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Distribution of Biochar Technology as an organic planting medium and optimal biochar dose for Abelmoschus Esculentus l. Moench growth and production

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Abstract

Okra is a healthy vegetable and medication. Growing okra on an organic medium and adding charcoal may boost output. Okra plant growth metrics and yields will be examined about the organic growing medium and biochar dose. The study was place in March 2021 at Sekarpuro Village, Pakis District, Malang Regency. This study employed a factorial Randomised Block Design (RAK) with two factors: Organic Planting Media and Biochar dose. Plant height (cm), number of leaves (strands), number of crop fruits (fruit), fruit weight per plant (grammes), fruit diameter, length, and bar weight are observation metrics—analysis of variance using ANOVA and BNT 5% difference test. The study found that 7.5 tons/ha of manure and 10 tons/ha of coconut fibre biochar naturally increased okra plant growth and output. Fruit and stem weights also varied with planting medium and charcoal. The finding is that organic growing medium treatment and biochar dose affect okra plant development.

Keywords: Biochar Technology; Dissemination; Green Okra; Growth.

Introduction

Okra, scientifically known as Abelmoschus et al., is classified as a functional vegetable under the botanical family Malvaceae (Cornelia, 2020; Farooq, 2022; Tyagita, 2021). According to (A. Singh, 2023), this particular substance offers several health advantages and supplies essential nutrients to the human body, including vitamin C, vitamin K, significant folate and fibre levels, and antioxidants. The composition of young okra fruit may be described as follows: it contains around 85.70% water, 8.30% protein, 2.05% fat, and 1.4% carbs and provides 38.9% calories per 100 g (Azeem, 2020; Wirivutthikorn, 2022; Yildiz, 2023). Legumes are characterised by their high soluble fibre content (Abdillah, 2023), including pectin and mucilage (Sugara, 2018), constituting around 50% of their overall fibre composition (Adekiya, 2020; Rao, 2020). This particular fibre composition has many health benefits (Goud, 2022; Zafar, 2021), including the potential to decrease cholesterol levels and mitigate the likelihood of developing heart disease (Dapabko, 2021; Nuramalia, 2018).

The remaining portion consists of insoluble fibre, which has the potential to contribute to the maintenance of many health problems. The significance of the okra plant lies in its many advantages and applications (Javid-Naderi, 2023; S. Singh, 2022), as well as the growing consumer demand for this product (Aboyeji, 2021). Okra is becoming recognised as a nutritionally rich vegetable with various health benefits.

Okra, a kind of vegetable, provides several health benefits (Ghazal, 2021). The abundance of nutrients in these substances makes them highly sought after by many individuals (Adekiya, 2019). Farmers have challenges in increasing the production of nutritious crops while satisfying the needs of consumers. The need to meet the demand for a specific item must be carefully managed to attain the desired production level of that commodity (Darmayanti, Milshteyn et al., 2023; Sari et al., 2023; E. D. Yuniwati et al., 2023). One potential approach to enhancing production is the implementation of several strategies, such as the effective management of planting medium and the provision of biochar.

To address the prevailing market demand, it is essential to enhance the quality and productivity of Abelmoschus esculentus, often known as okra. This may be achieved by the use of a planting medium that exhibits a significant degree of fertility and has a fertiliser composition that is appropriate for the intended purpose (Hudha et al., 2023; Manasikana et al., 2023; Riono et al., 2023). The optimal planting substrate may be derived from both organic and inorganic constituents. Organic components, such as chopped ferns, compost, humus, sawdust, husk charcoal, and cocopeat, may be used in soil mixtures. Inorganic components used in soilless mixes include soil, grit, gravel, and hydrogel wulandari (Anjarwati et al., 2023; Widodo et al., 2023; Wulandari et al., 2022).

The addition of biochar has the potential to enhance the quality of the planting medium. Biochar is a solid substance often referred to as charcoal or agri-char (Liang, 2021), produced by subjecting organic matter to pyrolysis, a process involving the combustion of such matter in the absence of oxygen, typically at temperatures ranging from 250 to 500°C (Aryaseta et al., 2023; Darmayanti, Suyono, et al., 2023). Biochar has shown its efficacy as a soil amendment, exhibiting the ability to enhance crop productivity, particularly in soil conditions that are deteriorated or marginal (Hu, 2020; Huang, 2019). The enhancement of soil fertility, including chemical, physical, and biological aspects, is closely linked to the augmentation of crop yields. The use of biochar has been shown to have a substantial impact on enhancing many soil qualities, including both physical and chemical attributes, as well as facilitating root absorption. Effective management practices can enhance fundamental soil properties such as soil organic carbon (C), soil bulk density, and soil aggregate stability. In addition to this, it plays a significant role in enhancing soil fertility by promoting the absorption of essential nutrients such as nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), and cation exchange capacity (Dissanayake, 2020; Naveed, 2020; E. D. Yuniwati, 2019).

Numerous studies have been conducted to investigate the cultivation of Okra, with a predominant focus on planting media. However, it is worth noting that the commonly employed planting medium mainly consists of soil blended with certain additives (El-Naggar, 2018; Hariati et al., 2017; Turan, 2019). The distinguishing factor of this study is the use of biochar to enhance the functionality of the planting medium. Biochar is employed due to its capacity to enhance the soil's physical, chemical, and biological characteristics. The incorporation of biochar into the soil has been shown to enhance the accessibility of the primary cation, phosphorus (P), as well as the concentration of nitrogen (N) (El-Naggar, 2019; Muddarisna et al., 2021; W. et al. D. Yuniwati et al., 2012). The levels of cation exchange capacity (CEC) and soil pH have the potential to exhibit a maximum rise of 40%. The use of biochar has been shown to have a positive impact on soil conditions and plant productivity, particularly in the case of soils with lower fertility levels. According to (Fitriana et al., 2020; Saifullah, 2018), the capacity of biochar to retain water and nutrients in the soil plays a crucial role in mitigating fertiliser loss caused by surface erosion (runoff) and leaching. This property of biochar not only leads to savings in fertiliser use but also contributes to reducing residual fertiliser pollution in the surrounding environment.

Hence, the objective of this study is to examine the impact of organic planting medium and biochar dosage on the growth parameters and yield of okra, specifically about the interaction between planting media treatment and biochar dosage.

Research methods

The study was carried out on agricultural land located in the Sekarpuro Village region, specifically inside the Pakis District of the Malang Regency. The study started in March 2021, using organic medium (namely, dung) and coconut fibre biochar as the therapy for the investigation. The organic media used in the study consisted of three doses: M1 at a rate of 5 tonnes per hectare, M2 at 7.5 tonnes per hectare, and M3 at 10 tonnes per hectare. Additionally, medium-dosage biochar derived from coconut fibre was included in the experiment, with three doses: B1 at a rate of 7.5 tonnes per hectare, B2 at 10 tonnes per hectare, and B3 at 12 tonnes per hectare. The study used a factorial Randomised Group Design (RAK) with three replications (Sakhiya, 2020). Plant growth and output were observed, commencing at the 14-day mark following planting. The observation parameters used are shown in Figure 1.

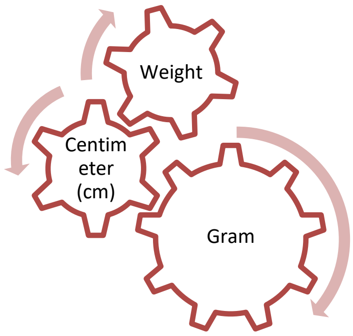

Figure 1. Observation parameters used

Figure 1 depicts the use of centimetres (cm) as the unit of measurement for the characteristics of Plant Height, Fruit Diameter, and Fruit Length. Additionally, the parameters Number of leaves (pieces), Number of fruits (fruit), Fruit weight per plant, and Stem weight are measured in grams. The statistical technique used to analyse variance was ANOVA (Analysis of Variance), whereas the BNT 5% test was utilised to assess the variations between treatments (Rhoads, 2021; Safitri et al., 2023).

Results and Discussion

Growth Parameter Response

Plant height

The observed augmentation in plant height was achieved using organic soil medium and the introduction of coconut fibre biochar, administered at the start of okra plant cultivation. The growth of the plants began at the start of the growth period, precisely 14 days after the planting event. Subsequently, a consistent and noteworthy development pattern was seen until the plants reached an age of 56 days after planting. During this period, the plants exhibited robust growth and healthy morphology. According to the observed morphology, there is a noticeable growth in plant height starting from 21 days after seedling transplantation (HST). This growth is characterised by taller stems and a proportional increase in the number of leaves, as indicated by the plant height measurements. This trend is observed in both the organic soil media treatment and the biochar treatment. Notably, the M2 B2 and M3B2 treatments exhibit particularly significant growth, as illustrated in Table 1.

Table 1 shows the okra plant height effects of organic planting material and biochar dose.

Treatment combination	Plant height (cm) at age						
	14 hst	21	28 hst	35	42	49	56
M_1B_0	13.06 a	18.52 ab	28.46 a	37.52 a	45.14 a	53.23 a	63.24 a
M_1B_1	14.44 cds	19.64 BC	30.43 BC	39.32 BC	47.23 b	55.35 b	65.34 b
M_1B_2	13.83 abc	18.24 a	30.02 abc	39.45 BC	47.45 BC	55.63 b	65.65 BC
M_1B_3	13.78 abc	18.45 ab	31.56 c	40.65 c	48.78	56.32 bc	66.31 c
M_2B_0	14.06 BC	19.14 b	29.91 ab	38.85 ab	46.65 ab	54.54 ab	65.31 b
M_2B_1	14.00 abc	19.75 BC	30.37 BC	39.65 ab	47.23 BC	55.63 bc	66.52 c
M_2B_2	15.61 e	20.35 c	34.42 d	43.74 d	49.45 c	58.74 c	69.62 d
M_2B_3	15.39 d	20.67 cds	35.12 d	44.54 e	50.65 d	59.85 cds	70.85 e
M_3B_0	14.22 BC	19.23 b	30.01 abc	39.21 b	47.85 BC	55.36 b	66.96 BC
M_3B_1	13.33 ab	18.35 ab	30.26 BC	38.45 ab	46.96 ab	54.65 ab	65.65 b
M_3B_2	13.44 abc	18.45 ab	30.64 BC	38.36 ab	46.65 ab	54.32 ab	65.41 b
M_3B_3	14.44 cds	19.65 BC	30.69 BC	39.21 b	47.78 BC	55.41 b	66.85 bc
BNT 5%	0.997	1,234	1,594	1,764	1,354	1,236	1,156

Columns with identical numbers The BNT test indicated no significant difference with a significance level of -5%.

Number of Leaves

The data collected from the observations of okra plant height revealed a noteworthy correlation with the number of leaves, indicating substantial growth throughout several observation periods ranging from 14 to 56 days after planting. Each of the organic medium treatments (M1, M2, and M3) exhibited favourable leaf growth, with a range of 3 to 7 leaves. In the case of organic media, namely manure, when applying a dosage of M1 at a rate of 5 tonnes per hectare, a higher leaf count is seen in comparison to treatments M2 (applied at a rate of 7.5 tonnes per hectare) and M3 (applied at a rate of 10 tonnes per hectare). In the context of biochar treatment derived from corn cobs, it was seen that the application of B1 (7.5 tons/ha), B2 (10 tons/ha), and B3 (12 tons/ha) resulted in significant enhancements in leaf growth, except the control treatment, B0. Additional information will be provided in the subsequent graph.

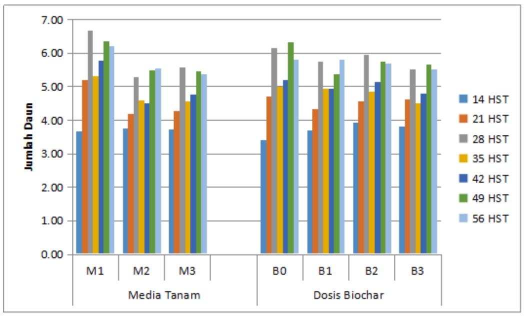

Figure 2. The average number of leaves (strands) depends on the planting media and biochar dosage.

Based on the visual representation provided, it is evident that the highest leaf count was observed in the M1 treatment after 28 days of planting, the M2 treatment after 56 days of planting, and the M3 treatment after 28 days of planting. Conversely, the biochar treatments B1, B2, and B3 exhibited an average leaf count at observation ages of 28 and 49 days. At 56 hours after the start of the experiment, there was an observed rise in the number of leaves. However, it is essential to note that the treatment without biochar (B0) still exhibited a higher leaf count.

The Quantity of fruits

A notable disparity is seen in the quantity of okra fruit upon observation. The use of organic media treatment, namely cow dung, in conjunction with biochar, had a favourable impact on the augmentation of the mean quantity of okra fruit. The optimal pairing consists of M3B2 and M3B3, exhibiting an average fruit yield of 3-4 per each okra plant. The use of organic soil media, namely cow dung, together with the incorporation of biochar, has been seen to have a beneficial impact on the generative growth of okra fruit, resulting in an increased yield of fruits. Table 3 presents the average number of fruits influenced by different types of planting media and biochar dosage at various observation ages.

Table 3 shows the average number of fruits affected by planting material and biochar dose at different observation ages.

Treatment Combination	Number of Fruits (fruit)
M_1B_0	3.22 c
M_1B_1	3.22 c
M_1B_2	3.11 BC
M_1B_3	3.00 BC
M_2B_0	2.33 b
M_2B_1	2.33 b
M_2B_2	3.11 BC
M_2B_3	2.44 b
M_3B_0	2.00 ab
M_3B_1	1.67 a
M_3B_2	3.78 d
M_3B_3	3.89 d
BNT 5%	1.02

The presence of identical numbers inside a column indicates no statistically significant difference, as determined by the BNT test at a significance level of 5%. The notation "tn" denotes that the values are not substantially different according to the BNT test at the 5% level.

The topic of discussion pertains to the measurement of the mass of fruits.

The weight of okra fruit was measured in a study examining the effects of several treatments on organic planting media (namely, manure) and biochar dosage. The treatment that yielded the highest weight was M2B3, which included using organic planting media at a rate of 7.5 tonnes per hectare and a biochar dosage of 12 tonnes per hectare. The average weight of the okra fruit in this treatment was 40 grammes per fruit. The average weight of this fruit is subject to the effect of generative developmental variables, such as the presence of minerals like potassium and phosphate, which can augment the fruit's weight. The following text provides a comprehensive account of the mean fruit weight of okra plants across several experimental conditions.

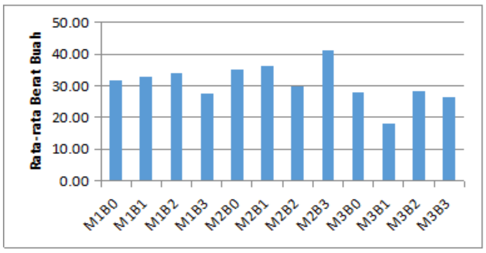

Figure 3. Average Fruit Weight Influence of Types of Planting Media and Biochar Dosage

Fruits Diameter

The measurement of the width of a fruit, often referred to as fruit diameter, is a significant parameter in fruit morphology analysis. Upon examination of the mean diameter of okra fruit, it was observed that the treatments exhibited considerable variations in organic growth conditions. However, no significant differences were seen in the biochar dosage treatment. The treatment that had the most significant impact on fruit diameter was the M2 treatment, namely the use of organic planting material (manure) at a rate of 7.5 tonnes per hectare. In contrast, applying biochar at several doses did not provide a statistically significant increase in the diameter of the okra fruit.

Table 5. Average Fruit Diameter (cm) Influence of Types of Planting Media and Biochar Dosage .

Treatment	Fruit Diameter
Types of Planting Media	
M_1	1, 51 ab
M_2	1, 61 b
M_3	1, 45 a
BNT 5%	0.120 _
Biochar Dosage	
B0	1, 56
B1	1, 50
B2	1, 54
B3	1, 50
BNT 5%	Mr

Information: The exact numbers in a column the same thing shows that it is not significantly different according to the BNT test at the 5% level; tn = not significantly different in the BNT test at the 5% level

Fruits Lenght

The average length of okra fruit was unaffected by the interaction between treatment with organic planting media (cow dung) and biochar dosage. The effect of organic planting media (specifically cow dung) treatment M2, applied at a rate of 7.5 tons per hectare, resulted in an observed okra fruit diameter of 10.37 cm. In contrast, applying biochar at varying doses did not yield significant variations; however, it did elicit discernible effects on fruit growth indices.

Table 6. Average Fruit Length (cm) Influence of Types of Planting Media and Biochar Dosage

Treatment	Fruit Length (cm)
Types of Planting Media	
M_1	10, 19b
M_2	10, 37b
M_3	9, 09a
BNT 5%	1, 087
Biochar Dosage	
B0	10.06
B1	9.04
B2	10.33
B3	10,10
BNT 5%	Mr

Information: The exact numbers in a column the same thing shows that it is not significantly different according to the BNT test at the 5% level; tn = not significantly different in the BNT test at the 5% level

Bar Weight

The assessment of plant biomass, namely the weight of Okra stems, provides a comprehensive indication of the response of the overall growth parameter. The experimental groups for the treatment of okra plants, which exhibited a favourable growth response, were designated as M2BO (14.75 kg), M1B2 (14.00 kg), M1BO (12.00 kg), and M2B2 (14.00 kg). This finding demonstrates that the concurrent application of organic soil media, specifically cow manure, with varying doses of biochar can result in a significant increase in the biomass of okra plant stems. Additional information will be provided in the subsequent graph.

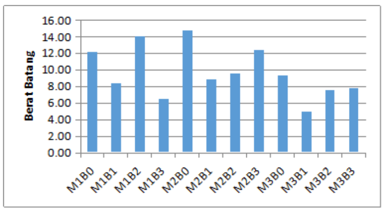

Figure 4. *Average Stem Weight Influence of Types of Planting Media and Biochar Dosage*

Plant production biochar and organic planting medium characteristics

This study explores the distinguishing features of organic planting media and biochar and their impact on plant production.

In this study, the impact of organic planting media, specifically cow manure, and the dosage of coconut fibre biochar were investigated. Before experimenting, laboratory observations were conducted to ascertain the composition of each specimen, which can be visually represented in the accompanying image. One notable observation is that the organic carbon concentration in biochar is significantly higher compared to that found in organic growth media, with a ratio of 50.26:6.35. Similarly, the carbon-to-nitrogen (C/N) ratio content is reported as 40.23 to 10.89. In addition, it should be noted that biochar exhibits increased water content and cation exchange capacity (CEC) compared to organic growth media. The remaining components of the two interventions exhibit a high degree of similarity in terms of their content.

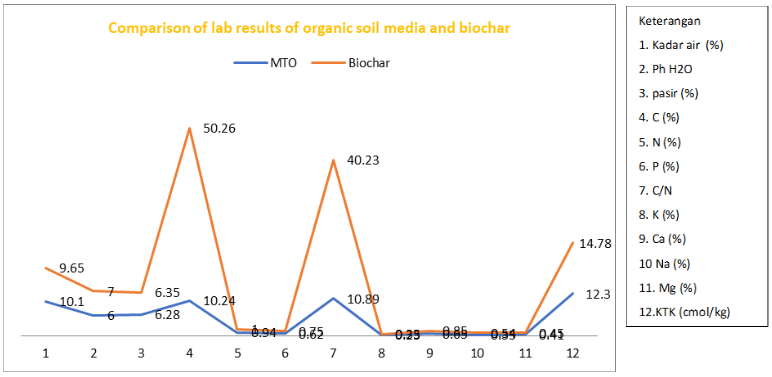

Figure 5. Characteristics of organic planting media (cow manure) and coconut fiber biochar during the experiment

The present discourse aims to engage in a discussion on the given topic.

The reported research findings in Table 1 display the data on plant height, indicating considerable variations resulting from the combination of organic planting media treatment and biochar dosage. The observed phenomenon can be attributed to the interplay between the organic planting medium, specifically cow dung, and the dosage of biochar, specifically coconut fibre. The respective dosages utilised were 7.5 tons per hectare and 10 tons per hectare. The observed phenomenon of natural interaction can be attributed to the efficacy of administering biochar at the onset of planting on organic planting media, as it is a supplementary source of nutrients. This is because the biochar provided acts as a collection of soil amendments accessible to plants (Premarathna, 2019; Zheng, 2018).

Similarly, the organic planting media supplied exhibits elevated concentrations of organic matter. According to the findings of a prior study conducted by (Wang, 2019), it was observed that intercropping cassava and maise using manure and biochar as planting media resulted in the presence of substantial quantities of organic carbon and nutrients that are readily accessible to plants. The planting media's composition facilitates water retention (Blaauw, 2014; Grossnickle, 2005; Zain et al., 2023), ensuring a constant supply for the plant's requirements. The incorporation of manure into the planting media serves to enhance the soil structure of the medium while supplying several essential nutrients required by plants. The enhanced availability of nutrients for absorption and use in plant growth fosters a more favourable manifestation of plants compared to other treatments. Biochar at a rate of 7.5-10 tons per hectare has been found to enhance the cation exchange capacity and water-holding capacity of the planting substrate. Essential nutrients facilitate optimal plant growth and development, enough water supply, well-aerated conditions, and adequate drainage within the growing media.

The highest average data was acquired by observing the number of stems in organic planting media, specifically cow dung, mixed with biochar derived from coconut fibre. This combination was applied at 7.5-10 tons per hectare. The utilisation of a planting medium composed of a blend of soil, sand, and manure has been found to facilitate optimal plant growth. This combination creates a conducive environment for the generative growth of stems and fruit, resulting in significant improvements in plant development. According to the assertion made by Nadira et al. (2009), the growth of plant genetics will experience a significant acceleration whenever there is an ample supply of phosphorus (P) and potassium (K) components in the soil medium, together with the presence of organic fertilisers.

The planting media treatment consisting of a combination of sand and coconut powder yielded the least favourable outcomes regarding okra fruit weight. The porous nature of the planting medium composition results in significant soil porosity, leading to limited water retention capacity within the media. The limited availability of water for plant requirements significantly impacts both plant development and yield, hence resulting in relatively diminished outcomes in terms of observed plant growth and yield.

Incorporating litter compost into the soil as a planting media treatment results in a notable increase in porosity due to the favourable aeration and drainage conditions it provides. In contrast to planting material mixed with manure, the nutritional content of the planting media is comparatively diminished. Consequently, the mean observation outcomes exhibit a decrease as well.

The magnitude of plant growth has a significant role in determining the magnitude of agricultural output in terms of harvest. Plants that exhibit robust leaf morphology, characterised by thick and broad leaves, tend to possess enhanced photosynthetic efficiency due to the more excellent anatomical coverage of their photosynthetic organs. Hence, variations in the type of the planting substrate and the quantity of coconut fibre biochar significantly impact the magnitude of plant development, thereby exerting a substantial influence on the crop's production (Bashan, 2002; Rymanowicz et al., 2020; E. D. Yuniwati, 2018).

Plants incorporated inside a composite medium consisting of soil, sand, and manure exhibit a heightened efficacy in conducting photosynthesis. This can be attributed to the substantial quantity of leaves present, which therefore augments the photosynthetic surface area, thereby facilitating an enhanced production of photosynthesis. The surplus photosynthate utilised during the growth phase is kept within the plant's storage organs, specifically in the fruit. According to (Handayani et al., 2023), there exists a positive correlation between the amount of photosynthate generated and the resulting plant yield. Conversely, a decrease in photosynthate production is associated with decreased plant yield.

Conclusion

The findings derived from this study can be summarised as follows: The growth response and yield of okra plants, particularly in plant height, fruit weight, and stem weight, are influenced by the combination of planting media and dosage of biochar. The observed outcome can be attributed to the successful combination of organic planting media, specifically the application of 7.5 tons/ha of manure and biochar and the utilisation of coconut fibre media at 10 tons/ha. The planting medium consisting of a combination of cow dung and biochar at a rate of 7.5-10 tons per hectare resulted in the maximum weight of okra fruit. Using organic growing media treatment in conjunction with varying biochar dosages demonstrates a significant efficacy in providing essential nutrients to okra plants. The growth response of okra exhibits a propensity for achieving high yields.

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