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RESEARCH ARTICLE

Conservation of Soil Physical and Chemical Properties by Application of Compost and Biochar in Tambakrejo Village, Malang Regency

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ABSTRACT

Soil degradation is often indicated by reduced land productivity, which affects soil physical, chemical, and biological properties. The application of compost and biochar fertilizer serves as an alternative method for improving the physical and chemical properties of the soil. This study was conducted to determine the effect of applying compost and biochar to the soil on its physical and chemical properties. The research was conducted in Tambakrejo Village, Sumbermanjing Wetan, South Malang. The study employed a Randomized Complete Block Design (RCBD) with four treatments: control (P0), 15 kg of compost and 5 kg of biochar (P1B3), 10 kg of compost and 10 kg of biochar (P2B2), and 5 kg of compost and 15 kg of biochar (P3B1). The results indicated that the most effective application of compost and biochar in improving bulk density, soil temperature, C-organic, and available P content of the soil was the P3B1 treatment. The composition of compost and biochar P2B2 was found to increase soil pH. Additionally, the composition of P1B3 increased soil moisture, total N, and total K. Based on the results, the application of compost and biochar can reduce soil bulk density, improve soil temperature, pH, and moisture, as well as increase soil C-organic and NPK content.

Introduction

Indonesia has approximately 129 million hectares of forest area, 72 hectares of which are production forest areas [1]. Opportunities for production forest management that are supported by conservation aspects need to be implemented because conservation management can be adjusted to the forest type. Determining conservation methods is not only for economic purposes but also for ecological aspects that are useful for long-term forest sustainability [2]. One of the managers of production forests in Malang Regency is a group of forest farmers who are given permission by the forestry department. Soil and water conservation, in addition to the economic benefits obtained by farmer groups, are among the forest-area management issues that require attention.

Soil and water conservation are important for maintaining soil functions so that the soil remains in good condition. Soil health is a condition that can support plant growth for staple crops or agriculture. Damage to an area can be observed from a decrease in land productivity. Such conditions often become serious problems because land damage certainly affects the soil's physical, chemical, and biological conditions and will take a long time to recover [3]. One of these is the organic material in soil. Soil has low organic content and varying soil pH, possibly due to the toxicity of certain elements. Biochar application can positively influence soil properties, plant productivity [4] and sand filtration for removal microplastic [5]. In one study, it was found that the formula for soil amendment biochar from agricultural waste and a mixture of compost had a positive effect on the soil [5].

Providing compost and biochar is an alternative method for improving the physical and chemical properties of soil. The application of organic materials, such as compost, has a significant effect on the C-organic content of the soil; in approximately three months, it can increase the C-organic content of the soil by almost 50%

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[6]. The addition of organic material also affects the total N value, and adding compost can increase the total N by approximately 0.54% [7]. The application of compost and biochar can increase soil chemical properties in the form of soil C-organic by 33.5% and 67%, respectively, and increase the soil pH value by 13.5% [8]. According to Hanim et al. [9], the application of a combination of compost and agricultural waste biochar did not show any effect. However, it tends to increase soil porosity and reduce the volume and specific gravity of soil particles. The combination of compost and biochar can increase the P content in the soil and increases the P content by 73.37% compared to untreated soil [10].

The use of compost and biochar is a solution for increasing soil fertility and reducing soil damage. The application of compost and biochar can also be used as an effort to overcome environmental problems, because they can bind carbon in the soil. Based on existing problems related to the lack of physical and chemical soil conditions in the area, the problem to be addressed in this research is the effect of the application of compost and biochar on the physical and chemical properties of soil in Tambakrejo Village, Malang Regency. This study aimed to determine the effect of compost and biochar application on the physical and chemical properties of soil in Tambakrejo Village, Malang Regency.

Materials and Methods

Study Area

This research was carried out from June to September 2022, in the social forestry area in Tambakejo Village, Sumbermajing Wetan, Malang. The tools and materials used in research are field equipment for taking soil samples, such as a global positioning system (GPS), ring sampler, soil drills, plastic bags, label paper, markers, cameras, and laboratory equipment that support research. In addition, it uses materials such as compost, biochar, and chemicals that are available in the laboratory for analysis.

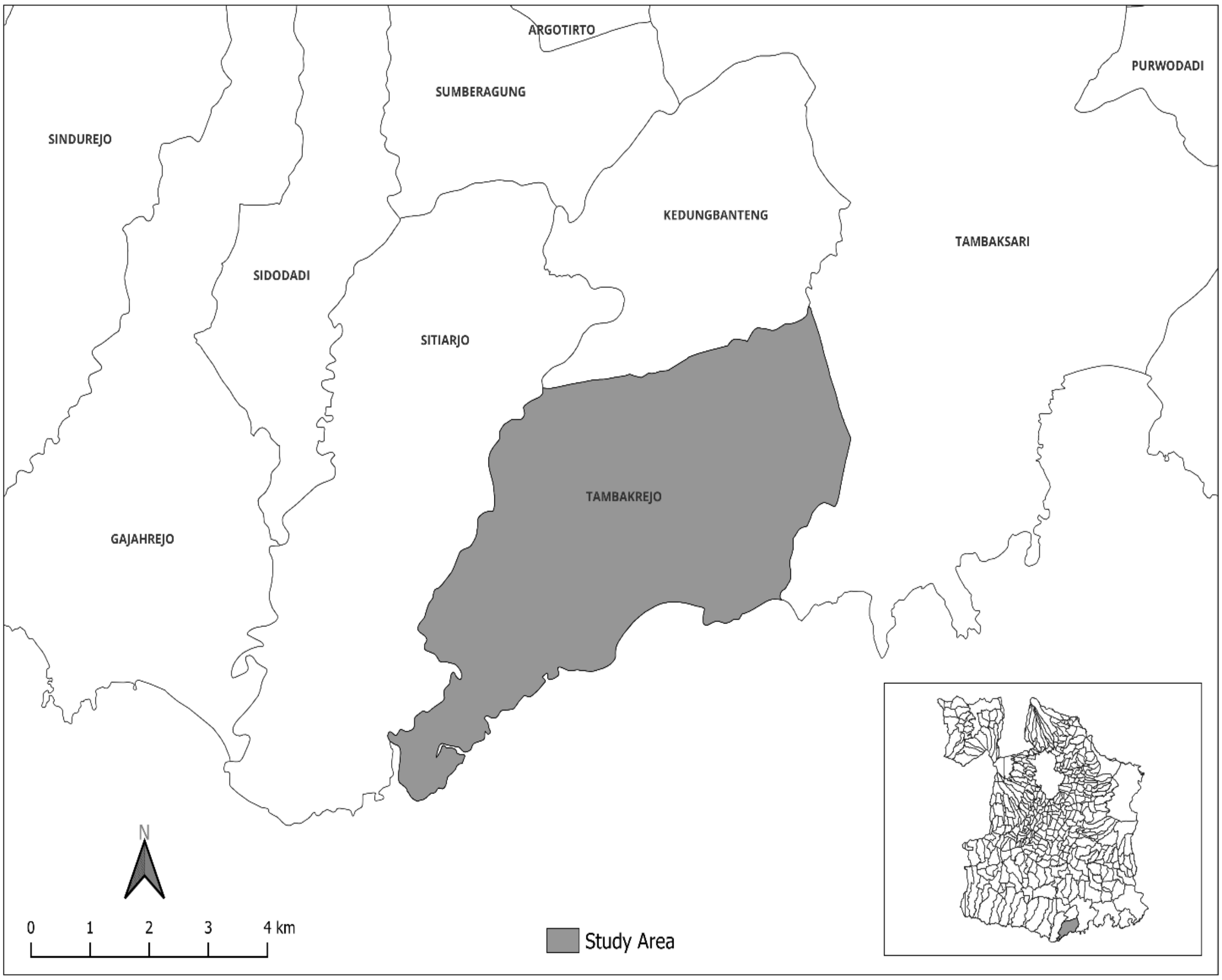

Figure 1. Map research area.

Research Design

The field experiment used a 1 factor randomized complete block design (RCBD) with four treatments: 1) control (P0), 2) compost 15 kg (P1) + biochar 5 kg (B3), 3) 10 kg compost (P2) + 10 kg biochar (B2), and 4) compost 5 kg (P3) + biochar 15 kg (B1). Biochar is made by pyrolysis (incomplete combustion) using a combustion device at a temperature of 250 to 350 °C for 2 to 3.5 hours to obtain charcoal containing high carbon [11]. The charcoal used comes from burning rice husks. The treatment was repeated 3 times with an observation plot / plot area of 5 × 5 m with 12 experimental plots.

Observed and Measured Variables

The variables observed in this study were the effects of compost and biochar application on the physical and chemical properties of the soil. The physical properties of soil consist of bulk density, soil temperature and soil moisture. Meanwhile, the soil chemical properties observed were soil C-organic content, soil pH and soil nitrogen, phosphorus, and potassium (NPK) value. Soil quality assessment can be seen from the physical, chemical, and biological components of the soil and their interactions [12]. Bulk density is determined by comparing the weight of wet soil to the weight of soil that has been in the oven. Soil temperature and humidity are determined using a soil tester by sticking the tip of the sensor into the soil at a certain depth.

The C-organic content was analyzed using the Walkley and Black method. The Walkley and Black method means that the organic material content is determined from the amount of C-organic resulting from the titration, which is then multiplied by a certain constant. Determining soil by using a soil tester. Nitrogen using the titrimetric method is a chemical analysis aimed at determining the level of a substance in a sample using a standard solution. Phosphorus was analyzed using the Olsen or Bray Method. The Olsen or Bray Method is used as a benchmark for comparing the use of methods based on differences in application in soil conditions, namely acidic and alkaline. The Bray Method is generally used for alkaline soils, while the Olsen Method is used for acidic soils. Potassium content was analyzed using the AAS (Atomic Absorption Spectroscopy) method. The AAS is a quantitative analysis method used to determine the levels of metal and metalloid elements based on the principle of light absorption at certain wavelengths, using absorption optical radiation in free atoms in a gaseous state.

Procedure

Determination of observation plots using the purposive sampling method. The purposive sampling method is sampling based on certain criteria [13]. Purposive sampling produces a sample that can logically be considered representative of a population. The sample points are determined diagonally. The first subpoint is in the middle of the plot, and the next points are at each corner of the plot used. Field experiments used 5 × 5 m plots with 12 observation plots. The plants around the research location are dominated by teak.

The activity carried out after seeing plots are continued by providing treatment at each observation point. Compost and biochar were applied to each observation plot according to the research design. The available compost is applied to the soil in each plot and left for one month by checking twice a week. Checking the location aims to ensure the condition of the treatment that has been carried out. This research uses the application of compost and biochar (rice husks). Soil organic matter content can maintain the physical quality of the soil so that it can improve the porosity and stability of soil aggregates. The addition of biochar can be used as a carbon fix, increasing fertility and C-organic content in the soil. Biochar is a solid that contains a lot of carbon obtained from biomass conversion.

Data collection was carried out using the ring sample method, collection using a ring tool aims to obtain soil samples that will be used in laboratory analysis. Soil samples taken must be intact, especially the physical condition of the soil. Soil was taken using a ring that had a height of 4 cm, an inner diameter of 7.63 cm, and an outer diameter of 7.93 cm. Before sampling, clean the surface of the soil from grass and dig up the soil around the sampling site. Place the ring on the surface of the soil, then press the ring to a depth of 0 to 20 cm, dig the tube using a shovel, and carefully clean the soil on the ring so that the surface of the soil is the same as the surface of the ring. Cover the top and bottom of the ring using plastic and put a label on the top ring cover containing depth, date, and location information. The soil samples that have been taken are put in a plastic bag and then analyzed in the laboratory [14].

Soil drill and composite soil sampling were used for the analysis of soil chemical properties. Sampling was carried out diagonally by determining one point as the central point in the middle of the plot and then determining the surrounding points. The number of points is five, with one center point and four diagonal points. The soil surface was cleaned of grass or plant residues, and each collection point was drilled to a depth of 20 cm. The soil samples were mixed and stirred in one place, the remaining plant roots were cleaned, and 1 kg of soil was taken and put in a plastic bag. Place a label on the plastic bag containing the date, name of the taker, soil sample number, location, and depth [14].

Data Analysis

Data analysis was performed using ANOVA with the Tukey HSD. Further testing to determine the differences between treatments by providing a notation on the analysis results if the Tukey test data indicates significance. In addition to difference test, pearson correlation to determine the relationship between variables using Minitab Software.

Results

Effect of Compost and Biochar on Soil Physical and Chemical Properties Soil Physical

Based on the data in Table 1, applying compost and biochar as soil amendments did not significantly affect the soil bulk density variables. However, compost and biochar application significantly affected soil temperature and moisture. Biochar has a good soil function. In the litter decomposition process, the use of biochar has better results in helping to decompose the litter [15].

Table 1. Average test results of soil physical properties.

Treatment	Bulk density (g/m^3)	Soil moisture (%)	Soil temperature (°C)
Control (P0)	1.136 a	60.67 b	28.77 a
P1B3	1.077 a	75.67 a	27.33 ab
P2B2	1.051 a	71.33 a	27.47 c
P3B1	0.948 a	69.33 a	27.07 a
Average	1.053	69.25	27.66
Tukey HSD	0.067	2.01	0.471

Note: Numbers followed by the same letter in the same column indicate no significant difference, P: compost, B: biochar.

Bulk Density

Based on the analysis results in Table 1 and Figure 2, the lowest bulk density in the 5 kg compost and 15 kg biochar (P3B1) treatment was 0.948 g/m^3. These results were not significantly different from the 10 kg compost and 10 kg biochar (P2B2) treatment, 15 kg compost and 5 kg biochar (P1B3), and control (P0) were 1.051 g/m^3, 1.077 g/m^3, and 1.136 g/m^3, respectively. Bulk density is very important for calculating water or fertilizer needs in each area. However, judging from each treatment, soil amendments can reduce bulk density.

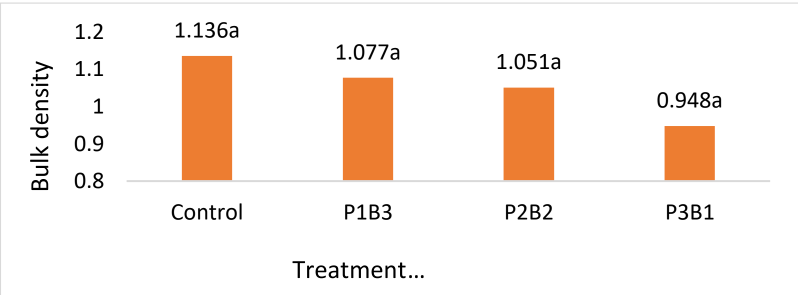

Figure 2. Average bulk density results.

Soil Temperature

Table 1 and Figure 3 explain that the lowest amount of compost and biochar was given in the 5 kg compost and 15 kg biochar (P3B1) treatment with a result of 27.07 °C, and this result was significantly different from the 10 kg compost and 10 kg biochar (P2B2) treatment, 15 kg compost and 5 kg biochar (P1B3) were 24.47 °C and 27.33 °C respectively. However, it significantly differed from the control treatment (P0), namely 28.77 °C. This shows that the application of compost and biochar reduced soil temperature. Soil temperature greatly influences plant growth and determines soil fertility. The lower the soil temperature in an area, the higher the plant growth rate, and vice versa, except for some plants that require high temperatures for growth.

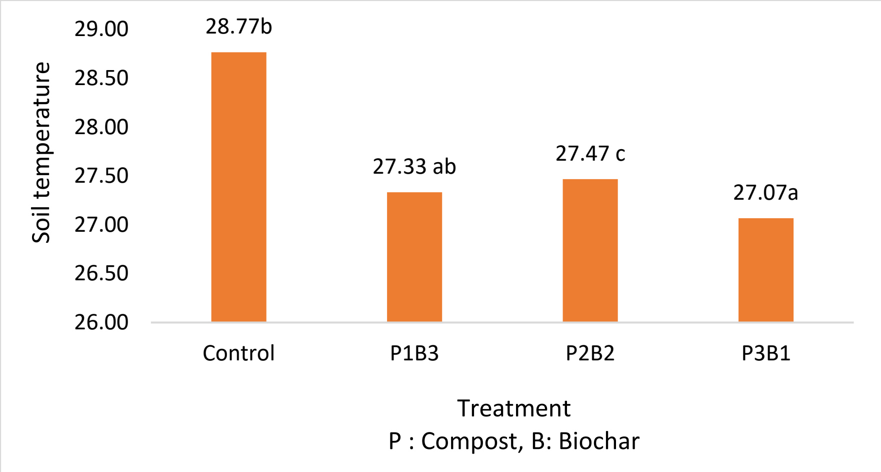

Figure 3. Average soil temperature results.

Soil Moisture

As shown in Table 1 and Figure 4, the highest humidity in the treatment with 15 kg compost and 5 kg biochar (P1B3) was 75.67%. This result was not significantly different from the treatments with 10 kg compost and 10 kg biochar (P2B2) and 5 kg compost and 15 kg biochar (P3B1), 71.33% and 69.33 %, respectively. However, it differed from the control treatment (P0), that is 60.67%, indicating that adding soil amendments in compost and biochar can improve soil moisture.

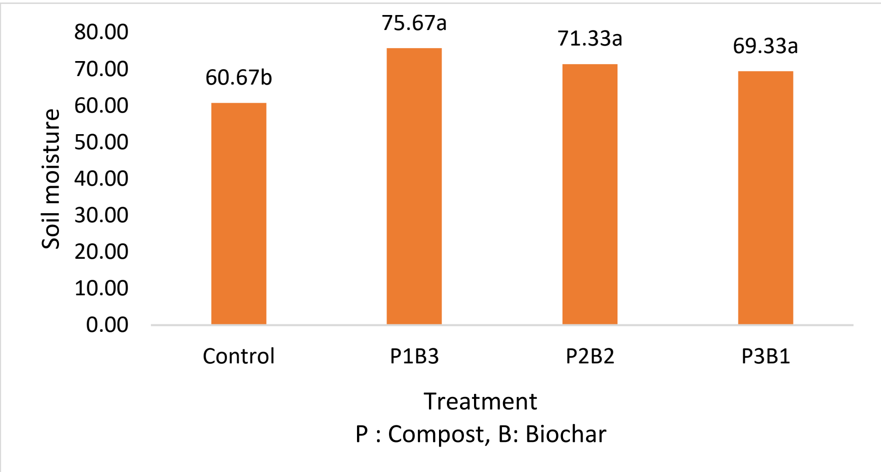

Figure 4. Average soil moisture results.

Soil Chemical Properties

Based on the data, the application of compost and biochar as soil amendments significantly affected soil pH and soil C-organic. However, it had no real effect on the Nitrogen, Phosphorus, and Potassium contents of the soil. The average results of the analysis of soil chemical properties are presented in Table 2.

Table 2. Average soil chemical properties test results.

Treatment	pH	C-organic (%)	N total (%)	P available (ppm)	Potassium (cmol/kg)
Control	5.2 b	2.81 b	0.36 a	6.66 a	0.36 a
P1B3	6.5 a	3.79 ab	0.56 a	61.30 a	0.65 a
P2B2	6.7 a	4.03 a	0.49 a	86.30 a	0.56 a
P3B1	6.4 a	4.61 a	0.53 a	259.00 a	0.62 a
Average	6.2	3.81	0.49	103.32	0.55
Tukey HSD	0.354	0.321	0.106	153	0.106

Note: Numbers followed by the same letter in the same column indicate no significant difference, P: compost, B: biochar.

Soil pH

Table 2 and Figure 5 show that the highest soil pH in the treatment of 10 kg of compost and 10 kg of biochar (P2B2) was 6.7. This result was not significantly different from the treatment of 15 kg of compost and 5 kg of biochar (P1B3) and 5 kg of compost and 15 kg biochar (P3B1), with results 6.5 and 6.4, respectively. In contrast to the control treatment (P0), with a pH of 5.2, adding compost and biochar can elevate the soil pH to a range of 5.4 to 6.7. This application effectively neutralizes initially acidic soil by increasing its pH level. The pH values of the acidic control were compared with those of P1B3, P2B3, and P3B1, which were classified as neutral pH. Soil with neutral pH ranges from 6.5 to 7.8 explained that the provision of soil amendments in the form of compost and biochar from burnt husks had a significant effect on soil pH, and the combination of these two organic materials could also increase the soil pH [5]. Soil pH plays an important role in determining whether plants easily absorb nutrients, determine the presence of toxic content, and influence the development of microorganisms [16,17].

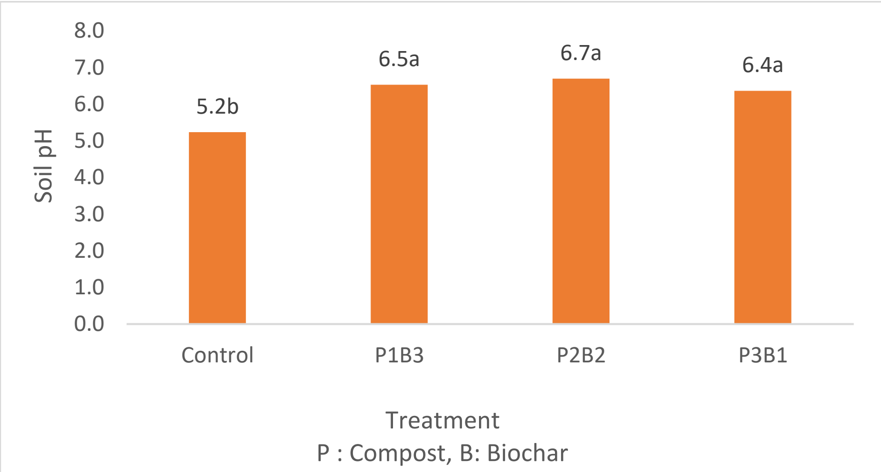

Figure 5. Average soil pH test.

C-organic Content

As shown in Table 2 and Figure 6 the highest C-organic content was observed in the 5 kg compost and 15 kg biochar (P3B1) treatment (4.61%), and this result was not significantly different from the 10 kg compost and 10 kg biochar (P2B2) treatments and the 15 kg treatment compost and 5 kg of biochar (P1B3), with results of 4.04% and 3.79%, respectively. However, it significantly differed from the control treatment (P0), with a result of 2.81%. Treatments P0 and P1B3 were included in the medium C-organic content category [18], while treatments P2B2 and P3B1 were included in the high C-organic content category. Therefore, adding compost and biochar as soil amendments can increase the C-organic content of the soil. Based on the soil quality book, the C-organic content was very low (< 1%) and very high (> 5%) [19].

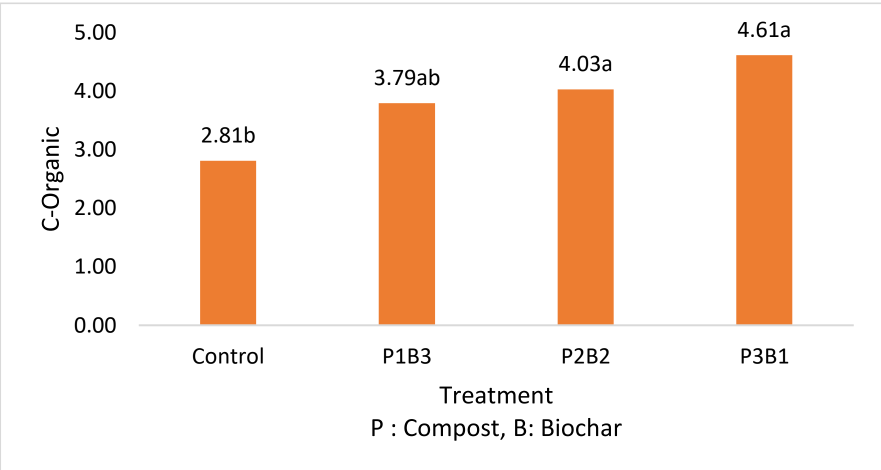

Figure 6. Average C-organic test results.

Nitrogen Total (N)

As shown in Table 2 and Figure 7, the highest total N in the treatment of 15 kg compost and 5 kg biochar (P1B3) was 0.56%, which was not significantly different from the control treatment (P0), 10 kg compost and 10 kg biochar (P2B2), and 5 kg compost and 15 kg biochar (P3B1), which were 0.36%, 0.46%, and 0.53%, respectively. Based on the soil assessment criteria, the control and P2B2 treatments were in the high category [20], whereas the P1B3 and P3B1 treatments were in the high category. Soil nitrogen content is categorized as low (0.1–0.2), medium (0.21–0.5), and high (0.51–0.75).

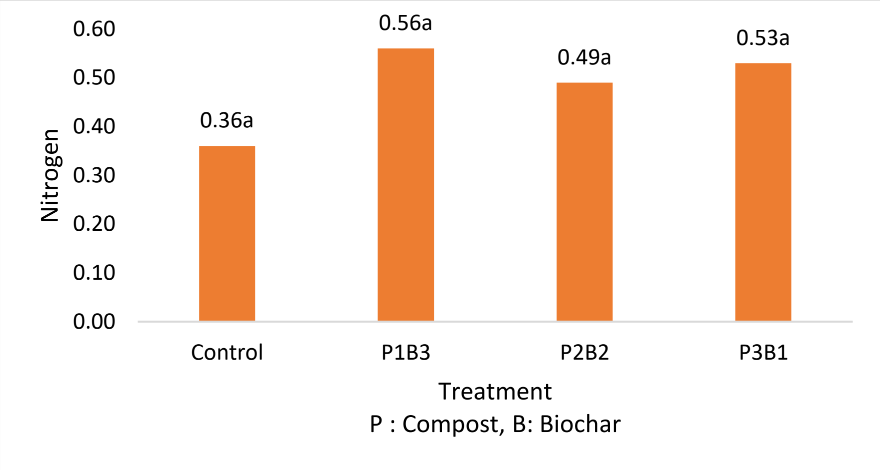

Figure 7. Graph of the average total N test results.

P available (P)

As shown in Table 2 and Figure 8, the highest amount of available P (259 ppm) was provided with compost and biochar in the 5 kg compost and 15 kg biochar (P3B1) treatment, which was not significantly different from the control treatment (P0), 15 kg compost and 5 kg biochar (P1B3), as well as 10 kg of compost and 10 biochar (P2B2) of 6.66 ppm, 61.30 ppm and 86.30 ppm respectively. The control treatment was included in the soil category with a low P content, whereas the other treatments were included in the soil category with a very high P content. Based on the soil quality book, the available P content was very low (< 5 ppm) and very high (> 20 ppm) [19]. Soil with very high nutrient levels will hamper the absorption of macronutrients because the P elements will bind the nutrients Cu, Fe, and Zn, making them unavailable to plants.

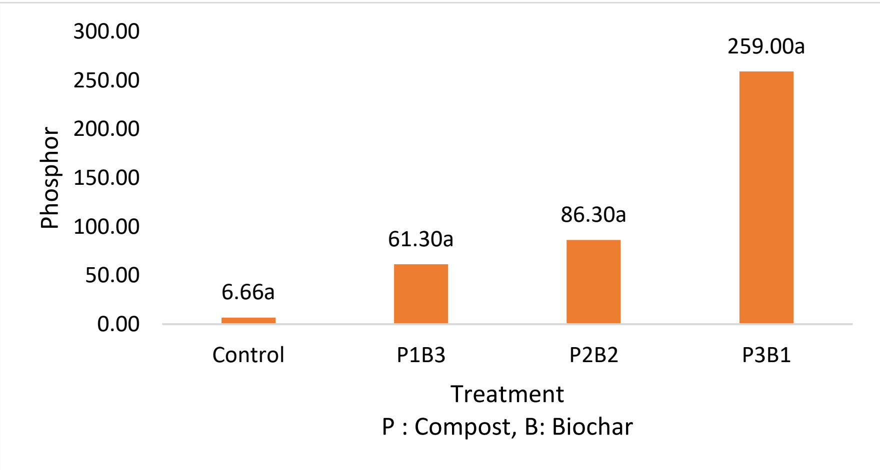

Figure 8. Graph of the average P test results is available.

The most effective treatment for increasing the P content of the soil is the P3B1 treatment. Biochar contains much organic material that can increase the nutrient content of the soil, especially the P content, and is very good for use as a material for improving soil fertility. Biochar can increase the amount of nitrate in the soil and the availability of P and K in the soil [21].

Potassium (K) Total

Based on Table 2 and Figure 9, shows that the effect of giving compost and biochar was highest in the 15 kg compost and 5 biochar (P1B3) treatment with a result 0.65 cmol/kg and this result was not significantly different from the control treatment (P0), 10 kg compost and 10 biochar (P2B2) and the treatment of 5 kg compost and 15 kg biochar (P3B1) were 0.36 cmol/kg, 0.56 cmol/kg and 0.62 cmol/kg, respectively. Based on the soil assessment criteria, the potassium content in the control treatment was included in the low category, whereas for the other treatments, it was included in the high category [20].

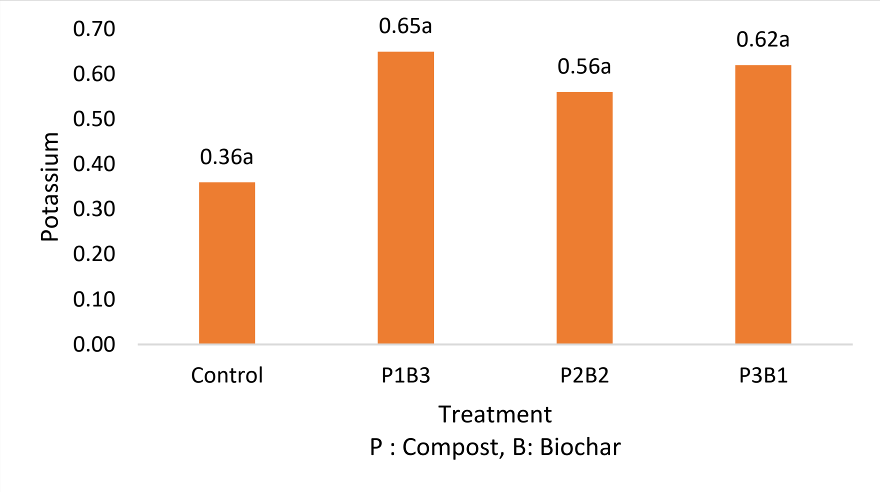

Figure 9. Average total K test results.

Correlation Between Physical and Chemical Properties of Soil

The relationships between soil physical properties and soil chemical properties are presented in Table 3. Based on Table 3, it is clear that there is a correlation between bulk density and P content in the soil (0.525), and there is a moderate relationship between the two. The negative direction of the relationship shows that the higher the bulk density of the soil, the lower the phosphorus content in the soil, and vice versa. This is to the research results [22], which explains that soil density is correlated with soil pores and drainage, but the relationship is not close. Soil bulk density affects plant growth and root length. The P element in the soil stimulates root growth and helps form the root system. If the soil has a high bulk density, plant roots cannot grow well, which affects plant growth. The combined application of compost and biochar in the field can increase carbon (C) absorption in the soil, provide water and nutrients, and improve plant growth [23–27]. Biochar can improve soil aeration, retain nutrients and water plants need, increase soil aggregate stability, and increase C-organic content and soil permeability [28].

Table 3. Correlation results of physical properties and chemical properties of soil.

Soil chemical properties	Soil physical properties		
	Bulk density	Soil temperature	Soil moisture
Soil pH	–0.321 ns 0.154	–0.585** 0.023	0.742 ** 0.003
C-organic	–0.397 ns 0.1	–0.642** 0.012	0.527 ** 0.039
N	–0.397 ns 0.101	–0.628** 0.014	0.449 ns 0.072
P	–0.525 ** 0.04	–0.461 ns 0.066	0.064 ns 0.422
K	–0.196 ns 0.27	–0.516 ns 0.053	0.506** 0.047

Note: ns: non-significant, **: significant.

Discussion

Providing soil amendments in compost and biochar can reduce bulk density, although it does not differ for each treatment. Soil that initially has a clay texture will be loose. The most effective treatment in reducing soil bulk density is the P3B1 treatment. The organic material content in compost and biochar can increase soil aggregation, making it more porous and decreasing its bulk density. This is appropriate for research, which states that the provision of compost and biochar causes a decrease in the soil bulk density value because compost and biochar can provide biomass to the soil so that it can increase the source of soil organic matter and ultimately reduce the soil bulk density value [29]. Soil bulk density is a physical property closely related to soil aeration and drainage. Normal bulk density ranges from 0.6 to 1.2 g/m^3 [14,30,31]. Soils with high total pore space tend to have low bulk volumes.

The most effective treatment was P3B1, which showed that the soil temperature dropped by approximately 1.7 °C from the initial treatment. This is because compost and biochar contain many nutrients needed for soil fertility, so microorganisms in the soil can work well. In this process, they can improve soil fertility, especially soil temperature. The normal soil temperature in open fields ranges from 27.2 to 28 °C, whereas the soil temperature required by teak plants for growth ranges from 26 to 32 °C. High doses of compost and biochar can influence the organic content and neutralize soil temperature [32]. Normally, the soil temperature in the forest ranges between 25.8 to 27.2 °C [33,34]. The deeper the soil, the slower the sun's propagation; thus, the soil temperature is lower. Factors that influence high or low soil temperatures are the vegetation around the plants and the solar radiation entering the area [35].

The most effective treatment is the P1B3 treatment because compost and biochar contain many nutrients that can improve soil fertility. Applying compost and biochar can increase humidity by retaining air in the pores of the compost and biochar, which form aggregates with the soil. Applying organic material can improve soil fertility, with normal soil moisture of 69.2 to 76.4% at a depth of 5 cm, while the moisture needed by teak plants for growth is 60 to 80% [36]. The high or low soil moisture levels in an area are related to high or low soil temperature measurements. Soil was classified as acidic if the pH was below 6.5 and alkaline if the pH exceeded 7.5 [37]. Depending upon its maturity or type, incorporating organic material into the soil influences soil pH. These ions also exhibit phytotoxicity and impair plant nutrient absorption, inhibiting optimal growth.

The most effective treatment is the P3B1 treatment because compost and biochar contain a lot of organic material that can increase soil fertility. The high organic material content in biochar can help microorganisms work so that the C-organic content in the soil increases. Adding humus organic matter can increase the C-organic content of the soil, which occurs because of the C / N ratio of compost and biochar. The size of the existing ratio significantly influences the decomposition level of the organic material [21]. C-organic undergoes decomposition during the decomposition process to release carbon in the form of CO_2 and CH_4, which can produce energy [38].

Nitrogen is the fertilizer element that plants need the most, but if it is excessive, it will have a negative impact. Based on the soil quality book, nitrogen (N) content was very low (< 0.1%) and very high (> 0.75% [19]. If the N content is above 0.75%, the plant will be easily attacked by pests or fungi, so the plant will not be strong and easily collapse. The amount of nitrogen in the soil varies around 0.06 to 0.5% [39]. The most effective treatment for increasing soil N content is the P1B3 treatment because compost and biochar contain a lot of organic material that can increase soil fertility. This increases soil N and plant nutrients and nitrogen, including essential elements in the form of amino acids, nucleic acids, and chlorophyll [21]. Soil organic matter acts as a source of energy for the growth of organisms and is one of the triggers for nutrient availability [40].

The K content in the soil can be categorized as high if the soil K value ranges from 0.6 to 1.0 cmol/kg. Based on the soil quality book, the K content is said to be very low if < 0.1% and very high if > 1% [19]. Potassium plays a role in plant physiological processes such as photosynthesis and regulation of water flow [41]. Soil deficient in K can cause plant leaves to dry and fall. In addition, if the plant has excess K, plant growth will be hampered, causing a deficiency. The most effective treatment for increasing the K content of the soil is the P1B3 treatment because compost and biochar contain a large amount of organic material that microorganisms need to increase soil potassium. The soil's low content of soil nutrients in the form of N, P, and K is beneficial for providing soil amendments in the form of compost and biochar. This fact also proves that the combination of compost and biochar is necessary in nutrient-poor soil [5]. Based on research on the use of compost and biochar as soil amendments, the best composition was a treatment of 5 kg of compost and 15 kg of biochar (P3B1). This can be seen from the cheapest composition treatment, in which the price of the biochar used is lower than that of compost.

There was a correlation between temperature, humidity, and soil pH, with 0.585 and 0.742 categorized as medium and high [42]. This indicates that temperature, humidity, and soil pH have a moderate relationship. A negative relationship indicates that the higher the soil temperature, the lower the soil pH. In contrast, a positive relationship indicates that the higher the soil moisture, the higher the soil pH, and vice versa. Soil temperature affects the soil pH value. There is a correlation between temperature, soil moisture, and soil C-organic of 0.642 and 0.527, where the correlation between the two has a very strong relationship. The negative direction of the relationship shows that the higher the soil temperature, the lower the soil C-organic content. In contrast, the positive direction of the relationship shows that the higher the soil moisture, the higher the soil C-organic content. Providing compost and biochar can increase C-organic in the soil, thereby reducing soil temperature and increasing soil moisture. The organic matter contained water in the soil to maintain soil moisture. The higher the C-organic content in the soil, the higher the humidity [43].

In addition, there was a moderate correlation between soil temperature and soil nitrogen (N) content (0.628). The negative direction of the relationship shows that the higher the soil temperature, the lower the soil N. During decomposition, microorganisms utilize several compounds in organic materials to produce energy. Mineralization includes the decomposition of organic material involving microorganisms, which is determined by enzyme dynamics and soil temperature conditions. Temperature has a different influence on N mineralization; the higher the temperature, the smaller the N mineralization [44]. At 30 °C, it produces smaller minerals than the other treatments.

There was a moderate correlation between soil moisture and potassium (K) content in the soil (0.506). The positive direction of the relationship shows that the higher the soil moisture, the higher the K content in the soil. Potassium is an important nutrient required by plants after nitrogen and phosphorus. Soil moisture affects soil water availability and nutrient concentrations. It determines the flow of water to plant roots, and the plant root system will be better with sufficient water content. KCl fertilizer applied to the soil can interact with and maintain soil moisture.

Conclusion

The application of soil amendments in the form of compost and biochar can improve soil fertility in forested areas. Compost and biochar are improving materials containing the organic materials that plants need, including teak plants. Providing compost and biochar influences the physical and chemical properties of the soil, although some variables do not have a statistically significant effect. Compost and biochar can reduce the soil bulk density and improve the soil temperature, humidity, and pH. In addition, it can also increase the levels of other nutrients, such as C-organic and soil NPK. The higher the amounts of compost and biochar used, the faster the increase in soil nutrients. The most effective treatment was 5 kg compost and 15 kg biochar (P3B1).

Author Contributions

FACW: Supervision, Conceptualization, Methodology, Investigation, Writing - Review & Editing; **DA**: Investigation, Writing - Review & Editing; **MC**: Supervision, Conceptualization, Methodology, Investigation, Review**.**

Conflicts of Interest

There are no conflicts to declare.

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