Effectiveness combination of *leucaena* compost and coconut shell biochar on reduce soil compaction and corn growth in ultisol.

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Abstract. This study aims to identify optimal dose combinations that significantly impact reducing soil compaction in Ultisols and corn growth. The randomized block design (RBD) was utilized to conduct the study. The ameliorant materials consisted of leucaena compost and coconut shell biochar, which were divided into ten treatments and three treatments with 10 treatments & 3 group for each treatment. The treatments were combinations of coconut shell biochar leucaena compost and inorganic fertilizer. Soil physical parameters, such as soil organic matter, bulk density, porosity, and penetration resistance, were monitored during the study. The analysis was conducted using ANOVA at 95% confidence level (α = 5%). Subsequently, Duncan Multiple Range Test (DMRT) was conducted to evaluate the average effect of treatment. The result of the study indicated that Treatment of 5 tons/ha compost + 5 tons/ha biochar + ½ dose of inorganic fertilizer was able to reduce soil density compared to the control and showed a decrease in bulk density, as well as an increase in soil porosity, and a decrease in the value of soil penetration resistance. Treatment of 10 tons/ha of compost with 10 tons/ha of biochar + ½ dose of inorganic fertilizer is the best treatment for corn growth.

supports plant growth.

INTRODUCTION

Ultisol is a type of soil used for agricultural cultivation in Jambi Province. Continuous use of Ultisols for agriculture without efforts to prevent soil damage will decrease productivity. Ultisol has soil physical properties that do not support plant growth: less stable soil structure, slow infiltration and permeability, low soil organic matter (SOM), and low porosity, so the soil tends to be denser—the low aggregate stability results in increased erosion hazard and high bulk density [1]. High soil bulk density indicates that the soil has a high soil-specific density. High soil bulk density inhibits plant growth and development because it is difficult for plant roots to penetrate the soil to obtain nutrients.

Soil that is too compact, air exchange becomes slow, oxygen content in the soil is quite low, and permeability is hampered, so water will stagnate and inhibit plant growth. The effect is that the plants become stunted and thin, making it difficult to absorb nutrients and water optimally [2]. Control of soil density by increasing soil organic matter. Soil organic matter can increase soil aggregation, make the soil structure crumbly, and improve aeration and soil percolation. Soil organic matter creates balanced soil micro and macro pores for water transmission and retention [3]. Compost can improve soil that experiences high density and can increase plant growth. One of the raw materials for compost that is easy and widely available is lamtoro (Leucaena). The leucaena plant is widespread throughout rural areas and can easily grow in almost all areas that receive sufficient rainfall. Compost can improve the physical properties of soil, especially reducing soil density. This can happen because there is organic material in the compost. Composted organic material can provide micro nutrients for plants, loosen the soil, improve soil structure, increase porosity, improve soil aerase, increase soil binding capacity. to water and facilitate root growth [4].

On the one hand, adding organic fertilizers such as compost, manure, and plant residues in tropical areas' agricultural systems can immediately provide nutrients. However, C-Organic stability lasts relatively short, only a few seasons. This matter is due to the rapid decomposition of organic matter. So that Soil amendments are needed to maintain C-organic stability in the long term. One material that is difficult to decompose in soil is biochar. The use of soil improvement materials made from agricultural waste, such as coconut shell, which is difficult to decompose, is one alternative that can be taken to accelerate the improvement of the quality of soil physical properties [5].

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Biochar is a soil amendment that can improve soil physical properties such as aggregate stability, C-organic content, water, and nutrient retention. Biochar can reduce volume weight by increasing soil porosity. A decrease in volume weight indicates a decrease in soil density [6]. Biochar of oil palm shells, coconut shells, and Sawdust given at 5 tons/ha and 10 tons/ha can improve soil density by reducing bulk density and increasing soil penetration resistance and porosity [7]. Rice husk biochar, sawdust, and coconut shells can reduce the soil volume weight value. Giving 5 tons/face can reduce soil density and increase soil porosity. However, the highest soybean yield was in plants given 10 tons/ha of rice husk biochar [8].

The weakness of biochar was the low content of organic matter,while improving the physical properties of the soil requires active organic matter. Therefore, it is necessary to combine biochar with other organic materials. Combining 5 tons/ha of biochar and 5 tons/ha of compost can increase available water content (8.39%), reduce soil penetration resistance so that sandy soil is more compact, and consistently increase aggregate stability. The combination of 10 tons/ha of compost and 40 tons/ha of corn stalk biochar can reduce bulk density (26.5%), increase porosity (9.2%), and reduce total plant water requirements (34.4%) as well as increase available soil water. (61.9%) [9]. Combining compost and biochar is expected to improve soil density and corn growth. This study aims to identify optimal dose combinations that significantly impact reducing soil compaction in Ultisols and corn growth.

MATERIALS AND METHODS

The study was conducted in Tangkit Village, Sungai Gelam Sub-District, Muaro Jambi District, Jambi Province. The soil type at the research site was Ultisol. The duration of the study was approximately six months. The research utilized various instruments, such as pyrolysis drums, weighing scales, soil ovens, sample rings, cone penetrometer. Research materials include fresh leucaena, coconut shell, corn seeds, inorganic fertilizer (Urea, KCl, TSP), chicken feces, rock phosphate, trichoderma, furan, and insecticides. This study was an experimental study using a randomized block design (RBD) with ten treatments with three repetitions for each treatment to obtain 30 experimental units. The treatments were combinations of oil palm shell biochar and leucaena compost as described below: **a0**: control (without Biochar and compost) + full dose inorganic fertilizer; **a1**: compost 5 tonnes/ha + biochar 10 tonnes/ha + 1/2 inorganic dose fertilizer; **a2**: compost 10 tonnes/ha + biochar 5 tonnes/ha + 1/2 dose inorganic fertilizer; **a3**: compost 10 tonnes/ha + without biochar + 1/2 dose inorganic fertilizer; **a4:** without compost + biochar 10 tonnes/ha + 1/2 dose inorganic fertilizer; **a5:** compost 5 tonnes/ha + biochar 5 tonnes/ha + 1/2 dose inorganic fertilizer; **a6:** compost 5 tonnes/ha + biochar 5 tonnes/ha + full dose inorganic fertilizer: **a7:** compost 10 tonnes/ha + without biochar + full dose inorganic fertilizer; **a8:** without compost + biochar 10 tonnes/ha + full dose inorganic fertilizer; and **a9:** compost 10 tonnes/ha + biochar 10 tonnes/ha + 1/2 dose inorganic fertilizer.

Research Stages

The biochar used in this study was derived from coconut shells that underwent pyrolysis and were subsequently sifted through 50 mesh (100% pass) and 80 mesh (50% pass) sieves. The compost used in the study was composed of fresh leucaena forage with Trichoderma decomposers and was subjected to a 4-week composting process. The experimental plots were sized at 3 x 4 meters and spaced at 75 x 40 cm. Treatment was carried out by broadcasting the materials onto the soil surface and incorporating them to a depth of approximately 20 cm. Treatment was administered based on the dry weight dose of organic matter and subsequently incubated for one week following even distribution.

Observational Variables

The plant variables observed in this study were: plant height. Soil variables observed include:

a. Soil organic matter (SOM)

The gravimetric method was utilized to measure bulk density. Intact soil samples were subjected to a 2 x 24-hour oven-drying process at 105°C, after which bulk density was determined using the equation below:

$$\% \, SOM = \left(\frac{sample\ dry\ weight - ash\ weight}{sample\ dry\ weight}\right) x100\%$$

b. Bulk density

The gravimetric method was utilized to measure bulk density. Intact soil samples were subjected to a 2 x 24-hour oven-drying process at 105°C, after which bulk density was determined using the equation below

$$Bulk\ density = \frac{soil\ dry\ weight\ (gr)}{soil\ volume\ (cm^3)}$$

c. Soil porosity

The gravimetric method was utilized to determine the soil porosity. Intact soil samples baked in sample rings for 2 x 24 hours at 105°C were used for the analysis. Based on the organic matter content value, which was greater than 1%, the total pore space was calculated using the equation provided below:

$$Total\ pore\ space = \left(1 - \frac{BD}{BJ - (0{,}02\ x\ \%\ BO)}\right) x\ 100\%$$

Description: BD = bulk density (gr/cm^3); BO = organic matter (%); BJ = weight of soil per unit volume of soil particles (gr/cm^3).

d. Soil penetration resistance

Soil penetration resistance measurements are carried out using a cone penetrometer by pushing the rod of the penetrometer cone into the ground with constant strength at a depth of 10 cm and 20 cm. The measurement value is read on a scale with 3 points on each plot. Measurement of penetration resistance begins two weeks after planting and is carried out once a week.

Data Analysis

In this study, a range of observational data was collected and analyzed. This included variables such as: soil organic matter (SOM), bulk density, soil porosity, and soil penetration resistance. The analysis was conducted using ANOVA at a 95% confidence level (α = 5%). Subsequently, the Duncan Multiple Range Test (DMRT) was conducted to evaluate the average effect of treatment.

RESULT AND DISCUSSION

Soil Physical Properties Before Treatment

The physical characteristics of the soil, as observed prior to treatment, indicated the presence of several physical properties that were not conducive to plant growth. The relevant physical properties of the soil prior to the completion of total treatment have been documented in Table 1.

Table 1. Physical soil properties before treatment.

Soil parameters	Measurement Results	Criteria
Organic matter (%)	2.12	low*
C-organik	1.23	low*
Bulk density (g/cm^3)	1.42	medium*
Porosity (%)	44.77	low*
Soil penetration resistance (KgF/cm): Depth 10 cm Depth 20 cm	 18.36 31.61	 high* high*

Note: * criteria based on Bogor Soil Research Center (1994); ** criteria based on National Soil Survey Center Natural Resource Conservation Service-USDA (1912).

Tabel 1 indicates that the soil in the low category contains 2.12% organic matter. This low organic matter leads to a medium bulk density value, which can reach 1.42 in the high category. Combination of low organic matter and medium bulk density results in soil compaction and a low porosity, which can be as low as 44.77% in the low category. Low soil organic matter is caused by organic matter. The soil has rotted, and there is no additional organic material, so it is necessary to add organic material. The organic matter content in the soil greatly influences other physical properties of the soil. Low soil organic matter content will result in high specific gravity and low porosity, as well as weak binding power between particles in the soil, so the impact of rainwater easily damages the soil. The crushed particles can cause the soil to clog the pores so that the soil becomes dense easily. Soil bulk density has a close relationship with soil porosity. Soil porosity can be obtained by determining soil bulk density, and the higher the bulk density of soil, the lower the porosity [10].

The research location, soil penetration resistance at a depth of 10 cm, was 18.36 KgFcm^{-2}, and at a depth of 20 cm, namely 31.61 KgFcm^{-2}, included in the high criteria. Soil with high density makes it difficult for corn seeds to grow. Soil compaction can reduce soil aeration, reduce water availability for plants, and inhibit root growth and plant germination [11].

Characteristics of Compost and Biochar.

Table 2 displays the complete analysis results of leucaena compost before its application. The analysis reveals that the compost adheres to the Indonesian National Standard (SNI) 19-7030-2005, indicating its high quality. Furthermore, the compost has undergone complete decomposition, making it appropriate for application with a C/N value of 15.41%. It is worth noting that the C/N ratio of the compost has also reached 12.56.

Tabel 2 Compost and biochar analysis

Parameters	Compost	Biochar
Water content (%)	38.00	9.40
C-organik (%)	28.97	32.82
N-total (%)	1.88	-
C/N	15.41	-
Ash content (%)	-	8.60

Results of analysis of leucaena compost and coconut shell biochar. Table 2 shows that the c-organic content in biochar is quite high, namely 32.82% and is also in accordance with the c-organic biochar quality standard of 9.8-32. Biochar has strong properties so it can provide a place for microorganisms to grow, because biochar contains high C-organic, so it can be used as an energy source for microorganisms in the soil. The process of making biochar shows that around 50% of the organic C present in the base material can be contained in biochar. Biological decomposition of biochar is usually less than 20% after 5-10 years [12].

The water and ash content of biochar have values of 9.4% and 8.6%, respectively, where the water content and ash content meet the standard criteria for biochar quality. Therefore, the ash content in biochar greatly affects the quality of the biochar because it can cause blockage of the pores in the biochar so that its surface area will be reduced [13]. The water content in the compost is 38.00%, c-organic 28,97%. It is in accordance with compost quality standards where the carbon content contained in the compost is a minimum of 9.8% and a maximum of 32.82%. Compost will increase the soil's ability to store water, besides that compost can loosen the soil so that it can become a medium for plant growth.

The nitrogen content in the compost is 1.88% and meets the criteria for compost quality standards, namely 0.4%. The C/N ratio of leucena compost is 15.41, where the maturity level of the compost is by the Compost Quality Standards of 10-20. This condition indicates that the compost is completely decomposed and ready to use.

Effects of treatment on soil organic matter

Tabel 3 displays effect of compost and biochar significantly increased soil organic matter (SOM). Treatment a2 and a9 significantly from control (a0) to increased soil organic matter. Treatment a1 not significant to increased soil organic matter.

Tabel 3 Effect of treatment doses on SOM

Treatments	SOM (%)
Control (without Biochar and compost) + full dose inorganic fertilizer (a0)	2.33 e
Compost 5 tonnes/ha + biochar 10 tonnes/ha + 1/2 inorganic dose fertilizer (a1)	5.67 ab
Compost 10 tonnes/ha + biochar 5 tonnes/ha + 1/2 dose inorganic fertilizer (a2)	6.00 a
Compost 10 tonnes/ha + without biochar + 1/2 dose inorganic fertilizer (a3)	5.33 abc
Without compost + biochar 10 tonnes/ha + 1/2 dose inorganic fertilizer (a4)	4.00 d
Compost 5 tonnes/ha + biochar 5 tonnes/ha + 1/2 dose inorganic fertilizer (a5)	5.33 abc
Compost 5 tonnes/ha + biochar 5 tonnes/ha + full dose inorganic fertilizer (a6)	4.33 cd
Compost 10 tonnes/ha + without biochar + full dose inorganic fertilizer (a7)	4.67 bcd
Without compost + biochar 10 tonnes/ha + full dose inorganic fertilizer (a8)	5.40 bcd
Compost 10 tonnes/ha + biochar 10 tonnes/ha + 1/2 dose inorganic fertilizer (a9)	6.33 a

According to Table 3, effect of compost and biochar on soil organic matter was significant. The treatments a2 and a9 are significantly different from treatment a0. Treatment a1 is not significantly different from treatments a3, a5, a7, and a8 but is significantly different from treatments a4 and a6 and without treatment. The analysis results showed that 5 tonnes/ha of compost and 5 tonnes/ha of biochar were able to increase the organic matter content in the soil compared to the control. Organic matter added to the soil can increase the SOM content, and increasing the SOM influences the physical, chemical, and biological properties of the soil for the better [14]. The analysis showed that the combination of compost and biochar was able to increase the SOM by 71.67% - 171.67%. Compost decomposes slowly, providing organic matter in the soil, and biochar is also biological charcoal that functions as a habitat for carbon-degrading microorganisms.

Effects of treatment on bulk density

Bulk density is an indicator of soil density. Table 4 displays effect of compost and biochar significantly reduce bulk density. Combination 10 tons/ha of compost and 10 tons/ha of biochar can reduce the largest bulk density value.

Tabel 4 Effect of treatment doses on bulk density

Treatments	Bulk density (g/cm^3)
Control (without Biochar and compost) + full dose inorganic fertilizer (a0)	1.58 a
Compost 5 tonnes/ha + biochar 10 tonnes/ha + 1/2 inorganic dose fertilizer (a1)	1.15 c
Compost 10 tonnes/ha + biochar 5 tonnes/ha + 1/2 dose inorganic fertilizer (a2)	1.16 c
Compost 10 tonnes/ha + without biochar + 1/2 dose inorganic fertilizer (a3)	1.25 bc
Without compost + biochar 10 tonnes/ha + 1/2 dose inorganic fertilizer (a4)	1.33 b
Compost 5 tonnes/ha + biochar 5 tonnes/ha + 1/2 dose inorganic fertilizer (a5)	1.23 bc
Compost 5 tonnes/ha + biochar 5 tonnes/ha + full dose inorganic fertilizer (a6)	1.24 bc
Compost 10 tonnes/ha + without biochar + full dose inorganic fertilizer (a7)	1,23 bc
Without compost + biochar 10 tonnes/ha + full dose inorganic fertilizer (a8)	1.29 bc
Compost 10 tonnes/ha + biochar 10 tonnes/ha + 1/2 dose inorganic fertilizer (a9)	1.14 c

Tabel 4 illustrates that treatments a9, a1, a2 were significantly different from treatments a4 and a0 but not significantly different from treatments a3, a5, a6, a7 and a8 in reducing bulk density. The combination of compost and biochar in a ratio of 1:1, 1:2, or 2:1 with the addition of half the recommended inorganic fertilizer can reduce soil bulk density by 15.92% - 27.35%. Sedangkan perlakuan 10ton/ha kompos dan 10 ton/ha biochar mampu menurunkan bulk density sebesar 28.05%. The decrease in bulk density occurred because an increase influenced it in SOM (Table 3), which caused a decrease in bulk density. The higher the SOM in the soil, the lower the bulk density value. The higher the som causes the bulk density to be lower, and the porosity value becomes high. Bulk density is inversely proportional to porosity. If the soil has a high bulk density, then the porosity is low, and if the lower the bulk density value, the higher the porosity value [15].

Effects of treatment on porosity

The combination of compost and biochar had the effect of increasing porosity compared to the control (without compost and biochar). However, the research results showed that the treatments were not significantly different and increased total porosity significantly.

Tabel 5 Effect of treatment doses on porosity

Treatments	Porosity (g/cm^3)
Control (without Biochar and compost) + full dose inorganic fertilizer (a0)	39.18 b
Compost 5 tonnes/ha + biochar 10 tonnes/ha + 1/2 inorganic dose fertilizer (a1)	54.68 a
Compost 10 tonnes/ha + biochar 5 tonnes/ha + 1/2 dose inorganic fertilizer (a2)	54,31 a
Compost 10 tonnes/ha + without biochar + 1/2 dose inorganic fertilizer (a3)	51.02 a
Without compost + biochar 10 tonnes/ha + 1/2 dose inorganic fertilizer (a4)	48.21 a
Compost 5 tonnes/ha + biochar 5 tonnes/ha + 1/2 dose inorganic fertilizer (a5)	51.74 a
Compost 5 tonnes/ha + biochar 5 tonnes/ha + full dose inorganic fertilizer (a6)	51.74 a
Compost 10 tonnes/ha + without biochar + full dose inorganic fertilizer (a7)	51.80 a
Without compost + biochar 10 tonnes/ha + full dose inorganic fertilizer (a8)	49.44 a
Compost 10 tonnes/ha + biochar 10 tonnes/ha + 1/2 dose inorganic fertilizer (a9)	54.84 a

Tabel 4 illustrates that Treatment of compost, biochar, and a combination of compost - biochar at doses of 1:1, 1:2, or 2:1 with the addition of ½ recommended inorganic fertilizer has been able to increase porosity by 22.84% - 39.38%. Organic materials derived from compost and biochar can improve soil structure. Soil with a good soil structure results in the soil becoming loose and crumbly and having high porosity.

The application of biochar causes increased soil porosity. Biochar can reduce soil density so that soil porosity increases. Biochar has nesting properties, so when mixed into the soil, it causes the soil to become loose. Biochar from various materials and various manufacturing temperatures, which, when added to the soil, increases soil porosity. When added to the soil, biochar from various materials can increase soil porosity. Biochar can also reduce soil density in the top layer of soil and grow organic carbon.1 [16,17,18,19].

Effects of treatment on soil penetration resistance.

Soil penetration resistance shows the soil's ability to be penetrated by plant roots. Low soil penetration resistance causes roots to develop and penetrate the soil layers quickly. The effect of treatments on soil penetration resistance at depths of 10 cm and 20 cm was showed Tabel 6.

Tabel 6 Effect of treatment doses on soil penetration resistance

Treatments	Soil penetration resistance (KgF/cm)	
	10 cm	20 cm
Control (without Biochar and compost) + full dose inorganic fertilizer (a0)	29.12 a	35.92 a
Compost 5 tonnes/ha + biochar 10 tonnes/ha + 1/2 inorganic dose fertilizer (a1)	25.49 d	32.06 d
Compost 10 tonnes/ha + biochar 5 tonnes/ha + 1/2 dose inorganic fertilizer (a2)	26.28 cd	32.86 cd
Compost 10 tonnes/ha + without biochar + 1/2 dose inorganic fertilizer (a3)	27.76 bc	34.44 b
Without compost + biochar 10 tonnes/ha + 1/2 dose inorganic fertilizer (a4)	26.74 bcd	33.61 cd
Compost 5 tonnes/ha + biochar 5 tonnes/ha + 1/2 dose inorganic fertilizer (a5)	27.08 bcd	32.40 cd
Compost 5 tonnes/ha + biochar 5 tonnes/ha + full dose inorganic fertilizer (a6)	26.51 bcd	32.74 cd
Compost 10 tonnes/ha + without biochar + full dose inorganic fertilizer (a7)	28.21 bc	34.33 b
Without compost + biochar 10 tonnes/ha + full dose inorganic fertilizer (a8)	28.41 bc	32.63 cd
Compost 10 tonnes/ha + biochar 10 tonnes/ha + 1/2 dose inorganic fertilizer (a9)	25.04 d	32.06 d

Tabel 4 illustrates that penetration resistance to a depth of 10 cm indicates treatment a9 significantly different from treatments a0, a3, and a7. Treatments a2, a4, a5, a6 and a8 are not significantly different from treatments a1 and a9. However, regarding penetration resistance to a depth of 20 cm, treatment a9 significantly differed from treatments a3, a7, a8, and a0.

The treatment of a2, a4, a5, a6 is not significantly different from a1 and a9. Providing compost, biochar, or a combination of coconut shell compost-biochar in a ratio of 1:1, 1:2, or 2:1 with the addition of ½ recommended inorganic fertilizer has been able to reduce penetration resistance value by 9.57% - 17.22% at a depth of 10 cm 7.76 % - 16.22 % at a depth of 20 cm. This condition occurs because the higher organic material content affects bulk density and porosity. Increased SOM is able to bind soil grains, the soil structure becomes crumbly, reduces density, and can improve soil pores. Penetration resistance will be lower with increasing levels of organic material added to the soil [20].

The application of compost, biochar, and a combination of compost-biochar significantly affected soil penetration resistance compared to no treatment. Observation of penetration resistance at a depth of 10 cm, the lowest penetration resistance value was 15.00 (kgF/cm^2) in the combination treatment of 10 tons/ha of compost and 10 tons/ha of biochar. Meanwhile, the highest penetration resistance value was 18.29 (kgF/cm^2) in the control treatment (without compost and biochar). Penetration resistance at a depth of 20 cm: the lowest penetration resistance was 20.29 (kgF/cm^2) in the combination treatment of 10 tons/ha of compost and 10 tons/ha of biochar, while the highest penetration resistance was 24.22 (kgF/cm^2) in the control treatment (without compost and biochar). The dynamics of soil penetration in each treatment are presented in Figures 1 and 2.

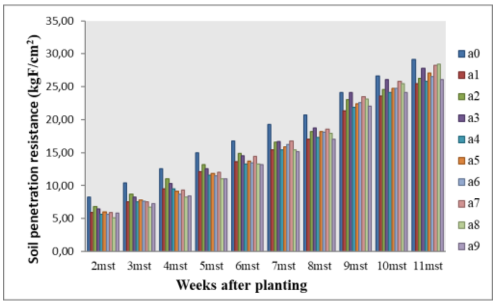

Figure 1. Penetration resistance at a depth of 10 cm

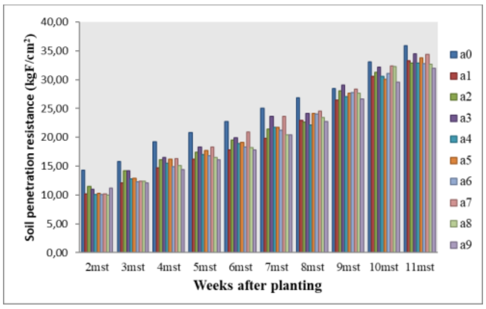

Figure 2. Penetration resistance at a depth of 20 cm

Two graphs illustrates that A0 treatment has the highest soil penetration resistance. Soil penetration at a depth of 10 cm and 20 cm has increased quite significant resistance. As the plant ages, soil penetration resistance will increase. This condition is caused by the impact of raindrops on the ground surface so that the soil becomes solid. In addition, plant roots with high vegetative growth will bind soil particles more tightly so that soil penetration resistance is higher. High penetration resistance indicates dense soil that has high bulk density and low porosity and organic matter.

Effects of treatment on corn growth.

The results of the research showed that the provision of compost and biochar had a significant effect on the growth of corn plants. The average values of plant height and corn yield as well as the results of further tests using the Duncan Multiple Range Test (DMRT) are presented in Table 6.

Table 7. Effects of treatment on corn growth

Treatments	height
Control (without Biochar and compost) + full dose inorganic fertilizer (a0)	168.42 c
Compost 5 tonnes/ha + biochar 10 tonnes/ha + 1/2 inorganic dose fertilizer (a1)	238.83 a
Compost 10 tonnes/ha + biochar 5 tonnes/ha + 1/2 dose inorganic fertilizer (a2)	239.42 a
Compost 10 tonnes/ha + without biochar + 1/2 dose inorganic fertilizer (a3)	198.25 bc
Without compost + biochar 10 tonnes/ha + 1/2 dose inorganic fertilizer (a4)	194.17 bc
Compost 5 tonnes/ha + biochar 5 tonnes/ha + 1/2 dose inorganic fertilizer (a5)	220.42 ab
Compost 5 tonnes/ha + biochar 5 tonnes/ha + full dose inorganic fertilizer (a6)	229.33 ab
Compost 10 tonnes/ha + without biochar + full dose inorganic fertilizer (a7)	228.58 ab
Without compost + biochar 10 tonnes/ha + full dose inorganic fertilizer (a8)	227.25 ab
Compost 10 tonnes/ha + biochar 10 tonnes/ha + 1/2 dose inorganic fertilizer (a9)	245.58 a

Tabel 7 illustrates that Plant height in treatments a1, a2, and a9 was significantly different from treatments a3, a4, and without but not substantially different from treatments a5, a6, a7, and a8. Providing compost and biochar and half the recommended inorganic fertilizer increased the percentage of corn plant height by 15.28% - 45.81%. The treatment contributes organic material to the soil as a plant nutrient supply. Organic materials play a role in absorbing nutrient elements, such as nitrogen element. The element nitrogen plays an important role in plant growth, especially in the vegetative phase such as root, stem and leaf growth, so that increasing nitrogen in the soil results in plant height increasing. Nitrogen is needed by plants in the vegetative and generative phases and is mobile in plants. The nitrogen nutrient content is required to stimulate stem growth, which stimulates plant height growth [21].

Treatment of 10 tons/ha of compost and 10 tons/ha of biochar contributed better to height growth. Ten tons/ha of compost and 10 tons/ha of biochar provide more organic material and nutrients than other treatments. Organic fertilizer in the form of compost can provide nutrients for plants. Organic fertilizer can also maintain and improve soil fertility so that plant growth is better.

CONCLUSION

Research shows that the application of 5 tons/ha of compost with 5 tons/ha of biochar with the addition of ½ recommended inorganic fertilizer can reduce soil density compared to without treatment. This condition is characterized by a decrease in bulk density, an increase in porosity, and a reduction in the value of soil penetration resistance. Ten tons/ha of compost with 10 tons/ha of coconut shell biochar and adding ½ recommended inorganic fertilizer is the best treatment for improving soil density.

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