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Changes of Soil Density and Water Content at the Treatment of Compost Media and Husk Charcoal on Lettuce Plants in the Land Degradation

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Abstract: Soil density and soil water content are physical properties that greatly affect the process of nutrient absorption in plants. This study aims to determine changes in soil density and soil water content in the treatment of compost and husk charcoal on lettuce production on degraded land. Degraded soil is soil that is low in nutrients. Thus, to increase the fertility of the soil, it is very necessary, one way is to provide compost and husk charcoal in the planting media. This study used four treatments with six replications, (M_0) control (M_1) compost 2.50 kg (M_2) husk charcoal 2.5 kg and (M_3) compost and husk charcoal 2.50 kg. Changes in soil water content and the highest was compost and husk charcoal (M_3) volume 13.03 to 39.50 %, the best soil density was husk charcoal (M_3) 0.66 gcm-3. The highest lettuce production was (M_3) 1.32 kg. The use of compost and husk charcoal (M_3) gave the best changes in soil properties and resulted in the highest production of lettuce.

Keywords: Compost Media; Husk Charcoal; Land Degradation; Lettuce Plant; Soil Density; Soil Moisture content; Water Content

Introduction

Lettuce *(Lactuca sativa L.)* is a short-lived vegetable crop and is suitable for planting in the lowlands and highlands and has a fairly high economic value. Lettuce plants have quite promising market opportunities because people are aware that their nutritional content and production do not meet people's needs. One of the efforts to increase lettuce production is to fulfill nutrient needs in lettuce cultivation (Abazajian et al., 2022; Majid et al., 2022; Miller et al., 2022; Tayyab et al., 2022). The needs of lettuce plants technology and the carrying capacity of soil fertility are strongly supported by technology and carrying capacity of soil fertility. Cultivating lettuce on dry land on Inceptisol soil often has constraints on nutrient availability and soil moisture. Therefore, giving biochar charcoal husk and compost fertilizer to increase nutrients and maintain soil moisture in lettuce planting application of organic matter is one of the efforts to improve the physical, chemical and biological properties of soil and biochar is considered a potential strategy to absorb C-organic. Efforts to reduce nutrient leaching can be in the form of adding biochar to the soil (Liu et al., 2014). Biochar is produced by the pyrolysis of different carbon-rich residues from natural agriculture and forestry (Trinh et al., 2017). Wijitkosum's research (2022) reports that rice husk is the main by-product of the rice processing industry and is produced in large quantities. Improvement of soil properties, growth and increase in crop production can be achieved as a result of adding biochar to the land (Prasertsuk & Wijitkosum, 2021).

Biochar is a biological charcoal obtained from incomplete combustion, leaving nutrients and 50% carbon (C) which can improve nutrient circulation and soil drainage (Wijitkosum, 2022). Research on the effect of biochar on soil fertility and plant growth has been widely reported, but research on the effect of biochar on vegetable cultivation is still limited (Manolikaki & Diamadopoulos, 2017; Mehmood et al., 2018).

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Information about the effect of biochar on soil physical properties is also important to study (Ghorbani et al., 2019; Nabila et al., 2021) stated that husk charcoal biochar could affect all parameters of plant growth and production to be the highest compared to other treatments. Furthermore, Agu & Neonbeni (2019) stated that the addition of husk charcoal biochar and compost to lettuce plants had the highest effect on plant height and wet weight of lettuce plants.

Organic matter in the form of compost applied to the soil surface reduces evaporation and provides a more suitable environment for root growth and releases nutrients that increase vegetative cover. Furthermore, Kannan et al. (2021) and (Subramanian et al., 2022; Usman et al., 2022) stated that the addition of compost to the soil can increase chlorophyll in plant leaves, added by Tan et al. (2021) that the addition of compost to the planting medium is a treatment best for the growth and production of vegetable crops. Compost is able to reduce nutrient leaching including nitrogen which can play a direct role in plant growth (Galsim et al., 2021), further Dahlianah (2019) stated that adding 250 g of compost to plants had the highest effect on plant height and plant wet weight.

Chaff charcoal is a soil enhancer that can improve soil properties in efforts to rehabilitate land and improve plant growth. Adding husk charcoal to Inceptisols soil planting media which has poor drainage can increase the total pore space and accelerate groundwater drainage (Setyawati et al., 2021). Furthermore, Dakiyo et al. (2022) added that husk charcoal added to the planting medium in lettuce plants had a significant effect on plant height and number of leaves of lettuce plants. The application of rice husk biochar on inceptisol soil is expected to affect the physical properties of the soil and can provide plant nutrients through the overhaul of compost organic matter in lettuce plants. Added by Komariah et al. (2022) that on dry land planting lettuce on Inceptisol soil during the rainy season can guarantee the availability of water so that it can help the shallow and delicate roots of lettuce in the absorption and respiration processes. Applying rice husk charcoal biochar to the planting medium can increase the availability of organic matter and when combined with compost, the previous soil which had nutrient availability constraints can gradually provide nutrients while maintaining soil moisture and increasing water availability for lettuce plants (Agu & Neonbeni, 2019). Therefore, efforts to improve soil moisture and aeration of Inceptisols so that they can be planted with lettuce every season need to be carried out, so that the availability of nutrients from the breakdown of organic matter from compost and changes in water availability in the soil can increase the growth and production of lettuce plants.

By using the right composition of the planting medium and using the appropriate dosage of compost, it is hoped that it will be able to change the weight of the soil and the water content of the soil so as to encourage maximum growth and production of lettuce so that it can increase the weight of lettuce plants. The purpose of this study was to determine the effect of planting media on changes in soil volumetric properties and soil water content and production of lettuce *(Lactuva sativa L.)* on inceptisol soil.

Method

This research was conducted at the UGN Tor Simarsayang Padangsidimpuan agricultural campus from December 2019 to February 2020. The research was conducted on Dystropepts soil with a loamy clay structure, the soil samples were dried and ground to pass through a 2-mm sieve. Soils were measured by the method: Soil pH and electrical conductivity (EC) were measured in a 1:1 soil-to-water solution and in saturated extract, respectively. Bulk density (BD) is determined by the ring method (Blake & Hartge, 1986), soil water content by gravimetric method.

Biochar

The biochar used results from the process of slow pyrolysis of rice husk under limited oxygen conditions. Rice husk pyrolysis was carried out using a biochar reactor where 50% of rice husk biomass was converted into biochar. After pyrolysis, the biochar samples were collected and cooled to room temperature.

Research Stages

The research area used was first cleaned of weeds, leveled the ground surface and made drainage trenches to avoid stagnant water when it rains. After that the mixed planting medium is left for 24 hours so that the microorganisms in the media decompose. Before planting, the seeds used are curly lettuce seeds after that the seeds must first be sown in a germination tub. Seeding is done until the plant seeds have 3-5 leaves. Water needs are met at the start of seeding. Planting was carried out simultaneously in each treatment. Lettuce seeds are planted directly in polybags as much as 2 seeds/polybag.

Experimental design

The lettuce was planted after the nursery and then planted in 5 kg polybags. This research was conducted using a Non-factorial Randomized Block Design (RBD), with 4 treatments and 6 replications. The treatment factors in this study were: M0: Control, M1: Compost (2.5 kg soil + 2.5 kg compost), M2: Rice husk (2.5 kg soil + 2.5 kg charcoal), M3: Compost + charcoal (1.5 kg of soil

+ 1.5 kg of compost + 1.5 kg of husk charcoal). Variables in this study include: plant height, number of leaves, leaf length, plant wet weight, soil weight, soil water content.

Result and Discussion

Result

Observation of the results in this study in the growth and production phase of lettuce plants was observed from the age of one (1) week after planting to five (5) weeks after planting. These observations included plant height (cm), leaf length (cm), number of leaves (strands) and fresh weight of lettuce plants (kg). Observations on the physical properties of the soil are soil bulk density (gcm-3) and soil water content (%)

Plant height

The results of observing the height of lettuce plants at the age of 1-5 weeks after planting can be seen in the following table 1.

Table 1. Average plant height at the samples age 1-5 weeks after planting (cm).

Treatment	High of Plant (cm)				
	I	II	III	IV	V
M0	7.6a	8.8a	10.9 a	11.5a	12.3a
M1	9.1b	10.3ab	12.9b	14.5bc	15.7b
M2	9.5bc	11.5bc	13bc	13.9b	15.3b
M3	9.2b	12.6c	14.4c	15.6c	16.3c

Note: Numbers followed by the same letter in the same column shows numbers that are not significantly different in the 5% analysis of variance

In Table 1 it can be seen that the M3 treatment (soil, compost, husk charcoal) had a significant effect on week V. The increase in plant height in the M3 treatment (soil, compost, charcoal husk) was higher when compared to other treatments. The application of compost and husk charcoal affects the physical properties of the soil and the soil is increasingly able to decompose organic matter slowly so that the nutrients needed by lettuce plants are available. Sugiarto et al. (2021) informed that the biological activity of microorganisms in treated soil is in the form of additions (amendments), so this greatly affects microbial activity in the breakdown of organic matter into available nutrients.

Several studies reported that the addition of biochar and compost can accelerate biochar mineralization by microbes due to the addition of substrate (Sánchez-Monedero et al., 2019). Thus, the addition of biochar and compost has a beneficial impact on plants because it can support soil pH to normal and can affect the availability of nutrients for plants (Ghorbani et al., 2019). Added by Gusnidar et al. (2019) that applying compost can increase plant growth and can replace 50% of the need for synthetic fertilizers.

Leaf Length

Based on the results of observations of the leaf length parameter, it can be seen from the results of the average number of lettuce leaves at the age of observation 3-5 WAP as follows:

Table 2. Average Leaf Length (cm) 3-5 WAP

Treatments	Leaf Length (cm)		
	III	IV	V
M0	11.1 a	12.6 a	13.2 a
M1	11.7 b	12.7 ab	14.2 c
M2	11.9 b	12.6 b	13.6 b
M3	13.1 c	14.5 c	17.4 d

Note: Numbers followed by the same letters in the same column show numbers that are not significantly different in Duncan's 5% test.

In Table 2 it can be seen that each observation from week I to week V of the M3 treatment (soil, compost, husk charcoal) had a significant effect on leaf length compared to other treatments. According to Fadhillah & Harahap (2020) that adding husk charcoal to the planting medium can improve the porosity and rooting of plants so that plants can absorb nutrients resulting in better growth. Further added Okalia et al. (2021) that when the plant undergoes an overhaul, the nutrients in the biochar and manure planting media are available for the plant. Nutrients available in the soil will be directly absorbed by plants and used in metabolic processes so that plants can grow and produce. Furthermore, Siadari (2022) added that biochar planting media can have a significant effect on the formation of leaf length and harvest wet weight in mustard greens.

Number of Leaves

The results of observing the number of leaves of lettuce plants at the age of 3-5 WAP can be seen in the Table 3.

Table 3. Average Number of Leaves (strands) ages III-V MST

Treatment	Number of Leaves		
	III	IV	V
M0	5.8 a	7.8 a	9.1 a
M1	6.6 b	8.1 ab	11.6 c
M2	6.6 b	9.6 b	10.6b
M3	6.8 c	10.6 c	11.6 c

Note: Numbers followed by the same letter in the same column show numbers that are not significantly different in Duncan's 5% test.

In Table 3 it can be seen that the number of leaves on lettuce plants at III MST did not have a significant

effect between treatments M1 (soil + rice husk) and M2 (soil + compost) where the media used in the treatment had not decomposed in the short term. At V MST. The process of overhauling organic matter in the soil takes time to decompose organic matter into an organic matter. Related to research from Titiaryanti et al. (2018)that changes in soil properties due to the application of organic matter can have a direct effect on plant growth and also have an indirect effect. The direct effect is a change in soil chemical properties characterized by the availability of nutrients that can be absorbed by plant roots. While the indirect effect is a change in the nature and characteristics of the soil that supports the improvement of aerase and soil structure and soil moisture. The histogram of the number of leaves can be seen in Figure 1.

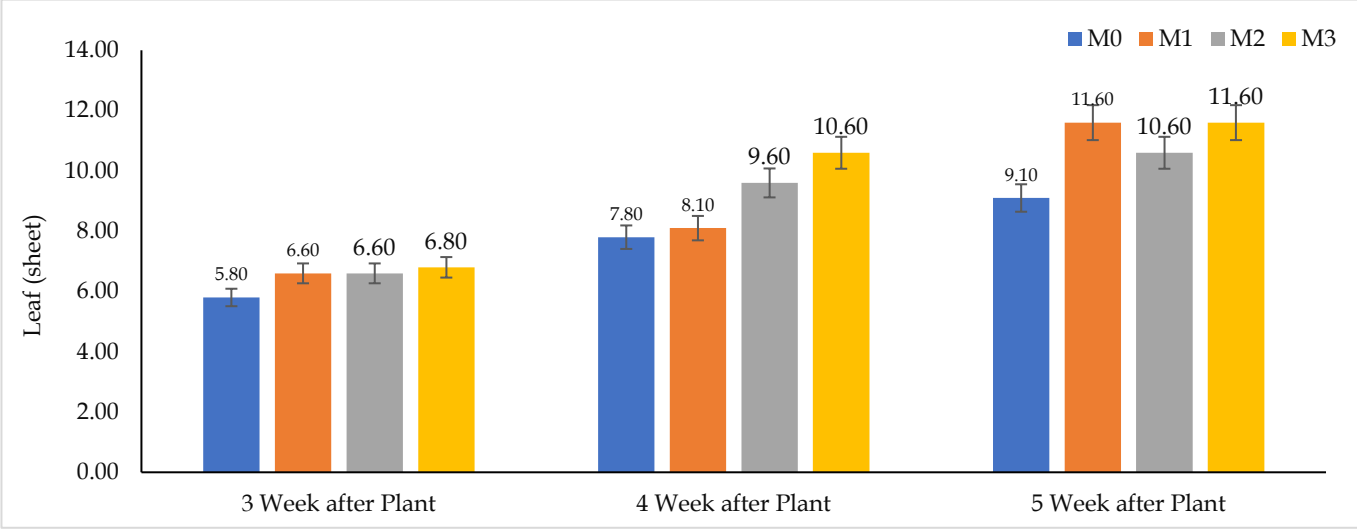

Figure 1. Histogram of the number of lettuce leaves in each treatment 3-5 WAP

From the graph above the percentage of the number of leaves of lettuce plants can be seen that the highest average number of leaves was in the 5th week of MST with the M1, M2 and M3 treatments, while the lowest was in the M0 treatment where the media used in M0 was the control or without treatment where the control had limited nutrient content so that lettuce plants require additional nutrients in the soil through the addition of organic matter needed by plants for the growth of lettuce plants.

The number of leaves of lettuce plants is influenced by the availability of nutrients found in the planting medium of husk charcoal and compost. The results of Jumhari et al. (2018) stated that husk charcoal can be used as a planting medium because it can withstand leaching of nutrients, reduce the toxicity of heavy metal elements so as to support the development of microorganisms in the soil. Thus, the rice husk mixture in the planting medium can improve soil structure due to better aeration and drainage.

Lettuce Wet Weight

The treatment of planting media with compost and rice husk charcoal had a significantly different effect between treatments, this can be seen in the observations of the wet weight results of lettuce plants aged 5 weeks after planting as shown in Table 4.

Table 4 the results of Duncan's test of variance show that the treatment of the weight of the lettuce gave results that were not significantly different.The average fresh weight of lettuce plants showed that the highest weight of lettuce plants was found in treatment M3, which was 1.32, M1, which was 1.28, M2, which was 0.55, and M0, which was 0.37. The media used in the M3 treatment (soil + compost + husk charcoal) had the highest effect on the average fresh weight of lettuce plants. This is because the application of planting media to inceptisol soil, compost and husk charcoal can affect the weight of lettuce and an increase in plant production because plants really need good nutrients for growth to plant production and in polybags there is an increase in exchange bases and CEC after application compost.

Table 4. Average Wet Weight of Lettuce Plants (g)

Treatments	Lettuce Wet Weight (kg)
M0	0.37 a
M1	1.28 c
M2	0.55 b
M3	1.32 d

The highest average fresh weight of lettuce plants was in the M3 treatment (compost and husk charcoal). It is suspected that the compost media and rice husk charcoal affect the physical properties of the soil so that the soil becomes looser and can increase soil porosity

which causes roots to absorb nutrients more optimally. Dodi et al. (2018) stated that compost media can increase the absorption of plant roots for water and nutrients. Compost media can increase the area of absorption of nutrients.

Charcoal growing media is produced from burning husks which causes materials that are harmful to plants to be burned so they do not contain toxins for plants. Chaff charcoal has a lighter weight than other organic materials so it has the ability to hold more water. This is in accordance with the statement Manullang et al. (2019) which states that rice husk charcoal is able to hold higher water and is black in color and can absorb radiation and has a high pH and is suitable for acid soils. Husk charcoal growing media gave the best effect on lettuce plants.

Soil Fill Weight

The average weight of soil content in lettuce plants due to the treatment of compost and rice husk charcoal planting media can be seen in Figure 2.

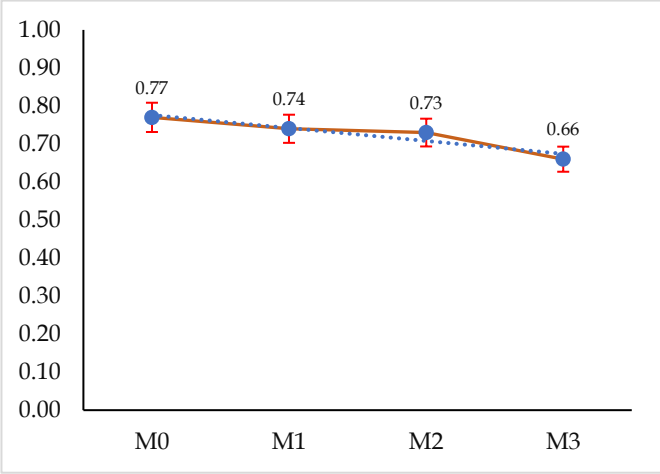

Figure 2. Average of Soil Bulk Density

Based on Figure 2, it can be seen that the parameter of soil bulk density in lettuce plants. The bulk weight of the soil before giving treatment was 0.77 g cm-3. The effect of compost and rice husk charcoal planting media on soil bulk density can be seen that the highest average bulk density was in treatment M0, namely 0.77 grcm-3, while the lowest average bulk density was found in treatment M3, namely 0.66 grcm-3. 3 with the treatment (soil + rice husk + compost) decreased the bulk density of the soil, while the M2 treatment (soil + charcoal husk) had a soil bulk density value of 0.73 grcm-3 lower than the M1 treatment (0.74 grcm -3).

The soil unit weight value indicates the particle density of the soil portion. If the bulk density of the soil is high, the soil particles will be denser, making it difficult for water to pass through and plant roots can penetrate them. Compost and rice husk planting media have a light bulk density compared to soil. Thus, the addition of compost media and husk charcoal to the soil will reduce the bulk density of the soil. This was stated by Rosman et al. (2019) in his research that the application of organic fertilizer doses can reduce soil bulk density by 15.57%, and increase 10.38% soil water content, 12.97% soil porosity and 49.77 % soil permeability.

Compost and rice husk charcoal immersed in the soil can reduce soil bulk density so that soil macro pores begin to form and make it easier for plant roots to penetrate. Sugiarto et al. (2021) states that applying charcoal and manure to the land can improve soil structure so that the soil becomes more friable and reduces soil bulk density and improves soil structure and soil porosity. This is very beneficial for plant roots in absorbing nutrients in the soil. When organic particles are combined with mineral particles, the unit weight of the soil will be low. This has an effect on the higher water content and retention and the infiltration rate is also higher.

The addition of husk charcoal biochar to the soil greatly affects soil structure and has the effect of reducing soil bulk density. In accordance with the results of research (Toková et al., 2020) stated that the application of biochar combined with other organic materials or inorganic N fertilizers to the soil is a technology that increases the sustainability of intensive agriculture which improves soil physical and hydrophysical properties that affect soil structure.

Soil Water Content

The results of the analysis of observations of soil water content due to the treatment of compost and biochar planting media on lettuce after harvest can be seen in the Table 5.

Table 5. Average Soil Water Content (% volume)

Treatments	Soil Water	
	Before	After
M0	13.03	13.05
M1	13.03	37.00
M2	13.03	37.67
M3	13.03	39.50

Table 5 shows changes in soil water content before the soil was treated and soil water content after the planting media was treated. The lowest water content after being treated was 13.05% by volume in treatment M0 while the highest water content was found in treatment M3 which was 39.50% by volume. Changes in water content in each treatment can be seen in Figure 3.

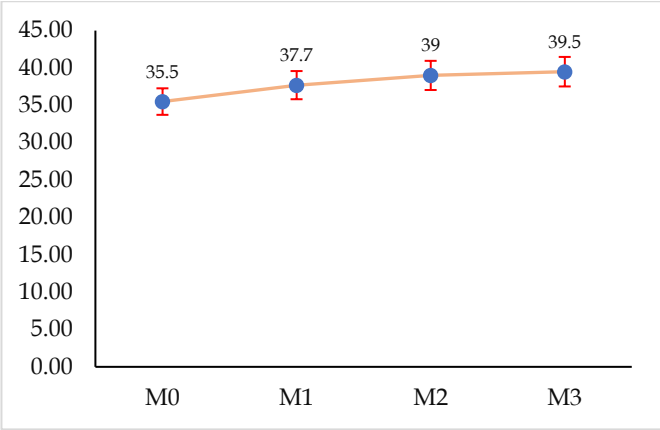

Figure 3. Average soil water content in each treatment

Based on Figure 3, it can be seen that the parameters of soil water content in lettuce plants after the planting media treatment had an effect on all treatments, of all treatments there was the highest soil water content in the M3 treatment. It is possible that the planting medium used can increase soil water content because the planting medium of compost and rice husk as organic matter can increase the water holding capacity in the soil. This is in line with Blanco-Canqui (2021) that applying biochar has the same effect as manure, which can reduce soil compaction and increase soil moisture content.

The highest water content was found in the M3 treatment (compost and husk charcoal) and the lowest was in the M0 treatment, namely the control. Media compost and husk charcoal have wide pores so that the soil becomes loose to absorb water in the soil. Research Seyedsadr et al. (2022) shows that applying biochar can significantly increase soil bulk density and soil porosity. Applying biochar and compost as well as manure can increase water retention and also nutrient retention. This is a recommendation for drought-prone soils to apply mixed organic matter amendments.

The application of organic fertilizers to the soil media affects the amount of water in the soil which is related to the bulk density of the soil where the lighter/loose the bulk density of the soil, the better the rate of infiltration, aerase and drainage of water in the soil. According to (Barus et al., 2022; Kannan et al., 2021) states that biochar is effective in increasing soil water content and soil pores and because of the porous soil structure which can increase the presence and activity of microorganisms, in the end the availability of nutrients increases.

Conclusion

The use of biochar and compost in this study was studied based on several soil physical properties including changes in soil bulk density and water content (%) by volume and tested on the growth and production of lettuce plants. The treatment in the form of giving biochar and compost had a better effect on bulk density, soil moisture content, growth and production of lettuce plants. The best treatment for lettuce plants, namely the application of biochar and compost (M3) affected plant height, leaf length, number of leaves, plant wet weight (1.32 kg). The change in bulk density after application of biochar and compost was from 0.76 g cm-3 down to 0.66 g cm-3, the change in soil water content before being given treatment was 13.03 % by volume to 39.50 % by volume. Biochar and compost can affect soil bulk density and water content so as to increase nutrient availability and support vegetative and generative growth for lettuce plants.

Author Contributions

This paper was compiled by two authors. The first author and the second author worked together in writing this manuscript until it was published.

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Conflicts of Interest

No Conflicts of interest.

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