Ilmu Pertanian (Agricultural Science)
http://journal.ugm.ac.id/jip
Vol. 9 No. 3 December, 2024: 138–146 | DOI: doi.org/10.22146/ipas.92816

Impact of organic matter and sand on soil characteristics, leaf area, and chlorophyll of sweet corn (*Zea mays saccnutritionta* Sturt) on Vertisol from Bojonegoro

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Article Info

Received : 4th January 2024
Revised : 17th September 2024
Accepted: 6th November 2024

Keywords:
Compost, organic matter, sand, sweet corn, vertisols

Abstract

Vertisols contain clay minerals that expand significantly during the rainy season and shrink during the dry season. This condition causes changes in the availability of water and soil ions. This study aimed to examine the effect of adding organic matter (OM) and sand on changes in vertisols and plant growth. The study was conducted using a factorial Randomized Block Design (RBD). The first factor was 5 kinds of OM: control (B0), 15 tons of banana peel compost ha^{-1} + cow dung (10:1) (B1), 15 tons of leaf litter compost ha^{-1} (B2), 15 tons of water hyacinth compost ha^{-1} + cow dung (1:1) (B3), and 1 ton of biochar ha^{-1} (B4). The second factor was the provision of sand as much as 3 level, namely: 0% (P0), 20% (P1), and 40% (P2). Each treatment combination was repeated 3 times. Sweet corn was used as a growth indicator. The observed soil chemical parameters were soil pH, organic C, NH_4^+ and NO_3^-, and Cation Exchange Capacity (CEC) using standard methods. Leaf area was measured using the Arnon method. The results showed providing banana peel compost + cow dung with 40% sand increased the best NO_3^- and soil pH levels. The highest soil C-organic content was found in the treatment with aloe vera compost + cow dung and 0% sand. The best leaf area and plant chlorophyll levels were achieved using banana peel compost + cow dung with 20% sand.

INTRODUCTION

Due to a high percentage of clay, vertisols have limited access to water and soil nutrients. Montmorillonite clay minerals (type 2:1) are present in vertisols, soils that expand when wet and contract when dry (Rajiman et al., 2022). Vertisols feature low organic matter content (often less than 1%) and high cation exchange capacity (CEC). It is nutrient-rich, making it one of the most fruitful soils chemically. However, a high clay concentration sequesters nutrients, reducing nutrient availability to plants and limiting crop yield due to numerous management challenges (Teshale, 2023). According to multiple studies, adding organic matter is the most effective way to improve the low fertility level of vertisols, since it will act as a buffer to reduce soil shrinkage or expansion (Subagyo, 2019). According to research by Zhang et al. (2022) adding organic matter to rice straw can decrease nitrogen leaching, improve the long-term availability of nutrients like NO_3^-, and reduce nitrogen leaching. The organic matter content in the soil, as well as the availability of P and Ca cation exchange capacity, is significantly increased by applying cow dung (Suntoro et al., 2018). Additionally, the application of organic matter affects microbial activity, which in turn affects nutritional availability (Zhou et al., 2023). The primary feature of vertisol soil is its high clay content; therefore, it requires minimal modification to enhance soil productivity. The addition

How to cite: Sasongko, P.E., Mindari, W., Jayanti, F.A., and Fatiha, C.Z. (2024). Impact of organic matter and sand on soil characteristics, leaf area, and chlorophyll of sweet corn (*Zea mays saccnutritionta* Sturt) on Vertisol from Bojonegoro. *Ilmu Pertanian (Agricultural Science)*, 9(3), pp. 138–146.

ISSN 0126-4214 (print) ISSN 2527-7162 (online)

of sand is one possible endeavor. Mindari et al., (2023), stated that increasing sand fraction can reduce soil stability from 23.33 cm to 19.08 cm, and improve porosity and aggregate stability from 37.14% to 44.36%. In their study, Wang et al. (2023) found that adding sand improved soil structure, increased water retention and infiltration, and decreased soil salinity.

Compost made from agricultural waste can enhance the physical, chemical, and biological characteristics of soil, hence improving land quality. According to Ani et al. (2016), the compost made from cow dung and banana peels has an 18.88 C/N ratio, 2.22% nitrogen, 0.39% phosphorus, and 12.72% potassium. Because it contains organic C 27.3%, total N 1.30%, C/N ratio 20.94%, total P 0.29%, and total K 0.48%, agricultural waste in the form of leaf litter can be composted to create organic matter (Widowati et al., 2022). In addition, the compost made from water hyacinth and cow dung has a C/N ratio of 15.54, a phosphorus content of 0.72%, a potassium content of 3.94%, a nitrogen content of 2.28%, and an organic-C content of 35.42% (Wulandari et al., 2016). The application of biochar derived from various tobacco or rice plant wastes results in different nutrient contents of N, P, and K.

The addition of manure to biochar increases the N and P content while the addition of compost enhances the K content (Kolambani, 2022). Biochar is believed to be an efficient carbon store since it can be produced through composting, scrubbing, or biomass charring (biomass pyrolysis) (Mindari et al., 2018). The physical, chemical, and biological qualities of the soil can all be enhanced by adding biochar. It can increase nutrient availability, enhancing soil fertility.

While some earlier research has improved the use of sand and organic materials, the combination of the two has not yet been studied. Therefore, this study involved the application of sand in combination with organic components such as rice husks, banana peels, leaf litter, and water hyacinth. The purpose of this study was to determine how the addition of sand and organic matter can improve vertisol soil conditions and promote the growth of sweet corn plants.

MATERIALS AND METHODS

Research design

The study was conducted at the Experimental Garden of the Faculty of Agriculture UPN "Veteran" East Java from September to December 2022. Soil and sand samples were taken from Bojonegoro, vertisol soil at 0–20 cm depth. The soil chemical properties were analyzed at the Land Resources Laboratory, Faculty of Agriculture, UPN "Veteran" East Java. The factorial randomized block design was used to set up the experiment. The first factor consisted of five categories of organic materials: control (B0), which contained no organic materials; 15 tons ha^{-1} compost made from banana peels and cow dung (10:1) (B1); 15 tons ha^{-1} compost made from leaf litter (B2); 15 tons ha^{-1} compost made from water hyacinth and cow dung (1:1) (B3); and 1 ton ha^{-1} biochar (B4). The second factor was the provision of sand at three levels, namely 0% (P0), 20% (P1) which was 1600 g, and 40% (P2) which was 3200 g. There were 5x3=15 treatments, with each combination repeated three times, resulting in a total of 45 treatments. The treatments were applied using polybags with a volume of 8 liters. Sweet corn was used as an indicator of plant growth.

Preparation of treatment media and organic materials

This study was carried out in phases, beginning with preparation, followed by the addition of sand and organic materials, planting, and plant care. During the four-week preparation stage, media was prepared and organic materials made from banana peels, cow dung, leaf litter, and water hyacinth were composted. Rice husks were pyrolyzed to create biochar. The medium used was vertisol, extracted from Bojonegoro at a depth of 0–20 cm. After being transported to the lab, vertisol samples were crushed, sieved using a 2 mm sieve, weighed according to the treatment, and then placed in 8-liter polybags. The soil texture belongs to the dusty clay group and has a slightly alkaline reaction, according to the findings of the preliminary analysis (Table 1).

Application of organic matter and sand

After that, sand and organic material were added to the polybag containing the planting media. Control, which contained no organic matter (B0); 41.06 grams/polybag compost made from banana peels and cow dung (10:1) (B1); 41.06 grams/polybag compost made from leaf litter (B2); 41.06 grams/polybag compost made from water hyacinth and cow dung (1:1) (B3); and 2.74 grams/polybag biochar (B4). The organic matter used in the B1 treatment had the following properties: pH 10.11, Organic-C 53.98%,

Table 1. Vertisol characteristics

Parameter	Unit	Result	Criteria*
pH		7.85	Slightly alkaline
Organic-C	%	1.46	Low
P_2O_5	ppm	12.18	Medium
Ammonium	ppm	374.32	-
Nitrate	ppm	97.99	-
CEC	$cmol.kg^{-1}$	29.74	High
Texture			
Sand	%	4	Silty loam
Silt	%	83	Silty loam
Clay	%	13	Silty loam

Remarks: *) criteria sourced from Eviati and Sulaeman (2009).

ammonium and nitrate levels of 1894.97 ppm and 359.24 ppm, respectively; Organic-C 10.87%, pH 6.77, ammonium and nitrate levels of 969.21 ppm and 392.49 ppm; and the final B3 treatment, pH 7.59, Organic-c 11.45%, ammonium and nitrate levels of 951.85 ppm and 388.98 ppm, respectively.

Plant corn to harvest and plant maintenance

The Bonanza F1 type of corn seeds was utilized. The NPK 15-15-15 250 kg/ha fertilizer and the urea fertilizer were applied three times: just before planting and twenty and thirty-five days after planting (DAP). Plant upkeep included watering, weeding, and managing pest. Thirty-five days after planting (DAP), the plants were harvested.

Observation

Titrimetric distillation was used to measure available nitrogen (NH_4^+ and NO_3^-), the electrometric method was used to measure pH values, the Walkey and Black method was used to measure Organic-C, and the NH_4OAc pH 7 method was used to measure Cation Exchange Capacity (CEC). The Arnon method was used to analyze chlorophyll and the l x w x c method was used to measure leaf area. At 0, 30, and 60 DAP, soil samples were taken to measure soil chemical characteristics. At 40 DAP, measurements of leaf area and chlorophyll parameters were taken.

Data analysis

The data obtained were analyzed for diversity (ANOVA) with an F test at an error rate of 5%, to determine the effect of the applied treatment. If there is a significant difference between treatments, a further test of Honest Significant Difference (HSD) is conducted at a 5% significance level.

RESULTS AND DISCUSSION

Soil pH

The availability of nutrients and chemical reactions in the soil are correlated with the pH level of the soil. The application of sand and organic matter significantly changed the soil's pH value at 0 DAP, but not at 30 or 60 DAP, according to the statistical analysis's findings (Table 2). Since the soil's pH is greater than 7.0, it is generally categorized as alkaline. The optimal combined treatment for soil pH is 20% sand (B0P2) at 0 DAP with no organic matter. The pH of the soil is lower in this treatment than it was in the first and subsequent treatments, because applying compost and biochar can alter the soil's pH level. The pH of vertisol soil is classified as alkaline (Charishma et al., 2023). Adding organic materials will significantly increase the pH of the soil. Plants cannot thrive in soil that has an alkaline pH. Because it binds to calcium, it can render certain nutrients, including available P, unavailable to plants (Johan et al., 2021). The further decomposition of mixed organic matter during planting has released OH^- ions from the absorption complex, increasing soil pH (Wirawan, 2018). In the meantime, adding sand can alter the soil's pH because it is said that the pH of the soil steadily drops as more sand is added to the vertisol (Arvienda et al., 2023).

Soil organic carbon (SOC)

Organic carbon, a vital part of soil organic matter, is important for determining the fertility and productivity of the soil, which in turn affects the physical, chemical, and biological properties of the soil. Adding sand and organic matter to organic-C

Table 2. Soil pH value at 0, 30, and 60 days after planting (DAP)

Treatment	pH		
	0 DAP	30 DAP	60 DAP
B0P0	7.85 cdef	7.79	7.95
B0P1	7.86 def	8.14	8.12
B0P2	7.66 a	8.23	8.18
B1P0	7.93 fg	7.84	7.97
B1P1	7.98 g	8.07	8.13
B1P2	7.79 bcde	8.12	8.15
B2P0	7.95 fg	7.85	8.03
B2P1	7.99 g	8.01	8.25
B2P2	7.73 ab	8.03	8.20
B3P0	7.75 abc	7.83	8.12
B3P1	7.79 bcd	7.96	8.14
B3P2	7.79 bcd	8.05	8.28
B4P0	7.90 efg	7.79	8.08
B4P1	7.95 fg	8.08	8.08
B4P2	7.99 g	7.96	8.27
HSD 5%	0.10**	ns	Ns

Remarks: B0 = without organic matter, B1 = 15 ton.ha^{-1} banana peel + cow dung compost (10:1), B2 = 15 ton.ha^{-1} leaf litter compost, B3= 15 ton.ha^{-1} water hyacinth + cow dung compost (1:1), B4 = 1 ton.ha^{-1} Biochar, P0 = 0% of sand, P1 = 20% of sand, and P3 = 40% of sand, * indicates significant result between the group means, ** indicates highly significant result between the group means, and ns indicates not significant result between the group means.

Table 3. Organic-C of soil at 0, 30, and 60 days after planting (DAP)

Treatment	Organic-C (%)		
	0 DAP	30 DAP	60 DAP
B0P0	1.73 cd	1.60 abcd	2.28
B0P1	1.24 abc	1.22 abc	1.88
B0P2	1.71 cd	1.08 ab	1.79
B1P0	1.67 bcd	1.66 bcd	2.38
B1P1	1.38 abcd	1.03 a	1.88
B1P2	1.76 cd	1.23 abc	1.55
B2P0	1.59 bcd	1.60 abcd	2.39
B2P1	1.31 abcd	1.26 abcd	2.09
B2P2	1.84 d	1.48 abcd	1.55
B3P0	1.69 bcd	1.48 abcd	2.48
B3P1	1.15 ab	1.28 abcd	2.05
B3P2	1.74 cd	1.74 cd	1.01
B4P0	1.48 bcd	1.83 d	2.06
B4P1	2.63 e	1.07 a	2.00
B4P2	0.94 a	1.39 abcd	0.99
HSD 5%	0.54**	0.58*	ns

Remarks: B0 = without organic matter, B1 = 15 ton.ha^{-1} banana peel + cow dung compost (10:1), B2 = 15 ton.ha^{-1} leaf litter compost, B3= 15 ton.ha^{-1} water hyacinth + cow dung compost (1:1), B4 = 1 ton.ha^{-1} Biochar, P0 = 0% of sand, P1 = 20% of sand, and P3 = 40% of sand, * indicates significant result between the group means, ** indicates highly significant result between the group means, and ns indicates not significant result between the group means.

soil had a significant effect between 0 and 30 DAP, but not at 60 DAP, according to statistical analysis (Table 3).

The combined treatment of biochar and 20% sand (B4P1) at 0 DAP produced the greatest results, while the combined treatment of biochar and 0% sand (B4P0) produced the best results at 30 DAP. As the carbon in rice husk biochar is stable and difficult for soil microbes to break down, applying it can increase the amount of organic carbon in the soil (Abel et al., 2021). Adding biochar to soil is possible to increase organic carbon and nutrient content. However, offering 0% and 20% sand is preferable to 40% because the addition of sand causes the soil to have higher levels of aeration and drainage. Air exchange in the soil is significantly affected by proper drainage and aeration, which in turn affects the activity of soil microbes involved in the breakdown of organic matter. Low amounts of soil organic matter can result from excessive oxidation of organic matter into soil minerals caused by excessive aeration (Tangketasik et al., 2012).

Available nitrogen (NH_4^+ and NO_3^-)

One of the most essential nutrients, nitrogen plays a crucial part in the growth phase of plants. In order to sustain their growth phase, corn plants require nitrogen elements. Nitrogen (N) from the soil is often absorbed by non-legume plants as nitrate (NO_3^-) or ammonium (NH_4^+), On the other hand, nitrate is the type of nitrogen (N) that plants mostly absorb in most agricultural soils (Tando, 2018). The application of sand and organic matter to NH_4^+ had a significant effect at 0 and 60 DAP, but not at 30 DAP, according to the statistical analysis results (Table 4). The combined treatment of cow dung and banana peel compost with 0% sand produced the best NH_4^+ result (B1P0). At 0, 30, and 60 DAP, the supply of sand and organic matter had a substantial impact, according to the statistical analysis results of NO_3^- (Table 4). The combination of 40% sand, cow manure, and composted banana peels produced the best results (B1P2).

When compost is sufficiently mature, its pace of decomposition is perfect. The process of decomposition yields basic molecules, such CO_2, that microbes can use fast and that plants may use as nutrients and inorganic ions, such as NH_4^+, NO_3^-, Ca^{2+} and K^+ (Ravn et al., 2020). Since most of the nitrogen found in nature is in organic forms that plants can not consume, its availability is determined by the mineralization or degradation processes. The materials used, soil pH, temperature, moisture, and microbes are some

Table 4. Available-N of soil at 0, 30, and 60 days after planting (DAP)

Treatment	NH_4^+ (ppm)			NO_3^- (ppm)		
	0 DAP	30 DAP	60 DAP	0 DAP	30 DAP	60 DAP
B0P0	294.30 bc	255.69	172.05 ab	200.52 de	152.26 c	68.28 bc
B0P1	229.77 ab	121.09	170.31 ab	291.15 f	60.61 ab	19.89 a
B0P2	197.37 a	107.95	152.59 ab	149.41 bc	69.74 ab	72.20 bc
B1P0	389.91 d	235.76	181.86 ab	222.35 e	105.31 bc	68.46 bc
B1P1	255.27 ab	186.49	189.89 b	147.38 bc	74.04 ab	33.40 ab
B1P2	333.38 cd	148.25	317.82 c	303.40 f	38.39 a	102.79 c
B2P0	254.89 ab	255.21	148.81 ab	128.97 b	149.89 c	94.99 c
B2P1	231.94 ab	184.06	151.30 ab	201.86 de	83.85 ab	104.71 c
B2P2	203.82 a	148.49	141.44 ab	66.05 a	59.39 ab	87.31 c
B3P0	367.42 cd	221.13	155.96 ab	172.57 cd	59.01 ab	80.82 c
B3P1	245.24 ab	175.30	191.23 b	226.97 e	79.18 ab	174.50 d
B3P2	180.11 a	129.28	194.90 b	125.18 b	75.96 ab	75.55 bc
B4P0	219.48 ab	180.51	185.57 ab	79.47 a	81.47 ab	59.95 abc
B4P1	235.29 ab	127.59	274.58 c	183.48 cd	72.09 ab	57.54 abc
B4P2	203.38 a	102.91	130.72 a	149.59 bc	71.06 ab	79.46 bc
HSD 5%	76.10**	Ns	57.32**	36.87**	59.84**	47.01**

Remarks: B0 = without organic matter, B1 = 15 ton.ha^{-1} banana peel + cow dung compost (10:1), B2 = 15 ton.ha^{-1} leaf litter compost, B3= 15 ton.ha^{-1} water hyacinth + cow dung compost (1:1), B4 = 1 ton.ha^{-1} Biochar, P0 = 0% of sand, P1 = 20% of sand, and P3 = 40% of sand, * indicates significant result between the group means, ** indicates highly significant result between the group means, and ns indicates not significant result between the group means.

of the variables that affect the breakdown of organic matter (Piaszczyk et al., 2022). Because banana peel compost has the highest nitrogen content (1894.97 ppm) in comparison to other treatments, the NH_4^+ results in this study indicated that the best outcomes were obtained in banana peel + cow dung with 0% sand. When 40% sand was added to banana peel + cow dung compost, the NO_3^- parameter showed the best results. Sand application can increase NO_3^- levels because nitrification, one of the nitrogen mineralization processes, transforms NH_4^+ into NO_3^-. Soil aeration can affect this process (Ayiti and Babalola, 2022).

Sand treatment can improve the texture of vertisol soil, enhancing drainage and aeration. The storage of plant nutrients, particularly accessible nitrogen (ammonium and nitrate), water movement, and nutrients uptake are most effectively possible for plant growth in soil with adequate drainage and aeration. This study found that sand did not substantially alter the characteristics of vertisol soil, which has a high clay content and acts as a soil colloid to bind nutrients. The fact that the NH_4^+ content is greater than the NO_3^- content is demonstrated in Table 4. This is due to the soil's nitrate's easy leaching due to its negative charge. In contrast to the positively charged ammonium, soil colloids bind it; therefore, ammonium is not easily lost through the leaching process (Kusuma, 2023).

Soil cation exchange capacity (CEC)

The ability of soil to exchange cations (positively charged ions) with other cations in soil solution is known as cation exchange capacity or CEC. The degree to which clay can absorb and exchange cations is another way to define the exchange capacity of cations. Both organic and inorganic particles, as well as anions (negatively charged ions), can be absorbed by cations (Masria et al., 2019). One of the key chemical characteristics of soil is its cation exchange capacity, which influences the availability of nutrients to plant roots, determining how easily and readily they can be absorbed. Sand and organic matter treatment did not significantly affect soil CEC at 0, 30, or 60 DAP, according to statistical analysis results (Table 5). Soil CEC levels at 0 and 60 DAP can be increased by treating the soil with sand and organic matter overall. Nevertheless, at 30 DAP, the CEC value dropped from the soil's pretreatment state.

A decline in CEC could be caused by two conditions.

Table 5. CEC of soil at 0, 30, and 60 days after planting (DAP)

Treatment	CEC (cmol.kg^{-1})		
	0 DAP	30 DAP	60 DAP
B0P0	35.68	26.01	38.49
B0P1	32.81	24.85	37.02
B0P2	22.56	13.38	32.56
B1P0	37.96	23.56	37.03
B1P1	31.57	24.01	35.05
B1P2	22.81	14.92	30.62
B2P0	34.11	27.07	29.62
B2P1	32.40	24.92	32.78
B2P2	23.76	18.50	31.99
B3P0	37.36	23.84	32.38
B3P1	26.95	18.84	31.21
B3P2	23.30	14.03	32.89
B4P0	35.27	24.68	32.53
B4P1	24.21	17.77	32.82
B4P2	24.02	17.57	34.91
HSD 5%	ns	Ns	ns

Remarks: B0 = without organic matter, B1 = 15 ton.ha^{-1} banana peel + cow dung compost (10:1), B2 = 15 ton.ha^{-1} leaf litter compost, B3= 15 ton.ha^{-1} water hyacinth + cow dung compost (1:1), B4 = 1 ton.ha^{-1} Biochar, P0 = 0% of sand, P1 = 20% of sand, and P3 = 40% of sand, * indicates significant result between the group means, ** indicates highly significant result between the group means, and ns indicates not significant result between the group means.

The first was due to less biological matter available. Because soil microbes use organic matter as fuel, the amount of organic matter in the soil diminishes. Microbes reuse the organic matter in the soil after the supplied organic matter has fully broken down (Halasan et al., 2018), which lowers the organic-C content and, consequently, the CEC. The second was the application of sand with a low surface area, lowering CEC in vertisol soil.

Sand content had a negative correlation with soil CEC, whereas clay and organic matter content had a positive correlation. Yunan et al. (2018) showed that clay content and organic matter were positively correlated with soil CEC, while sand content was negatively correlated with CEC. Clay content in the soil increases the buffer capacity of the soil and minimizes nutrient leaching (Minhal et al., 2020). This study showed that the treatment with the highest soil CEC value (B0P0) had a value of 38.49 $cmol.kg^{-1}$, whereas the treatment with the lowest value (B0P2) had a value of 13.38 $cmol.kg^{-1}$. This results in a low CEC value because of the soil's high sand concentration. As sand lacks the negative or colloidal charge present in soils with a more dominant clay fraction, it is unable to absorb or release cations, which is why high sand fraction soils frequently result in nutrient leakage (Bahar et al., 2020).

Leaf area and chlorophyll

Both naturally occurring and cultivated plants will grow. In theory, leaf growth indicates its expansion, and the leaf growth causes and explains conditions of enhanced growth. With regard to leaves, one of the crucial factors required to assess plant growth is leaf area. Furthermore, because it facilitates photosynthesis, the amount of chlorophyll in leaves is a crucial factor in plant growth. The statistical analysis's findings demonstrated that the addition of sand and organic matter significantly affected the sweet corn plants' leaf area and chlorophyll (Table 6). The highest value was obtained in the treatment with banana peel compost + cow manure and sand 20% (B1P1) with a leaf area of 577.63 cm^2 and chlorophyll content of 68.48 $mg.l^{-1}$. The lowest leaf area was obtained in the treatment with hyacinth compost + cow manure and sand 20% (B3P1) with a value of 279.10 cm^2 and the lowest chlorophyll content was obtained in the treatment with leaf litter compost and sand 40% (B2P2) with a value of 21.43 $mg.l^{-1}$. When compared to alternative treatments,

Table 6. Leaf area and chlorophyll at sweet corn plant

Treatment	Leaf area (cm^2)	Chlorophyll ($mg.l^{-1}$)
B0P0	429.96 de	31.37 ab
B0P1	308.02 abc	64.12 ef
B0P2	338.05 abcd	38.04 bc
B1P0	564.60 f	22.54 a
B1P1	577.63 f	68.48 f
B1P2	297.83 ab	44.58 cd
B2P0	448.43 e	48.51 cd
B2P1	392.87 bcde	48.86 cd
B2P2	312.17 abc	21.43 a
B3P0	453.68 e	24.30 a
B3P1	482.13 ef	38.06 bc
B3P2	279.10 a	61.89 ef
B4P0	458.00 e	27.18 ab
B4P1	405.75 cde	46.16 cd
B4P2	289.00 ab	56.16 de
HSD 5%	106.11**	12.18**

Remarks: B0 = without organic matter, B1 = 15 $ton.ha^{-1}$ banana peel + cow dung compost (10:1), B2 = 15 $ton.ha^{-1}$ leaf litter compost, B3= 15 $ton.ha^{-1}$ water hyacinth + cow dung compost (1:1), B4 = 1 $ton.ha^{-1}$ Biochar, P0 = 0% of sand, P1 = 20% of sand, and P3 = 40% of sand, * indicates significant result between the group means, ** indicates highly significant result between the group means, and ns indicates not significant result between the group means.

the inclusion of banana peel compost, cow manure, and 20% sand can yield the best results. Compost that has been combined with cow dung and banana peel waste has an organic-C content of 41.74%, 2.22% nitrogen, 0.39% phosphorus, 12.72% potassium, and an 18.88 C/N ratio (Ani et al., 2016).

The amount of nitrogen has a significant impact on the vegetative growth of plants. Nitrogen is absorbed by plants in the form of NH_4^+ and NO_3^- through the roots. Plants with an adequate supply of nitrogen can develop more quickly on their stems, branches, and leaves. It is believed that a balanced comparison of NH_4^+ and NO_3^- concentrations can promote more leaf chlorophyll production in plant tissues, increasing photosynthetic activity and the amount of carbohydrates produced during photosynthesis (Aziz and Kurnia, 2015). However, a 20% sand treatment can improve the physical characteristics of vertisol, creating the best growing circumstances for plants, particularly in corn plants' leaf area and chlorophyll content. River sand can improve the physical characteristics of vertisol soil by increasing its porosity, aeration, and drainage, which will increase the soil's oxygen content and provide microorganisms with the energy they need to move around, so promoting plant growth and development (Arvienda et al., 2023).

CONCLUSIONS

According to the study's findings, the combined treatments between banana peel compost and cow dung with 0% sand and 40% sand on NH_4^+ and NO_3^- content produced the best results. The control treatment with 40% sand had the best soil pH, and the combination between aloe vera compost and cow dung with 0% sand produced the highest soil organic-C. When it comes to leaf area and chlorophyll, the combined treatment of composted banana peels and cow dung with 20% sand produced the best results.

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