023) found that biochar treatment increased maize plant height at the greatest rates.

Number of leaves per plant

The treatment of various doses of biochar caused a considerable variation in the number of leaves on yard long bean (Table 2). Number of leaves per plant varies from 39.17 to 61.43. The highest (61.43) number of leaves were found in T_2 = biochar (6 t ha^{-1}) + RDF, while the lowest (39.17) were found in T_0 = no biochar + RDF. From T_1 = biochar (3 t ha^{-1}) + RDF, (49.34) was also recorded. Application of biochar greatly enhanced the number of leaves (Helliwell, 2015).

Chlorophyll Content

Due to the use of various biochar doses, the chlorophyll content of yard long bean leaves changed significantly (Table 2). Chlorophyll Content ranges between 44.43 and 63.43. The T_2 = biochar (6 t ha^{-1}) + RDF plant had the highest chlorophyll content (63.43), whereas the T_0 = no biochar + RDF plant had the lowest chlorophyll content (44.43). Additionally discovered from T_1 = biochar (3 t ha^{-1}) + RDF was (50.67). This result suggested that the application of different levels of bochar increased chlorophyll content of yard long bean significantly. A previous research work showed that addition of biochar improved leaf chlorophyll content in common bean (Farhangi-Abriz and Torabian, 2018).

Days of flowering

Days of flowering of yard long bean varied significantly due to the application of different doses of biochar (Table 2). It varies from 29.33 days to 35.33 days. The minimum days of flowering (29.33) recorded from T_2 = biochar (6 t ha^{-1}) + RDF, while the maximum (35.33) was recorded from T_0 = no biochar + RDF. Also (31.67) flowering days was recorded from T_1 = biochar (3 t ha^{-1}) + RDF. Early flowering was recorded in biochar treated plots as compared to control. Days of flowering of mung bean was

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significantly increased by the application of biochar (Rab, 2016).

Table 2. Effect of biochar on yield and yield contributing character of yard long bean.

Treatment	Plant height (cm)	Number of leaves per plant	Chlorophyll Content	Days of flowering
T_0	24.67[c]	39.17[c]	44.43[c]	35.33[c]
T_1	28.67[b]	49.34[b]	50.67[b]	31.67[b]
T_2	33.33[a]	61.43[a]	63.43[a]	29.33[a]
CV (%)	3.65	1.31	1.18	1.50
LSD	3.96	2.46	2.34	1.98
Level of Significance	**	**	**	**

T_0= no biochar + Recommended doses of chemical fertilizer (RDF), T_1= biochar (3 t ha^{-1}) + RDF, T_2= biochar (6 t ha^{-1}) + RDF; CV = Co-efficient of variation; LSD = Least Significant Difference; ** = Significant at 1% level of probability.

Number of pods per plant

The number of pods per plant showed significantly a wide range of variation due to the application of different rates of biochar (Table 3). Number of pods per plant varies from 34.33 to 56.33. The maximum number of pod (56.33) recorded from T_2 = biochar (6 t ha^{-1}) + RDF and the minimum (34.33) recorded from T_0 = no biochar + RDF while (45.67) recorded from T_1 = biochar (3 t ha^{-1}) + RDF. Pod number of soybean was significantly increased by the application of biochar (Yooyen *et al.,* 2017).

Individual pod length

Application of various quantities of biochar was a significant impact on the length of each individual yard long bean pod (Table 3). Pod length varies from 20.67 cm to 31.77 cm. The longest measurement (31.77 cm) came from T_2 = biochar (6 t ha^{-1}) + RDF, and the shortest measurement (20.67 cm) came from T_0 = no biochar + RDF. Individual pod length of yard long bean was significantly affected by the application of different levels of biochar (Southavong *et al.,* 2015).

Pod diameter

Application of various quantities of biochar was a substantial impact on the individual pod diameter of yard long bean (Table 3). It ranges from 0.72 cm to 0.98 cm. The lowest pod diameter (0.72 cm) was observed from T_0 = no biochar + RDF, while the highest pod diameter (0.98 cm) was recorded from T_2 = biochar (6 t ha^{-1}) + RDF. Moreover, T_1 = biochar (3 t ha^{-1}) + RDF recorded 0.85 cm of pod diameter. This result indicated that the application of different levels of biochar significantly increased the pod diameter of yard long bean.

Table 3. Effect of biochar on yield and yield contributing character of yard long bean.

Treatment	Number of pods/ plant	Individual pod length (cm)	Pod diameter (cm)	Individual pod weight (g)	Number of seeds/pod	Yield (t/ha)
T_0	34.33[c]	20.67[c]	0.72[c]	10.57[c]	8.67[c]	2.63[c]
T_1	45.67[b]	25.13[b]	0.85[b]	13.87[b]	11.33[b]	3.77[b]
T_2	56.33[a]	31.77[a]	0.98[a]	17.70[a]	13.67[a]	5.49[a]
CV (%)	4.08	3.00	1.87	1.32	5.94	3.72
LSD	6.98	2.61	0.09	0.70	2.51	0.55
Level of Significance	**	**	**	**	**	**

T_0= no biochar + Recommended doses of chemical fertilizer (RDF), T_1= biochar (3 t ha^{-1}) + RDF, T_2= biochar (6 t ha^{-1}) + RDF; CV = Co-efficient of variation; LSD = Least Significant Difference; ** = Significant at 1% level of probability.

Individual pod weight

Application of various quantities of biochar was a substantial impact on the weight of individual yard long bean pod (Table 3). Pod weight varies from 10.57 gm to 17.70 gm. The highest (17.70 gm) was measured at T_2 = biochar (6 t ha^{-1}) + RDF, and the lowest (10.57 gm) was measured at T_0 = no biochar + RDF. Furthermore, T_1 = biochar (3 t ha^{-1}) + RDF recorded 13.87 gm of pod weight. Individual pod weight was significantly affected due to the application of biochar. These result were supported by the findings of Yooyen *et al.,* 2017.

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Number of seeds per pod

Application of various doses of biochar was a significant impact on the quantity of seeds per pod of yard long bean (Table 3). Per pod, seed ranges between 8.67 and 13.67. T_2 = biochar (6 t ha^{-1}) + RDF reported the maximum number of seeds per pod (13.67) whereas, T_0 = no biochar + RDF recorded the minimum number of seeds (8.67). Also, (11.33) seeds are obtain from T_1 = biochar (3 t ha^{-1}) + RDF. These results back with a prior study's conclusion that applying biochar had a substantial impact on the amount of garden pea seeds per pod (Berihun *et al.*, 2017).

Yield per hectare

In respect of pod yield per hectare (ton) showed significantly a wide range of variation due to the application of different rates of biochar (Table 2). Pod yield per hectare varies from 2.63 ton to 5.49 ton. The highest yield (5.49 t) was recorded from T_2 = biochar (6 t ha^{-1}) + RDF, while the lowest yield (2.63 t) was recorded from T_0 = no biochar + RDF. Also yield (3.77 t) was recorded from T_1 = biochar (3 t ha^{-1}) + RDF. The improvements of the yard long bean production from this experiment are similar to a previous literature where they also found that using different doses of biochar significantly increased pod yield per hectare (Williams *et al.*, 2023).

CONCLUSION

The findings showed that application biochar had a positive effect on the growth and yield parameters of yard long bean under saline condition. Comparative results of various parameters studied in the present investigation suggested that T_2 was the best treatment because the maximum plant height of yard long bean (33.33 cm), minimum days of flowering (29.33 days), highest chlorophyll content (63.43), maximum number of leaf (61.43) and pod (56.33) per plant, highest pod weight (17.70 g), pod length (31.77 cm), pod diameter (0.98 cm), maximum number of seeds (13.67) per pod and yield hectare (5.49 t) were found from T_2 = biochar (6 t ha^{-1}) + RDF. Observing the results, it can be stated that application of T_2 = biochar (6 t ha^{-1}) + RDF for yard long bean cultivation gave better growth and yield under saline condition.

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Conflict of Interest

The authors declare that there is no conflict of interests regarding the publication of this paper**.**

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