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Tender Coconut Husk Biochar Augments the Growth and Yield of Okra in Onattukara Sandy Plains

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ABSTRACT

A field experiment was carried out to study the effect of biochar produced from tender coconut husk on growth and yield of okra [*Abelmoschus esculentus* (L.) Moench] in Onattukara sandy plain' during 2023 at Onattukara Regional Agricultural Research Station, Kayamkulam, Kerala. The experiment was laid out in RBD with nine treatments which were replicated thrice. The treatments were T_1 (biochar @ 5 t/ha + 100% RDF), T_2 (biochar @ 10 t/ha + 100% RDF), T_3 (biochar @ 5 t/ha + 5 t/ha FYM + 100% RDF), T_4 (biochar @ 10 t/ha + 5 t/ha FYM + 100% RDF), T_5 (biochar @ 5 t/ha + 75% RDF), T_6 (biochar @ 10 t/ha + 75% RDF), T_7 (biochar @ 5 t/ha + 5 t/ha FYM + 75% RDF), T_8 (biochar @ 10 t/ha + 5 t/ha FYM + 75% RDF) and T_9 (20 t/ha FYM + 100% RDF). The results revealed that tender coconut husk biochar has good prospects for use as a soil conditioner for okra in the sandy loam soils of Onattukara. The soil application of biochar produced from tender coconut husk at the rate of 10 t/ha along with FYM @ 5 t/ha and 100 per cent recommended dose of fertilizer can be recommended for augmenting the growth and yield of okra in the sandy loam soils of Onattukara.

Key Words: Biochar, Growth, Okra, Tender coconut husk, Yield

INTRODUCTION

In India, the agricultural waste generated by crops is much greater compared to other countries. The lack of suitable technology to dispose the left-over crop residues, force the farmers to burn the residues as an easy way of clearing the field. According to Singh and Kaskaoutis (2014), about 43% of the total crop stubbles generated in India is burnt on the field. This leads to a lot of air pollution. Biochar, a carbonaceous product made by pyrolysis of biomass has low bulk density, high porosity, and high-water holding capacity (Punnoose and Anitha, 2015). When applied to soil, these properties make biochar, an ideal soil conditioner and improves the water and nutrient retention in soil, thereby improving the yield. Thus, the crop residues can be converted to biochar to serve as a potential technique to remediate the environmental problems caused by crop residue burning. In Kerala, tender coconut husk is an agricultural waste which require immediate measures for safe and quick disposal. A fraction of the tender coconut husk waste generated is effectively utilized by composting or as a mulch in coconut gardens. This is not sufficient compared to the quantity of waste generated. Tender coconut husk has great potential to be converted to biochar after drying. This waste can be routed back to enhance agricultural productivity by converting it to biochar. Onattukara tract of Alappuzha district is a problematic soil since it is coarse textured with loamy sand nature and low in nutrient status. Due to this nature of soil, the nutrients in the applied manures and fertilizers tend to be washed out from the site of application along with rain. Since biochar is having high water holding capacity and low bulk density, on application to agricultural soils, can increase the soil moisture content, thereby restricting the leaching out of applied nutrients. Hence, a study was undertaken to assess the potential of tender coconut husk biochar as a soil conditioner for okra in the sandy loam soils of Onattukara.

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MATERIALS AND METHODS

An experiment was conducted in the wetlands of the Instructional farm attached to Onattukara Regional Agricultural Research Station (ORARS), Kayamkulam, Kerala during the Summer of 2023. The field experiment was laid out in RBD with nine treatments which were replicated thrice. The treatments were T_1 (biochar @ 5 t/ha + 100% RDF), T_2 (biochar @ 10 t/ha + 100% RDF), T_3 (biochar @ 5 t/ha + 5 t/ha FYM + 100% RDF), T_4 (biochar @ 10 t/ha + 5 t/ha FYM + 100% RDF), T_5 (biochar @ 5 t/ha + 75% RDF), T_6 (biochar @ 10 t/ha + 75% RDF), T_7 (biochar @ 5 t/ha + 5 t/ha FYM + 75% RDF), T_8 (biochar @ 10 t/ha + 5 t/ha FYM + 75% RDF) and T_9 (20 t/ha FYM + 100% RDF).

The experimental area was cleared, stubbles were removed and clods were broken. Dolomite @ 1 t/ha was applied uniformly in the experimental area and incorporated into soil along with tillage. After the layout of the field, tender coconut husk biochar and farm yard manure, along with half N, full P and full K of chemical fertilizers were applied in soil as per treatments just before sowing. The remaining N was given in soil at one month after sowing. The seeds of okra (var. Arka Anamika) were sown in lines in the main field at a spacing of 60 cm x 30 cm. The crop was sown during the last week of January 2023. After sowing, uniform population was maintained by thinning and gap filling. The crop was raised under rainfed condition. Intercultural, weeding and earthing up were done at 10 days after sowing and at one month after sowing along with topdressing with nitrogen. The outer row in each plot was left out as border row and five plants from each net plot were tagged as observational plants. The growth characters *viz*. height of the plant and number of leaves per plant were recorded from each plot at monthly intervals upto harvest and the average was worked out. Height of the plant was measured from the ground (base of the plant) to the terminal bud and the average was worked out and expressed in cm. The number of fully opened leaves of the observational plants were recorded and the average was calculated.

The observational plants, at harvest, were carefully dug out using spade without any breakage of roots and was carefully washed in water to remove the soil. Root depth was measured by recording the length of the tap root of the observational plants and its mean was worked out and expressed in cm. For measuring the root volume, the roots were immersed in a measuring cylinder containing known volume of water. The increase in volume of water due to immersing roots is the root volume and is expressed in cm^3 (Musick *et al*, 1965). The number of days taken from sowing to opening of the first flower of the observational plants in each plot was recorded and the average was worked out. The total number of fruits obtained from the observational plants of each plot was recorded and the average was worked out. The length of the fruits from the tip of the fruit to the stalk end of the fruits is measured from the observational plants and the average was worked out and expressed in cm. The weight of the fruits from each of the observational plants was recorded after each harvest. After the final harvest, the total weight of fruits obtained from the observational plants of each plot from different harvests were worked out and expressed in kilograms for fruit yield per plant. The weight of fruits from each plots excluding the border plants was summed up after each harvest and at the end of the cropping season the yield in terms of kg/plot was calculated and converted into t/ha. Harvest index was calculated using the following formula suggested by Donald and Hamblin (1976).

The statistical analysis of the data was done by applying the technique of analysis of variance (ANOVA) for Randomised Block Design and was done using GRAPES statistical software developed by the Department of Agricultural Statistics, College of Agriculture, Vellayani (Gopinath *et al*, 2020).

RESULTS AND DISCUSSION

The heights of the plants were recorded at 30 DAS, 60 DAS and at 90 DAS (Table 1). In general, there was an increase in plant height with the age of the crop. No significant difference was observed among the treatments in plant height at 30 DAS. At 60 DAS and at 90 DAS, the application of biochar had significantly produced taller plants. The application of 100 per cent RDF produced taller plants compared to the plants that were given 75 per cent RDF. At 60 DAS, the treatment T_4 (105.82 cm) recorded taller plants and was found to

Table 2. Effect of different treatments on the yield attributes and yield of okra

Treatment	Fruit yield per plant (g)	Fruit yield (t ha^{-1})
T_1- biochar @ 5 t/ha + 100% RDF	480.30	10.44
T_2- biochar @ 10 t/ha + 100% RDF	487.23	12.25
T_3- biochar @ 5 t/ha + 5 t/ha FYM + 100% RDF	537.74	14.07
T_4- biochar @ 10 t/ha + 5 t/ha FYM + 100% RDF	544.93	15.71
T_5- biochar @ 5 t/ha + 75 % RDF	392.85	11.26
T_6- biochar @ 10 t/ha + 75 % RDF	415.59	11.89
T_7- biochar @ 5 t/ha + 5 t/ha FYM + 75% RDF	457.61	12.19
T_8- biochar @ 10 t/ha + 5 t/ha FYM+75% RDF	464.61	13.05
T_9- 20 t/ha FYM + 100% RDF (KAU POP)	380.24	7.65
SEm (±)	16.81	0.63
CD (0.05)	50.385	1.890

FYM- Farm yard Manure; NS- Not significant; RDF-Recommended dose of Fertilizer

Table. 1 Effect of different treatments on the growth attributes of okra.

Treatment	Height of the plant (cm)			Number of leaves per plant			Root depth (cm)	Root volume (cm^3)
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	at harvest	at harvest
T_1- biochar @ 5 t/ha + 100% RDF	23.45	99.10	118.70	6.00	19.89	6.56	20.23	16.68
T_2- biochar @ 10 t/ha + 100% RDF	24.28	101.32	121.37	6.00	20.66	6.89	20.60	16.67
T_3- biochar @ 5 t/ha + 5 t/ha FYM + 100% RDF	23.95	103.87	133.60	6.00	20.89	7.11	20.47	20.52
T_4- biochar @ 10 t/ha + 5 t/ha FYM + 100% RDF	21.77	105.82	141.00	6.00	20.44	7.89	15.80	25.64
T_5- biochar @ 5 t/ha + 75 % RDF	24.77	95.21	109.77	6.00	19.45	6.66	16.50	19.23
T_6- biochar @ 10 t/ha + 75 % RDF	24.98	95.48	109.77	6.00	20.00	6.67	18.03	15.39
T_7- biochar @ 5 t/ha + 5 t/ha FYM + 75% RDF	22.30	96.24	110.10	6.00	20.44	6.33	21.60	17.95
T_8- biochar @ 10 t/ha + 5 t/ha FYM + 75% RDF	20.57	97.94	111.27	5.89	20.33	6.34	23.60	16.67
T_9- 20 t/ha FYM + 100% RDF (KAU POP)	21.20	91.47	104.77	6.00	19.89	6.11	25.27	14.10
SEm (±)	1.09	2.00	2.79	0.04	0.38	0.21	0.35	1.97
CD (0.05)	NS	5.995	8.358	NS	NS	0.616	1.060	5.907

DAS- Days after sowing; FYM- Farm yard Manure; NS- Not significant; RDF-Recommended dose of Fertilizer be on a par with the treatment T_3 (103.87 cm) and T_2 (101.32 cm). This might be due to the supply of nutrients in the applied biochar combined with the application of recommended dose of nutrients. As the dose of biochar was increased, the height of okra was found to increase. This might be due to the adsorption capacity of biochar in decreasing leaching loss of nutrients and improving the water and nutrient retention. Jabin and Rani (2023) had also reported an improvement in growth of ginger due to the application of different biochars at various levels. At 90 DAS, taller plants were recorded for the treatment T_4 (141 cm) and was found to be on a par with the treatment T_3 (133.60 cm). Similar reports of increased growth parameters were reported by Southavong *et al* (2012) in water spinach due to application of rice husk biochar. Dainy (2015) had also reported that the biometric characters of yard long bean was greatly influenced by the addition of tender coconut husk biochar along with NPK as per recommendation.

The number of leaves per plant were observed at 30 DAS, 60 DAS and at 90 DAS (Table 1). The number of leaves per plant increased with the age of the crop till 60 DAS and was then found to decline till harvest. At 30 DAS and 60 DAS, there was no significant influence in number leaves per plant by the treatments. The application of biochar had significantly influenced the number of leaves per plant at 90 DAS. Higher number of leaves per plant was recorded from the treatment T_4 (7.89). The activated plant growth was due to the application of biochar and organic fertilizer on soil nutrient availability (Blackwell *et al*, 2009 and Schulz *et al*, 2013) and this might have improved the number of leaves per plant in okra. Punnoose (2015) had also obtained higher number of leaves per plant with the application of biochar along with 100% NPK in amaranths. As the quantity of biochar increased, an increase in leaf number per plant was obtained. Similar results of significantly superior number of leaves per plant due to the progressive addition of biochar were observed by Dainy (2015) in yard long bean. There was an overall increase of 25.39 per cent in number of leaves per plant for the treatment T_4 compared to T_9 (KAU POP). Akpa *et al* (2019) had also recommended the combined application of cow dung (@ 12 t/ha) and biochar (@ 8 t/ha) for optimum growth and development of okra.

The effect of different treatments on root depth and root volume of okra was significantly influenced by the application of biochar (Table 1). The root depth and root volume was found to follow an inverse relationship with each other. As the root depth increased, the root volume decreased. Roots from a depth of 25.27 cm were obtained for the plants that received the treatment T_9 (KAU POP). The root volume for the treatment T_9 was 14.10 cm^3 and was observed to be the lowest among the treatments. The roots might have gone deeper foraging for nutrients and water in T_9 plants which might be the reason for the lower root volume. Higher root volume was obtained from the treatment T_4 (25.64 cm^3). The higher root volume due to an increased root weight in okra might be due to the nature of biochar applied as soil conditioner which might have retained the nutrients and water at the top soil. Similar reports of increased fresh root weight in chilli due to application of coconut shell biochar @ 10 t/ha was reported by Amaral *et al* (2019). Jabin and Rani (2022) had also reported the influence of increased rate of biochar on the higher rhizome spread of ginger.

The highest yield per plant was obtained from T_4 with 544.93 g and was found to be on a par with the treatment t_3 (537.74 g/plant) (Table 2). This was 35.60 per cent increase over T_9 (KAU POP). Higher fruit yield per plant was observed for the plants that received biochar and FYM along with 100 per cent RDF. The adsorbing property of biochar might have slowed down the release of nutrients from FYM and chemical fertilizers. As the amount of biochar was doubled, there was an increase in fruit weight. This is in accordance with the findings of Dainy (2015) who also reported a progressive increase in yield and yield attributing characters in yard long bean as the levels of biochar increased from 10 to 30 t/ha when applied with the recommended dose of fertilizers. Similar reports of increased plant yield with the application of biochar and recommended dose of fertilizers was reported by Punnoose (2015) in amaranthus and Hashmi *et al* (2019) in *Pisum sativum* L. In the case of fruit yield/ha, the application of tender coconut husk biochar had significantly improved the yield per hectare in okra. Higher fruit yield per hectare was observed for the treatment T_4 (15.71 t) and was on par with T_3 (14.07 t) (Table 2). The control plants (T_9) could only produce

7.65 t/ha. Overall, there is a yield increase of 69 per cent in T_4 compared to T_9 (KAU POP). The lower yield per hectare in T_9 (KAU POP) might be due to the leaching loss of nutrients. There was 44 mm rainfall during the growth period of okra, which might have aggravated the leaching loss in the sandy loam soils of Onattukara. Nagula (2017) has also recommended the application of biochar @ 10 kg/ha along with the recommended dose of nutrients for higher yield in banana.

CONCLUSION

Tender coconut husk biochar has good prospects for use as a soil conditioner for okra in the sandy loam soils of Onattukara. The soil application of biochar produced from tender coconut husk at the rate of 10 t/ha along with FYM @ 5 t/ha and 100 per cent recommended dose of fertilizer can be recommended for augmenting the growth and yield of okra in the sandy loam soils of Onattukara.

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