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Research Article
Evaluation of Applying Different Levels of Compost and Biochar on Growth Performance of *Glycine max* (L.)

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Abstract

Background and Objective: Impacts of biochar application in combination with compost, at different levels are not fully understood. Hence, a pot experiment was conducted in Crop Farm, Eastern University of Sri Lanka to identify the effect of different levels of compost and biochar on growth performance of *Glycine max* (L). **Materials and Methods:** The experiment was arranged in a Complete Randomized Design (CRD) with six treatments and six replicates. Different levels of compost and biochar were defined as treatments viz., (T1) 100% compost, (T2) 75% compost with 25% biochar, (T3) 50% compost with 50% biochar, (T4) 25% compost with 75% biochar, (T5) 100% biochar and (T6) inorganic fertilizer (control). Plant height, leaf area, chlorophyll content, nodules and total biomass were measured. Analysis of variance was also performed. **Results:** It was found that T4 significantly increased the leaf area, chlorophyll content and nodules. There were no significant differences between T4 and T6 in plant height and total biomass. However, T4 recorded maximum values. **Conclusion:** Therefore, it could be concluded that, 25% compost with 75% biochar could be used instead of inorganic fertilizer to enhance growth in *Glycine max* without harming the environment.

Key words: *Glycine max* (L.), biochar, compost, inorganic fertilizers, chlorophyll content

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

The greatest problem in the current world is the degradation of bio-diversity with the modern agricultural practices. In order to overcome this challenge, sustainable farming methods are adopted globally. Soybean (*Glycine max* L.) is an annual legume that is grown on massive scale and categorized under Fabaceae family. It is most nutritious and easily digested food in the bean family, hence, considered as one of the richest and cheapest source of protein[1]. It is high in vegetarian protein as well as vegetable oil and it contain 40% protein and 20% oil and higher nutritional value containing essential amino acids, unsaturated fatty acids, carbohydrates, vitamins and minerals[2].

There is variety of soil amendments that could be applied to soils which helps to improve the conditions in soil and make its use as more favorable. Organic amendments are peat, compost, mulch, manures and biochar[3]. Compost is nutrient complex compound which contain Nitrogen (N), Phosphorous (P), Potassium (K), Sulfur (S), Calcium (Ca) and Magnesium (Mg) and other minor nutrients. These nutrients release to soil root zone slowly and enhance the development of plants. Composting is an environment friendly aerobic microbial process to convert biodegradable organic matter into humus like product. Biochar produced as the result of pyrolysis of biomass in an oxygen-limited condition[4]. Biochar improves water retention in farmlands, reduce the leaching losses of nutrients and reduce nitrous oxide emissions, balance soil acidity and increase soil organic carbon[5].

The prominent soil group which is found in the Batticaloa district in Sri Lanka is sandy regosols. Sandy soil has the big issue of leaching nutrients especially nitrogen. This leads to lack of development in agriculture sector in this region[6]. According to Chemining'wa *et al.*[7], legume production gets reduced due to declining soil fertility and poor nitrogen availability for plants growth. The farmers who cultivate legumes have lack of knowledge in the usage of biochar, compost and combination of biochar and compost for growth performance of the legumes. Hence, objective of this experiment was to study the growth performance of soybean with different levels of compost and biochar.

MATERIALS AND METHODS

Experimental design: A pot experiment was conducted in three months periods from September-November, 2017 at Crop Farm, Eastern University, Chenkalady, Sri Lanka (7.7944°N, 81.5790°E). Experiment was arranged in a complete randomized design (CRD) with 6 treatments. Different levels of compost and biochar were defined as treatments viz. (T1) 100% compost, (T2) 75% compost with 25% biochar, (T3) 50% compost with 50% biochar, (T4) 25% compost with 75% biochar, (T5) 100% biochar and (T6) inorganic fertilizer (control). Each treatment contained six replicates.

Preparation: Compost (2 t ha^{-1}) and inorganic fertilizer were applied according to the recommendation of Department of Agriculture and Biochar applied[6] 30 t ha^{-1}. Those particles were made into powder form (<2 mm) using pistil and mortar[6]. Pots were prepared using PVC pipes (5.2 cm inner diameter and 30 cm height). The filtering materials to the bottom of the soil column were placed by using nylon net. Soil mixture of top soil and red soil was filled up to each pot based on the 1:1 ratio. Then, treatments were applied according to their combinations, 3 days before planting of Pb-1 soybean variety seeds and other management practices were followed uniformly according to the recommendation.

Observed parameters

Plant height (cm): Plant height was measured from the base of the plant to the tip of the longest leaf (highest point). Plant height of each plant were measured by using meter ruler and expressed in centimeters as non-destructive sample measurements.

Leaf area (cm^2): Leaf area of the plant was measured by Portable Leaf Area Meter (Model- LICOR- 3000C, Lincon) and statistical analysis which was expressed in centimeter square.

Chlorophyll content (SPAD value) of the leaves: The SPAD values were determined by the SPAD 502 plus chlorophyll meter which provides an indication of the relative amount of chlorophyll present in plant leaves. Chlorophyll in a plant represents the nitrogen availability for plants. The reducing the chlorophyll content in plant leaves, fertilizer application needed to apply. Chlorophyll content in leaves was measured from 2nd WAP to 6th WAP.

Nodules: Nodules were counted after carefully removing the soil and then excision into halves was done to determine the pink color of the nodule tissue. The nodules in the pink color were counted and noted as effective nodules.

Total biomass: Dry weights of shoot and roots were taken, after they were chopped into thin pieces and subjected to oven dry at 80°C until constant weight was gained. (Model-Anon 2204).

Statistical analysis: Analysis of variance (one way ANOVA) was performed by using SAS 9.1 version statistical software package and mean comparison was performed within treatments using Duncan multiple range test (DMRT) at 5% significant level.

RESULTS

Plant height (cm): It was found that there was no significant difference among the treatments on the average plant height at 2nd, 3rd and 4th weeks after planting (WAP). But there were significant differences in the average plant height at 5th and 6th WAP. T4 treatment (6th WAP) recorded the maximum plant height (33.63 cm) among other treatments. T6 treatment recorded 32.57 cm plant height Table 1.

Chlorophyll content of the leaves (SPAD): There was no significant different ($p<0.05$) among the treatments at 2nd WAP and significant different was observed among treatment at 3rd, 4th, 5th and 6th WAP. According to the observations SPAD value in the plants higher at the initial stage and it decreased with the plant growth (Fig. 1).

Number of nodules per plant: Greatest average number of nodules (6.17) and number of effective nodules (5.33) at 6th WAP was recorded in T4 treatment with the combine application of 25% compost and 75% biochar. The lowest values of nodules and effective nodules (3.17 and 2.67) were observed in the T1 (Table 2).

Total biomass (g): The maximum total biomass (4.32 g) was recorded in 25% compost with 75% biochar (T4 treatment) and the minimum was recorded in the T5 treatment (2.58 g) which is 100% biochar amended soil mixture (Table 2).

Leaf area (cm²): The highest leaf area (430.58 cm^2) recorded due to the application of 25% compost with 75% biochar in T4. However, the lowest leaf area was recorded in T5 treatment (272.44 cm^2) which having only biochar as treatment (Table 2).

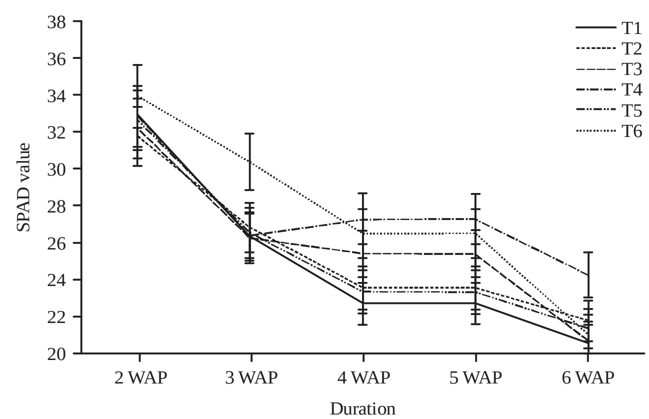

Fig. 1: Effect of different levels of compost and biochar on SPAD value of leaves at weekly interval

Table 1: Effect of different levels of compost and biochar on plant height of *Glycine max* (L.)

	Plant height (cm)				
Treatments	2 WAP	3 WAP	4 WAP	5 WAP	6 WAP
T1	17.12±0.14[a]	20.33±0.20[a]	22.12±0.20[a]	23.25±0.23[c]	27.08±0.14[bc]
T2	17.37±0.25[a]	20.37±0.19[a]	22.67±0.22[a]	24.27±0.20[bc]	28.95±0.41[b]
T3	17.72±0.18[a]	20.73±0.19[a]	21.97±0.30[a]	24.97±0.21[b]	29.10±0.33[b]
T4	17.67±0.15[a]	21.28±0.18[a]	22.87±0.22[a]	28.68±0.25[a]	33.63±0.32[a]
T5	17.07±0.13[a]	20.32±0.22[a]	21.55±0.31[a]	23.25±0.36[c]	26.07±0.21[c]
T6	17.43±0.30[a]	21.32±0.15[a]	22.95±0.21[a]	28.75±0.21[a]	32.57±0.37[a]
F-test	ns	ns	ns	*	*

Value represents mean±standard error of six replicates. *Significant at 5% probability level ($p<0.05$), ns: Not significant. Means with same letter are not significantly different in each column according to the DMRT at 5% level

Table 2: Effect of different levels of compost and biochar on nodules, total biomass and leaf area of *Glycine max* (L.)

Treatments	Nodules per plant (Nos)	Effective nodules per plant (Nos)	Total biomass (g)	Leaf area (cm^2)
T1	3.17±0.42[c]	2.67±0.32[c]	2.69±0.50[c]	275.37±4.75[c]
T2	3.83±0.38[bc]	3.67±0.43[bc]	2.97±0.08[c]	297.76±1.57[c]
T3	4.33±0.73[bc]	3.50±0.29[bc]	3.09±0.18[bc]	308.30±2.85[bc]
T4	6.17±0.47[a]	5.33±0.45[a]	4.23±0.28[a]	430.58±3.31[a]
T5	3.33±0.56[c]	2.83±0.45[bc]	2.58±0.29[c]	272.44±2.37[c]
T6	4.83±0.53[b]	3.83±0.60[b]	3.63±0.28[ab]	367.21±1.10[b]
F-test	*	*	*	*

Value represents mean±standard error of six replicates. *Significant at 5% probability level ($p<0.05$), ns: Not significant. Means with same letter are not significantly different in each column according to the DMRT at 5% level

DISCUSSION

Increasing the biochar application (up to 75%) increased the late vegetative stage of plant. This similar result was observed by Wang *et al.*[8] in mung bean. According to the Schulz *et al.*[9], similar result found in T4 due to biochar increase the fertilizer use efficiency and increase the plant height at the late vegetative stage. This study discovered the 25% compost with 75% biochar (T4) significantly increased the plant height by 3.25% when compared to the plants applied with the 100% application of inorganic fertilizer (T6). These results were in agreement with Rizieq *et al.*[10] where it reported that biochar and bio-compost treatments showed much better growth performance compared to non-added organic amendments.

With increasing the biochar content in the potting mixture the nutrient holding capacity got increased than the other treatment while 100% inorganic fertilizer application increased the nutrient loses and it reduced the chlorophyll content rapidly. These findings are in line with the results of Awad *et al.*[11] and Wang *et al.*[8]. Increasing the chlorophyll content in the plant leaves directly supported to the photosynthesis and determines of final yield of the crop[12]. Biederman and Harpole[13] stated that biochar has variable effects on plant-associated soil microbes and root nodulation by *Rhizobia* generally increased, because of the efficient nitrogen-fixation. Also, Ijima *et al.*[14] stated that biochar may be artificial shelter for soybean nodule bacteria. Combination of compost and biochar improved nodulation and nitrogen uptake by plants and increased the nitrogen content of plant by nitrogen fixation. That result was also proved by Rizieq *et al.*[10]. It was found that T4 treatment with 25% compost and 75% of biochar increased the total biomass by 16.52% compared to the control treatment in soybean plants. That may be due to increased plant growth parameters which help to increase the total biomass as a result of combined application of the compost and biochar as T4 treatment. Similar results were observed in maize and lettuce by Trupiano *et al.*[15] and Pan *et al.*[16] who found that paddy husk biochar increase the plant biomass of cabbage. Compost contains significant amount of valuable plant nutrients including Nitrogen, Phosphorous, Potassium, Calcium, Magnesium and Sulphur and a variety of essential trace elements and with the synergistic effect of higher biochar application improve the nutrient use efficiency for plant growth and finally increase the biomass of the plant. Increased activity of nitrogen fixing organisms ultimately improves total biomass[17]. The application of 25% of compost and 75% of biochar (T4) significantly increase the leaf area (17.25%) when compared to the plants applied with inorganic fertilizer (T6). Therefore, these results revealed that combine application of 25% of compost and 75% of biochar enhance the growth parameters of *Glycine max* (L.). Similar pattern of leaf area increased was recorded by Awad *et al.*[11] with Perlite and rice husk biochar substrate. Batool *et al.*[18] who reported that combination of biochar with gypsum also increased the leaf area compared to the control treatment in *Abelmoschus esculentus* (L). Similarly, Reyes-Cabrera *et al.*[19] proved that, increased leaf area by incorporation of 25 and 50 t ha^{-1} biochar in the top 0.15 m of soil grown plants. Combine application of compost and biochar increased not only the leaf area, but also amplified the leaf area index of the plant. Lashari *et al.*[20] reported that biochar with manure decreased the salinity and increases the leaf area index and plant performance with decrease in leaf electrolyte leakage in maize. This study could be further improved by comparing biochar of different plant origins.

CONCLUSION

The results of this study revealed that combined application of 25% compost with 75% biochar (T4) significantly increased the growth parameters of *Glycine max* (L.) in T4. This combination could serve as better soil amendment to increase the soybean growth performance in an environmental friendly way, which could also be an alternative way to reduce the current inorganic fertilizer usage.

SIGNIFICANCE STATEMENT

This study discovered the potential of combining compost and biochar that can be beneficial for enhancing growth and development of *Glycine max* (L.). This study will help the researchers to uncover the critical areas of synergistic effect of mixing more than one fertilizers that many researchers were not able to explore.

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