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Characteristics of compost and biochar from coffee husk waste and their effect on coffee plant growth

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Abstract The results showed that coffee husk compost for 6 weeks gave higher yields and significantly increased stem diameter, leaf area, wet weight, and dry weight of biomass per plant compared to 2 weeks of composting. Utilization of coffee husk waste as biochar with an application of 10 t ha^{-1} gave the highest yield and significantly increased plant height, number of leaves, leaf area, wet weight, and dry weight of biomass per plant compared to no biochar. In the application of 10 tons of biochar per hectare, there was an increase of 13.22%, 28.65%, and 15.81% compared to no biochar, respectively in plant height, wet weight, and the highest dry weight of the total biomass per plant.

Keywords: Organic fertilizer, Composting, Charcoal, Biochar, Coffee waste, Soil fertility

Introduction

Coffee is a very popular product all over the world. In its production, coffee produces a large amount of coffee husk waste as a by-product. By recycling these nutrient-rich by-products, we can reduce the amount of organic waste, while creating value-added products (Janissen and Huynh, 2018). From the coffee harvest, there is as much as 50% husk which is a by-product that can provide added value and can have an impact on environmental problems if not managed properly (Zoca *et al*., 2014; Oliveira and Franca, 2015). The rind and coffee grounds contain about 45% cherries, are one of the main by-products of the coffee agroindustry, and are valuable materials for a variety of purposes, including the extraction of caffeine and polyphenols (Esquivel and Jiménez, 2012). Utilization of coffee husk waste as compost and biochar can reduce environmental pollution and can increase pH, Ca, and K which can be used for plant growth (Filho *et al*., 2021). Coffee husk is rich in organic matter, with high C organic coffee husk up to 50.83% which is more than 20% lignin; 1.27% total N; 2.46% Potassium; 0.06% Phosphorus; and a ratio of C/N of 40.02 (Dzung *et al*., 2013). The utilization of organic waste contributes to

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increasing levels of organic matter and the fertility of agricultural soil (Bayadilova *et al*., 2022).

Coffee husk waste produced from wet processing and dry processing has a fairly high nutritional content. The dried coffee rind contains 58-85% carbohydrates, 8-11% protein, 0.5-3% fat, and 3-7% minerals (Blinová *et al*., 2017). Coffee skin contains polyphenols such as tannins, lipids, carbohydrates such as fermentable sugars, and several types of microorganisms such as fungi that grow on coffee skin waste (Kumar *et al*., 2018). In addition, the coffee rind has excellent potential as a substrate for value-added compounds (Bonilla-Hermosa *et al*., 2014). Coffee husk waste combined with Effective Microorganism4 (EM4) was proven to significantly increase fruit weight per plot, where the best interaction occurred in coffee husk waste compost of 30 t $ha^{-1}$with an EM4 concentration of 15 ml per liter of water (Adnan *et al*., 2021). Composting is the biological decomposition and stabilization of organic substrates under thermophilic temperature conditions as a result of biologically generated heat, to produce a final product that is stable, free from plant pathogens, and can be applied profitably to the soil (Taherzadeh and Richards, 2015). The application of 18.75 g per polybag of coffee husk compost or a combination of 12.5 g per polybag of coffee husk compost and 4 g per polybag of lime is recommended as a good amendment for acid soil management and coffee seedling growth (Takala *et al*., 2020).

Coffee husk waste generated from the coffee industry is very possible be produced into biochar, has high availability at low cost, and has high nutritional content (Tsai *et al*., 2012). Coffee husk waste roasted at a temperature of 250-500 ^{0}C will produce biochar charcoal. The characteristics of biochar depend on the raw materials used and the pyrolysis process (Huang and Gu, 2019). Biochar prepared in an enclosed space by pyrolysis at 500 ℃ can contribute to the enhancement of physicochemical and biochemical reactions to reclaim acid-salt-contaminated soil (Gunarathne *et al*., 2020). Biochar has several properties such as water retention, and cation exchange capacity which can increase plant growth and can increase the C/N ratio in the soil (Kumar and Bhattacharya, 2021). The application of biochar can also reduce the use of chemical fertilizers due to the reduced percolation of water and nutrients in the soil (ELsayed *et al*., 2021). The ability of N retention and the stable nature of biochar in the soil can increase N uptake by plants, and minimize N loss so that biochar has important potential to improve agroecosystems and ecological balance (Peng *et al*., 2021). In addition, biochar can last a long time in the soil because it is difficult to decompose. The main function of biochar is as a soil enhancer that can increase the productivity of agricultural land, especially those that have undergone a degradation process, prevent environmental pollution, and reduce greenhouse gas emissions.

Biochar application results in fewer restrictions on root length, volume, and surface area in times of water shortage. Root growth is mainly related to the increased availability of water and soil chemicals such as pH, P, and CEC which are changed by the biochar amendments (Kartika *et al*., 2021). The availability of water and organic matter is increased in the soil with the application of biochar (Zaheer *et al*., 2021). Organic carbon increased significantly by 23% in biochar and 55% in compost, soil pH decreased, and after the addition of biochar and compost, the number of microorganisms increased (Abujabhah *et al*., 2016). Biochar is a carbon-rich organic material that can be used to increase soil productivity and harvest (Torabian *et al*., 2021); Compost-biochar mixture from various organic sources, with a dose of 10-15 t ha^{-1} has the potential to improve soil properties (Sudita *et al*., 2021) reduce land degradation (Karim *et al*., 2020), and restore nutrient-poor land (Dariah *et al*., 2019; Agegnehu *et al*., 2017) while reducing the impact of greenhouse gas emissions (Agegnehu *et al*., 2016; Tan *et al*., 2017). The waste generated from the coffee processing industry has not been utilized optimally for various useful and value-added products. The development of coffee plantations will also indirectly increase the amount of coffee waste produced. The utilization of coffee husk waste which is processed into organic fertilizers such as compost and biochar, besides being able to be used to increase soil fertility and reduce environmental pollution, can also provide added value to the surrounding community. Therefore, it is necessary to study the utilization of coffee husk waste into compost and biochar, as well as evaluate its characteristics in Arabica coffee cultivation. This study aimed to evaluate the effect of composting time and biochar dose from coffee husk waste on the growth of coffee plants in nurseries.

Materials and methods

Experimental site

The study took place from August to November 2021. Analysis of the physicochemical properties of soil, compost, and biochar before the research was carried out at the Soil Laboratory of the Faculty of Agriculture, Udayana University, Denpasar Bali. Tests on the treatment of biochar and compost on soil media in polybags were carried out in the greenhouse of Catur Village, Bangli, Bali 80353, Indonesia, which is located at an altitude of 1250 m above sea level with a latitude of -9 º45' 37.7" and longitude 115 º14' 29".

Material

In this study, the materials used included Arabica coffee seeds from Catur Village, Bangli, wet coffee husk waste, waste from pruning coffee plants, cow dung, bran, dolomite, and EM4 (Microorganism Effectiveness4), and molasses (drops of sugarcane).

Composting

Composition of raw materials: 60% coffee husk waste, 25% livestock manure, 10% coffee leaf trimming waste, 5% bran/husk, plus 2% dolomite, 1% EM4 solution, and 1% molasses solution. For the manufacture of 100 kg of compost, the materials needed are 60 kg of coffee husk waste, 25 kg of livestock manure, 10 kg of coffee leaf pruning waste, 5 kg of fine bran, and 2 kg of dolomite which has been thoroughly mixed. Then, 100 ml of EM4 and 100 ml of molasses were dissolved in 10 liters of water. This solution is then watered evenly on the compost material above until it reaches a moisture content of 40%. EM4 is a solution that contains many beneficial bacteria, such as Photosynthetic bacteria, *Lactobacillus sp*, *Streptomyces sp*, Yeast, and Actinomycetes. Molasses containing sugars and organic acids can be used as a food source for bacteria. The addition of dolomite and bran is done so that the pH of the compost becomes neutral. The material is then tightly covered with a tarp or puts in a burlap sack and stirred once a week and if it is too dry then watering is done. During the composting process, the temperature on the tarpaulin or jute will rise ±50 ℃ and then the temperature will drop again. Compost can be harvested and used as fertilizer at the age of 14 days. Good decomposition can be seen in the blackish color, and the smell of the earth, there is the growth of white fungus on decaying organic matter (Chali *et al*., 2021).

Biochar production

Biochar from coffee husk waste biomass is produced through a simple pyrolysis technology using a coffee roaster tube with incomplete combustion at a temperature of 250-500 ℃. The process of burning/roasting 100 kg of dried coffee skin into charcoal takes about 1-2 hours with a charcoal yield of around 20-40%. Charcoal formed from this combustion is then crushed into small granules and sieved to obtain uniform charcoal granules called biochar. Biochar produced from this incomplete combustion process is ready to be packaged and used as a soil enhancer.

Desain experimental

In this study, a randomized block design was used which was arranged in a factorial manner with 2 factors. The first factor to be tested was composting (C) coffee husk waste which consisted of 3 levels, namely: compost C1= compost with a composting time of 2 weeks (50 g per polybag), compost C2= compost with composting 4 weeks (50 g per polybag), and compost C3= compost with composting 4 weeks (50 g per polybag). While the second factor tested was the dose of biochar (B) from coffee husk waste which consisted of 4 levels, namely: B0= 0 t ha^{-1}(control), B1= 5 t ha^{-1}(25 g per polybag), B2= 10 t ha^{-1} (50 g per polybag), and B3= 15 t ha^{-1} (75 g per polybag). Thus, 12 treatment combinations were obtained, each of which was repeated 3 times so that 36 experimental units (polybags) were obtained. The compost and biochar treatments were tested on 10 kg soil media in polybags containing 1-year-old coffee plant seeds carried out in a greenhouse.

Research variable

The plant variables observed in this study were height per plant, number of leaves per plant, stem diameter per plant, total wet weight per plant, and dry weight of total plant biomass per plant. Soil, compost, and biochar variables observed were soil moisture content (gravimetric method), pH H_2O (pH meter), Electrical Conductivity (EC), C-organic (Walkey and Black method), N-total (Kjedhal method), available P (Bray method), and K-available (HCl extract).

Statistical analysis

The research data collected were processed statistically by using an analysis of variance. The real effect on compost and biochar treatment was followed by the Least Significant Difference Test (LSDT) at the 5% level. Furthermore, to determine the close relationship between variables in the treatment of compost and biochar, a correlation test was carried out. Statistical data processing was carried out using excel 2011 for windows program.

Results

Characteristics of soil, compost, and biochar

The results of the analysis of soil properties before the study are presented in Table 1. From Table 1, it can be seen that the physical properties of the soil where the study is located are sandy loam texture with very good moisture content, field capacity, and specific gravity. Meanwhile, soil chemical properties such as pH, P content, and C/N are also very good for supporting plant growth. However, the content of N, C, and K which are classified as moderate is expected to be increased through the addition of compost and biochar from coffee husk waste so that plant growth will increase.

The characteristics of wet coffee husk waste that are processed into biochar and compost are shown in Table 1. The highest water content was obtained at 2 weeks of composting, followed by 4 and 6 weeks of composting. The results of composting 2, 4, and 6 weeks as well as biochar from coffee husk waste had a slightly alkaline soil pH with moderate total N and very high EC, C, P, K, and C/N values.

Table 1. Characteristics of soil, compost, and biochar properties from wet coffee husk waste*

Analysis type	Soil	Wet coffee skin waste			
		Biochar (B)	**Composting 2 weeks (C1)**	**Composting 4 weeks (C2)**	**Composting 6 weeks (C3)**
Texture	Sandy loam	-	-	-	-
Water content (%)	6.68	6.51	18.23	17.41	17.10
pH	7.10 (N)	8.10 (SA)	8.00 (SA)	8.30 (SA)	8.30 (SA)
EC (mmhos/cm)	1.60 (L)	32.20 (VH)	7.93 (VH)	14.44 (VH)	12.20 (VH)
C-organic (%)	2.49 (M)	29.05 (VH)	36.85 (VH)	36.59 (VH)	30.04 (VH)
N-total (%)	0.28 (M)	0.36 (M)	0.37 (M)	0.43 (M)	0.53 (M)
P (ppm)	161.07 (VH)	536.20 (VH)	562.91 (VH)	619.07 (VH)	621.14 (VH)
K (ppm)	154.68 (M)	449.36 (VH)	510.75 (VH)	611.71 (VH)	721.15 (VH)
C/N	8.89 (L)	80.69 (VH)	99.59 (VH)	85.09 (VH)	56.68 (VH)

SA (Slightly Alkaline), VH (Very High), M (Moderate), L (Low), N (Neutral)
*Soil Science Laboratory, Faculty of Agriculture, Udayana University (2021).

The results of soil analysis (Table 1) with C-organic content (2.49%) and N-total (0.28%) were classified as moderate, indicating that the level of weathering (C/N=8.89) in the soil was low. This soil condition is thought to be one of the reasons why the trials of compost and biochar which are rich in carbon and nutrients gave a real response to the growth of coffee plants. The

C/N ratio of biochar and compost used in this study was very high. This shows that biochar and compost are difficult to decompose in other words the weathering rate has not been going well, so the composting process must be carried out longer until the C/N value reaches the range of 10-20. Biochar with a very high C/N is very good for use as a soil enhancer. However, compost with a very high C/N value is less useful for improving soil chemical properties, especially in terms of the release of nutrients into the soil.

Plant height

Based on the results of statistical analysis of plant height (Table 2) on compost treatment, the effect was not significant ($P \geq 0.05$), while biochar had a very significant effect ($P < 0.01$). However, the interaction between compost and biochar has not shown a significant effect ($P \geq 0.05$) on plant height. Composting treatment for 6 weeks (35.41 cm) gave maximum plant height, but it was not significantly different from composting for 2 weeks (34.18 cm) and 4 weeks (34.71 cm). While the biochar treatment resulted in maximum plant height at a dose of 10 t ha^{-1}(36.66 cm) not significantly different from biochar 15 t ha^{-1}(35.43 cm), but significantly different from without biochar (32.38 cm) and biochar 5 t ha^{-1}(34.59 cm).

Stem diameter per plant

Stem diameter per plant on composting showed a very significant effect ($P < 0.01$), while biochar and the interaction between compost and biochar did not show a significant effect ($P \geq 0.05$). The treatment with 6 weeks of composting (0.46 cm) gave the highest stem diameter value per plant and was significantly different from 2 weeks of composting (0.38 cm) and not significantly different from 4 weeks of composting (0.44 cm). Biochar treatment with a dose of 15 t ha^{-1}(0.45 cm) gave the highest stem diameter value per plant which was not significantly different when compared to other biochar doses (Table 2).

The number of leaves per plant

Biochar treatment had a very significant effect ($P < 0.01$), while compost and its interactions had no significant effect ($P \geq 0.05$) on the variable number of leaves (Table 2). The highest number of leaves per plant was achieved at 6 weeks of composting (12.25 sheets) which was not significantly different from 2 weeks of composting (11.58 sheets) and 4 weeks of composting (11.83

sheets). Meanwhile, the highest number of leaves per plant was achieved with the application of 10 t ha^{-1}of biochar (13.11 sheet) and 15 t ha^{-1}(12.89 sheets), which were significantly different when compared to the treatment without biochar (10.56 sheet) and 5 t ha^{-1}of biochar (11.00 sheet).

Leaf area per plant

Leaf area per plant in the composting treatment showed a significant effect (P<0.05), while biochar had a very significant effect (P<0.01). However, the interaction between compost and biochar did not show a significant effect (P≥0.05) on leaf area per plant (Table 2). The treatment of 6 weeks of composting (332.40 cm^2) gave the highest leaf area value per plant and was significantly different from that of 2 weeks of composting (263.15 cm^2) but not significantly different from that of 4 weeks of composting (311.97 cm^2). Meanwhile, the highest leaf area per plant was achieved with the application of 10 t ha^{-1} of biochar (364.01 cm^2) and 15 t ha^{-1} (357.16 cm^2), which were significantly different from the treatment without biochar (222.46 cm^2) and a dose of 10 t ha^{-1}biochar (266.39 cm^2).

Table 2. Effect of compost and biochar application on plant height, stem diameter, number of leaves, leaf area, total wet weight, and total dry weight per plant

Treatment	Plant height (cm)	Stem diameter (cm)	Number of leaves (sheet)	Leaf area (cm2)	Total wet weight (g)	Total dry weight (g)
Interaction (CB)	ns	ns	ns	ns	ns	ns
Composting (C):	ns	**	ns	*	*	*
2-week (C1)	34.18 a	0.38 b	11.58 a	263.15 b	10.60 b	2.75 b
4-week (C2)	34.71 a	0.44 a	11.83 a	311.97 ab	11.29 ab	2.88 a
6-week (C3)	35.41 a	0.46 a	12.25 a	332.4 a	11.68 a	2.93 a
LSDT 5%	-	0.05	-	70.04	1.03	0.17
Biochar (B):	**	ns	**	**	**	**
0 t ha^{-1}(B0)	32.38 c	0.39 a	10.56 b	222.46 b	9.58 c	2.60 c
5 t ha^{-1}(B1)	34.59 b	0.42 a	11.00 b	266.39 b	10.83 b	2.82 b
10 t ha^{-1}(B2)	36.66 a	0.44 a	13.11 a	364.01 a	12.32 a	3.01 a
15 t ha^{-1}(B3)	35.43 ab	0.45 a	12.89 a	357.16 a	12.03 a	2.98 a
LSDT 5%	2.73	-	1.97	80.88	1.19	0.19

- ns= not significant (P≥0.05), **= very significant (P<0.01), *= significant (P<0.05)
- Numbers followed by the same lowercase letters in the same column are not significantly different at 5% LSDT.

Total wet weight of biomass per plant

The total wet weight of biomass per plant had a significant effect ($P<0.05$) on the composting treatment and very significant ($P<0.01$) on the biochar treatment (Table 2). However, the interaction between compost and biochar did not show a significant effect ($P\geq0.05$) on the total wet weight of the plant. The treatment of 6 weeks of composting (11.68 g) gave the highest total wet weight of biomass per plant and was significantly different from that of 2 weeks of composting (10.06 g) but not significantly different from that of 4 weeks of composting (11.29 g). While the highest total wet weight per plant was found in the application of 10 t ha^{-1} of biochar (12.32 g) and 15 t ha^{-1} (12.03 g) which were significantly different from the treatment without biochar (9.58 g) and biochar at a dose of 5 t ha^{-1} (10.83 g).

The total dry weight of biomass per plant

Oven dry weight of total biomass per plant significantly ($P<0.05$) on composting and very significantly ($P<0.01$) on biochar. However, the interaction between compost and biochar had no significant effect ($P\geq0.05$) on the total oven-dry weight of the plant (Table 2). The treatment of 6 weeks of composting (2.93 g) gave the highest total oven dry weight of biomass per plant and was significantly different from that of 2 weeks of composting (2.75 g) but not significantly different from that of 4 weeks of composting (2.88 g). The highest total oven dry weight per plant was found in the application of 10 t ha^{-1} of biochar (3.01 g) and 15 t ha^{-1} (2.98 g) which were significantly different from the treatment without biochar (2.60 g) and biochar at a dose of 5 t ha^{-1} (2.82 g).

The growth of coffee plant seeds is strongly influenced by the agro-climatic conditions of the research location. The climatic conditions of Bangli Regency are very supportive of Arabica coffee cultivation because it is located at an altitude of 1250 above sea level and the soil weathering process is very good. Based on the soil analysis before the study, it is known that the soil properties at the research site are as follows: sandy loam soil texture, soil pH is 7.10 which is classified as neutral, electrical conductivity 1.60 mmhos/cm (low), organic carbon content 2.49% (medium), total nitrogen 0.28% (medium), available potassium 154.68 ppm (medium), phosphorus available 161.07 ppm (very high), and C/N ratio 8.89 (low). The nutrient status of the soil was quite fertile with a very high level of weathering, so this soil was very good for planting media. The utilization of coffee husk waste as compost and biochar with relatively good physicochemical characteristics caused to change in physicochemical properties in the soil that encourage increased growth of coffee plants. Analysis of the chemical properties of biochar and compost derived from coffee husks showed a slightly alkaline pH and low total nitrogen. However, the electrical conductivity, C/N ratio, organic carbon, phosphorus, and available potassium are very high. Utilization of compost and biochar from coffee husk waste with better nutrient status from the soil has encouraged changes in soil properties and increased the growth of Arabica coffee plants.

The results of the analysis of coffee husk waste fermented for 2, 4, and 6 weeks obtained the value of water content 17.10-18.23, pH 7.10-8.30, organic C 30.04-36.85%, total N 0.37-0.53%, available P 562.91-621.14 ppm or 0.056-0.062%, available K 449.36-611.71 ppm or 0.045-0.061% and C/N ratio 56.68-99.59. When compared to coffee skin waste without composting, the water content is 17.30%, pH 5.74, carbon 50.80%, nitrogen 1.27%, potassium 2.46%, phosphorus 0.06%, and C/N 40.02 (Dzung *et al*., 2013). However, with 13 weeks of composting, the water content reached 22.30%, pH 7.50, carbon 28.20%, nitrogen 2.07%, potassium 2.87%, phosphorus 0.55%, and C/N 13.60. This condition shows that the longer the composting time, the better the physicochemical properties. The longer the composting time, the higher the water content, pH, total N, available P, and available K, but the value of C and C/N organic ratio decreased. Optimal composting time can contribute to better N, P, and K nutrients, but on the other hand, can reduce organic C content.

The soil C/N ratio of 8.89 indicated that the level of soil weathering at the study site is very good. Biochar has a very high C/N ratio of 80.69 and composting for 2, 4, and 6 weeks which has a C/N ratio of 99.59, 85.09, and 56.68 is also very high. It indicated that the weathering rate is relatively slow, in other words, the coffee skin waste material is still difficult to decompose. Initially, composting in increasing soil fertility was expected to release and contribute nutrients to plants, but because coffee husks decompose slowly, the function of compost is the same as biochar, namely as a soil enhancer. Organic matter that is difficult to decompose in the soil is more suitable for use as a soil enhancer that functions to improve the physical properties of the soil which encourages the formation of soil aggregates, porosity, aeration, and better soil drainage. Improving the physical properties of the soil will help plant roots to take up the nutrients needed for growth. The characteristics and composition of carbon and nitrogen content in coffee husk waste compost with a composting time of 2 weeks (C1), composting 4 weeks (C2), and 6 weeks (C3). The decrease in organic carbon of coffee husks from 36.85% in 2 weeks of composting decreased to 36.59% at 4 weeks of composting and decreased again to 30.04% at 6 weeks of composting. Meanwhile, the nitrogen content in 2-week composting increased from 0.37% to 0.43% in 4-week composting and

0.53% in 6-week composting. These results led to a decrease in the C/N ratio from 99.59 at 2 weeks of composting to 85.09 after 4 weeks of composting and 56.68 after 6 weeks of composting. From the results of this study, the C/N ratio in composting 2-6 weeks was still quite high, ranging from 56.68-99.59. The results showed that the highest total wet weight of biomass per plant was obtained at 6 weeks of composting, which was significantly different and increased by 10.22% compared to 2 weeks of composting. Meanwhile, the highest dry weight of total biomass per plant was obtained at 6 weeks of composting, which was significantly different and increased by 6.36% compared to 2 weeks of composting. The high total dry weight per plant in the 6-week composting treatment was highly correlated which was supported by plant height variables (r= 0.95**), stem diameter per plant (r= 1.00**), number of leaves per plant (r = 0.92**), leaf area per plant (r= 1.00**), total wet weight per plant (r= 1.00**) (Table 3).

The dose treatment of 10 t ha^{-1} of biochar gave the highest total wet weight of biomass per plant which was significantly different and increased by 28.65% compared to without biochar. Similarly, the treatment at a dose of 10 t ha^{-1} of biochar gave the highest total dry weight of biomass per plant which was significantly different and increased by 15.81% compared to without biochar (Table 2). The high yield of total oven dry weight per plant at a dose of 10 tons per hectare of biochar was supported by very significant correlations, such as plant height (r= 0.98 **), stem diameter per plant (r= 0.98**), number of leaves per plant (r= 0.94**), leaf area per plant (r= 0.97**), total wet weight per plant (r= 1.00 **).

Table 3. Variable correlation value (r) due to the effect of composting time

	Plant height	Stem diameter	Number of leaves	Leaf area	Total wet weight
Stem diameter	0.94**				
Number of leaves	1.00**	0.91**			
Leaf area	0.95**	1.00**	0.93**		
Total wet weight	0.97**	0.99**	0.95**	1.00**	
Total dry weight	0.95**	1.00**	0.92**	1.00**	1.00**

r (0.05; 7; 1) = 0.754 r (0.01; 7; 1) = 0.874

Table 4. Variable correlation value (r) due to the effect of biochar dose

	Plant height	Stem diameter	Number of leaves	Leaf area	Total wet weight
Stem diameter	0.90**				
Number of leaves	0.90**	0.92**			
Leaf area	0.93**	0.96**	0.99**		
Total wet weight	0.97**	0.97**	0.96**	0.99**	
Total dry weight	0.98**	0.98**	0.94**	0.97**	1.00**

r (0.05; 10; 1) = 0.632 r (0.01; 10; 1) = 0.765

Discussion

According to Karadag *et al*. (2013), the C/N ratio < 20 indicated that the compost was ripe. The C/N ratio is more suitable for soil improvement to improve soil physical properties. Usually, after the composting process, the content of potassium, calcium, phosphorus, and magnesium also increases. The number of microorganisms associated with the composting process in terms of dissolving poorly soluble phosphorus and potassium is also an indicator that can be used to assess the quality of compost.

The increase in dry weight of biomass per plant is due to the nature of biochar which can increase pH, availability of nutrients and water in the soil, and plant growth. Biochar increases the pH and availability of calcium ions and decreases the solubility of aluminum (Amoah-Antwi *et al*., 2020), due to an increase in the alkaline pH of biochar (Pandian *et al*., 2016). Biochar is beneficial for acid soils, increasing water retention, nutrients, and carbon storage in soil (Lima *et al*., 2018). In general, compost and biochar increase carbon mineralization and heavy metal bonding, producing carbonyl, phenol, and aromatic functional groups on the surface, thereby stabilizing the unstable organic matter fraction (Pandiyan *et al*., 2020). In addition, biochar aging produces NC=O groups and stable amino groups to adsorb nitrogen compounds. This reduces possible greenhouse gas emissions (Hui, 2021) and is useful as a climate change mitigation (Fidel *et al*., 2019). The use of biochar reduces soil erosion, increases soil pH, increases soil organic matter and water retention capacity, attracts beneficial microorganisms, increases cation exchange capacity, and retains nutrients, proven to improve overall soil quality. This is in line with (Schulz *et al*., 2013), that biomass production increases with an increasing amount of biochar and compost. Coffee husk waste which was composted for 6 weeks showed the highest and most significant yield on stem diameter and total wet weight of biomass per plant. Seedling height per plant and total plant biomass increased only by increasing the amount of biochar but not by the amount of compost. The longer the composting time, the higher the pH, EC, N, P, and K levels, but conversely the C-organic content and weathering rate are lower. The positive effect of composting to supply a nutrient deficiency in soil especially after application to soil, through weathering process has a positive effect on biomass production (Aubertin *et al*., 2021). Chemical and physical soil improvements supported by biochar, contribute to increased microbial activity (Sadegh-Zadeh *et al*., 2018; Mansoor *et al*., 2021). Biochar combined with organic fertilizers can improve soil hydraulic properties and crop yields (Sharma *et al*., 2021). Biochar and compost tests, whether carried out in the field or a greenhouse, have shown increased plant growth and restoration of soil fertility (Getahun *et al*., 2020; El-

Naggar *et al*., 2019), as well as supporting agricultural sustainability (Gogoi *et al*., 2019).

The conclusion of the study showed that the physicochemical properties of coffee husks fermented for 6 weeks tended to increase compared to those fermented for 2 weeks. The longer the composting time, the higher the pH, EC, N, P, and K values, but the lower the water content, C-organic, and C/N ratio. From the results of the study, it was found that the application of coffee husk waste compost could significantly increase stem diameter, wet weight, and dry weight of coffee plant biomass. The treatment of biochar amendments from coffee husk waste had a significant effect on plant height and a very significant effect on the wet weight and dry weight of plant biomass. The application of 10 tons of biochar per hectare resulted in the highest plant height, wet weight, and dry weight of the total biomass per plant, respectively increasing by 13.22%, 28.65%, and 15.81% compared to without biochar.

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