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A Study of The Physical Properties of Various Types of Planting Media in The Cultivation Of Mung Bean Plants (Vigna Radiata L.) in Polybags

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ABSTRACT
Planting media is an important component that plays a role in supporting optimal plant growth. This study aims to compare the physical properties of several types of planting media on the yield of mung bean plants. The study was conducted using a Completely Randomized Design (CRD) with three treatments of several types of planting media and six replications. The parameters observed included soil mass density, soil particle density, soil porosity, soil organic matter, soil texture, field capacity water content, permanent wilting point water content, water availability, plant fresh weight, plant height, and number of leaves. The treatments tested included: M1 (ultisol soil + rice husk charcoal), M2 (ultisol soil + cow manure), and M3 (ultisol soil + cocopeat). Data were analyzed using the analysis of variance (ANOVA) and continued with the Duncan Multiple Range Test (DMRT). The results showed that the type and composition of the planting media influenced the physical properties of the media and had a direct impact on the growth and yield of mung bean plants, so the use of organic materials is highly recommended in cultivating mung beans in polybags.
Keywords: Mung bean (Vigna radiata L.), Ultisol soil, rice husk charcoal, manure, cocopeat, soil physical properties.

ABSTRAK
Media tanam merupakan komponen penting yang berperan dalam mendukung pertumbuhan tanaman secara optimal. Penelitian ini bertujuan untuk membandingkan sifat fisik dari beberapa jenis media tanam terhadap hasil tanaman kacang hijau. Penelitian dilakukan menggunakan Rancangan Acak Lengkap (RAL) dengan empat perlakuan beberapa jenis media tanam dan enam ulangan. Parameter yang diamati meliputi kerapatan massa tanah, kerapatan partikel tanah, porositas tanah. bahan organik tanah, tekstur tanah, kadar air kapasitas lapang, kadar air titik layu permanen, ketersediaan air, bobot basah tanaman, tinggi tanaman, dan jumlah daun. Perlakuan yang diuji meliputi: M1 (tanah ultisol + arang sekam), M2 (tanah ultisol + pupuk kandang sapi), dan M3 (tanah ultisol + *cocopeat*). Data dianalisis menggunakan uji sidik ragam (ANOVA) dan dilanjutkan dengan uji *Duncan Multiple Range Test* (DMRT). Hasil penelitian menunjukkan bahwa jenis dan komposisi media tanam berpengaruh terhadap sifat fisik media dan berdampak langsung pada pertumbuhan serta hasil tanaman kacang hijau, sehingga penggunaan bahan organik sangat direkomendasikan dalam budidaya kacang hijau di *polybag*.
Kata kunci: Kacang hijau (*Vigna radiata* L.), tanah Ultisol, arang sekam, pupuk kandang sapi, *cocopeat*, sifat fisika tanah.

1. Introduction

Ultisols are a type of marginal soil classified as less fertile, characterized by low fertility, acidic soil reaction with a pH below 5, and minimal nutrient and organic matter content [1]. One way to improve the quality of Ultisol soil is through proper soil preparation and the application of appropriate fertilizers, particularly by adding organic matter. This initiative aims to ensure that Ultisol soils can be used optimally in crop cultivation and agricultural activities, thereby increasing their productivity [2].

Some common organic materials used as growing media include rice husk charcoal, cow manure, and cocopeat. Rice husk charcoal is known to improve aeration and water retention, cow manure serves as a source of nutrients and boosts the activity of soil microorganisms; and cocopeat has a high capacity for absorbing and retaining water.

The selection of crops was also a key factor in this study. The green bean (Vigna radiata L.) is a legume crop with high economic and agronomic value. This plant has several advantages, including being tolerant to drought, having a relatively short lifespan, suitable for cultivation in areas with low rainfall, and experiencing relatively low levels of pest and disease attacks. In addition, mung beans also have the potential to be developed on suboptimal land, including soil that has fertility limitations [3].

Overall, it is necessary to examine the physical properties of various types of growing media including mixtures of organic materials such as rice husk charcoal, cow manure, and cocopeat to determine the optimal composition for mung bean growth. Testing growing media for this crop could be a strategic step toward increasing productivity while identifying effective media formulations for Ultisol soil conditions.

2. Method

2.1. Research Time and Location

The research was conducted from October 2025 to January 2026. The mung bean was cultivated in the Greenhouse, and laboratory experiments were carried out at the Research and Technology Laboratory, Faculty of Agriculture, Universitas Sumatera Utara, Medan, Indonesia.

2.2. Research Tools and Materials

The equipment used in this study included 35 × 40 cm polybags as planting containers, a digital balance for weighing the growing media, a trowel for collecting soil samples, a ruler for measuring soil depth, a measuring tape for determining plant height, a camera for documentation, a measuring cup to determine the volume of irrigation water, a soil sieve for removing gravel and large soil aggregates, and standard laboratory equipment required for soil analysis. The materials used in this study consisted of Ultisol soil, rice husk charcoal, cow manure, cocopeat, Vima-1 mung bean seeds, and clean water.

2.3. Research Methods

This research employs an experimental method with a quantitative approach. Samples of the growing medium were analyzed in the laboratory to determine its physical properties. This study employed a Completely Randomized Design (CRD) consisting of three growing media treatments: Ultisol soil mixed with rice husk charcoal at a ratio of 2:1 (M1), Ultisol soil mixed with cattle manure at a ratio of 2:1 (M2), and Ultisol soil mixed with cocopeat at a ratio of 2:1 (M3). Each treatment was replicated six times, as determined using Federer's formula to ensure adequate experimental precision. Consequently, the experiment consisted of 18 experimental units, which were assigned randomly.

The research data were analyzed using Analysis of Variance (ANOVA) at the 5% and 1% significance levels to evaluate the effects of different growing media on soil physical properties and mung bean growth. When significant differences among treatments were detected, Duncan's Multiple Range Test (DMRT) was performed to compare the treatment means.

2.4. Research Procedures

The research began with the collection of Ultisol soil from the designated sampling site. The soil was air-dried, crushed, and passed through a 10-mesh sieve. Rice husk charcoal, cow manure, and cocopeat were also air-dried before being mixed with the soil. The growing media were prepared in 35 × 40 cm polybags by combining 20 cm of Ultisol soil with 10 cm of the respective organic amendment according to each treatment. The mixtures were homogenized and incubated for seven days at moisture content close to field capacity to promote interaction between the soil and the organic materials.

Vima-1 mung bean seeds were soaked overnight before planting to promote uniform germination. After incubation, three seeds were planted in each polybag at a depth of approximately 2 cm. Planting was carried out on 9 November 2025. Throughout the experimental period, routine maintenance practices, including irrigation, plant observations, and growing media maintenance, were conducted according to the treatment requirements. Harvesting was performed on 8 January 2026, corresponding to 60 days after planting. Soil samples were collected before planting and after harvest for laboratory analysis of their physical properties.

2.5. Research Parameters

The parameters observed in this study included soil physical properties and mung bean growth characteristics. Soil physical properties consisted of bulk density, particle density, soil porosity, soil organic matter, soil texture, field capacity moisture content, permanent wilting point moisture content, and available water content. Plant growth was evaluated based on plant height, number of leaves, and fresh weight.

Bulk density was determined using the core ring method by dividing the oven-dry mass of the soil by the volume of the core ring. Particle density was determined from the ratio of the mass of soil particles to their volume. Soil porosity was subsequently calculated using the bulk density and particle density values. Soil organic matter content was analyzed in the laboratory to determine the percentage of organic matter. Soil texture was determined using the hydrometer method, and the percentages of sand, silt, and clay were used to classify the soil according to the USDA textural classification system.

Field capacity moisture content was measured after the growing media had been saturated with water and allowed to drain freely until gravitational water was removed. Permanent wilting point moisture content was determined using the pressure plate method at a pressure of 15 bars. Available water content was calculated as the difference between field capacity moisture content and permanent wilting point moisture content.

Plant growth was evaluated based on plant height, number of leaves, and fresh weight. Plant height was measured from the soil surface to the highest growing point using a ruler. The number of leaves was determined by counting all fully expanded leaves on each plant. Fresh weight was measured immediately after harvest by weighing the entire plant using a digital balance.

3. Result and Discussion

3.1. Available Water

The soil's ability to store and supply water to plants is one of the key factors supporting plant growth. The results of the analysis of field capacity, permanent wilting point, and available water are shown in Table 1.

Table 1. Results of Analysis of Field Capacity Moisture Content and Permanent Wilting Point

Treatment	Field capacity moisture content (%)	Permanent wilting point (%)	Available water (%)
M1	51.71	27.20	24.51
M2	66.51	28.10	38.41
M3	79.58	28.20	51.38

Table 1 shows that treatment M3 (a mixture of organic cocopeat) had the highest available water content, meaning that this treatment provided the greatest amount of water that could be utilized by the plants before they experienced permanent wilting. This result is due to cocopeat's ability to retain water and its high water absorption capacity, as well as its ability to store water for long periods under field capacity conditions [4].

Treatments involving the addition of organic matter tend to yield higher values than those without such additions. This indicates that organic matter enhances the soil's ability to store water that can be utilized by plants and increases the volume of water contained and stored in the soil, thereby increasing the amount of water available to plants [5].

3.2. Bulk Density, Particle Density, and Porosity

Bulk density, particle density, and porosity are important parameters in research on improving soil physical properties, as they provide insights into soil health and its impact on sustainable plant growth. The results of the analyses of bulk density, particle density, and porosity are presented in Table 2.

Table 2. Results of Analysis of Bulk Density, Particle Density, and Porosity

Treatment	Bulk density (g/cm^3)	Particle density (g/cm^3)	Porosity (%)	Criteria
M1	0.60	2.10	73.43	Porous
M2	0.75	2.20	65.91	Porous
M3	0.68	2.38	71.43	Porous

Treatment M1 (a mixture of organic matter and rice husk charcoal) had the highest porosity, indicating that a porous growing medium increases water-holding capacity and helps maintain soil moisture, which is essential for plant roots during dry conditions. Rice husk charcoal is an organic material with high porosity that facilitates oxygen supply to the roots and provides good aeration and efficient drainage, allowing roots to develop without the risk of waterlogging that causes damage or disease and promoting plant growth. Additionally, the crumbly texture, large pores, and light weight of rice husk charcoal help improve air circulation [6].

Table 2 shows that the bulk density of soil mixed with organic materials such as rice husk charcoal, cattle manure, and cocopeat is relatively lower. Adding organic matter to the soil increases the amount of pore space and creates a crumbly soil structure, thereby reducing the soil's bulk density. These conditions generally support the development of the plant's root system because the roots can penetrate the soil more easily [7].

3.3. Soil Organic Matter

Organic matter has a positive effect on soil fertility and plant growth. The results of the analysis of organic matter content in Ultisol soil and mixtures of various growing media after treatment are shown in Table 3.

Table 3. Results of Analysis of Soil Organic Matter

Treatment	Soil organic matter (%)			
	Early stage	Criteria	Final stage	Criteria
M1	2.24	Medium	2.35	Medium
M2	2.19	Medium	2.40	Medium
M3	1.88	Low	2.05	Medium

In the initial phase, treatment M1 showed the highest organic matter content at 2.24%, higher than the others, indicating that rice husk charcoal is capable of improving soil physical properties and serving as a source of organic carbon for the growing medium, as it contains relatively high levels of stable organic carbon, thereby directly increasing the organic matter content of the growing medium after the mixing process. Furthermore, the porous and carbon-rich structure of rice husk charcoal allows its contribution to organic matter to be detected more quickly at the start of the observation period compared to other organic materials [8].

Conversely, in the final phase, the M2 treatment showed a higher organic matter content than the others. This is likely due to the fact that the addition of manure can increase soil organic matter content [9]. Cow manure contains a higher moisture content, this high moisture content causes soil moisture levels to rise, thereby accelerating the decomposition process and contributing to an increase in soil organic matter content [10].

3.4. Soil Texture

The ratio of sand, silt, and clay fractions reveals the particle composition of the soil and is used to determine soil texture. A hygrometer is used to determine soil texture, and the USDA triangle is used to classify the results. The results of the soil texture analysis are shown in Table 4.

Table 4. Results of Analysis of Soil Texture

Treatment	Faction (%)			Soil texture
	Sand	Silt	Clay	
M1	71	15	14	Sandy loam
M2	65	19	16	Sandy loam
M3	70	18	12	Sandy loam

Table 4 shows that all three treatments had a sandy loam soil texture, in which the sand fraction was dominant, while the silt and clay fractions were relatively lower. The highest percentage of the sand fraction was found in treatment M1 (a mixture of organic material and rice husk charcoal), the high sand fraction can improve soil aeration and porosity, thereby helping to create ideal growing conditions for plant roots as they are able to penetrate the soil and absorb water and nutrients [11].

The texture of sandy loam soil plays a key role in determining the availability of water and air in the root zone. Sandy loam soil has better drainage, which helps prevent waterlogging that can cause root stress or impair root respiration in cultivated plants. The high sand content in the soil indicates a high number of macropores, which facilitates water and air circulation in Ultisol soil [12].

3.5. Moisture Content

The soil moisture content results before and after planting are shown in Table 5.

Table 5. Results of Analysis of Soil Moisture Content

Treatment	Soil moisture content (%)
M1	14.67
M2	14.86
M3	12.90

In this study, the low soil moisture content was likely caused by the high water uptake by mung bean plants during the growth phase. Mung bean plants have relatively high water requirements from the vegetative phase through pod formation, causing water reserves in the growing medium to steadily decrease. Additionally, water is lost through evapotranspiration due to ambient temperatures and irrigation practices that do not always maintain the growing medium at field capacity [13]. The relatively low moisture content may also be influenced by the soil texture, which was sandy loam across all treatments. This texture has a relatively high sand content, resulting in lower water-holding capacity compared to soils with a higher proportion of fine particles; consequently, water moves and drains more easily than in clayier soils [14].

In treatment M3 (a mixture of organic cocopeat), the moisture content was the lowest; the high porosity of cocopeat and its significant water-holding capacity within its fiber structure also influenced this result. However, during laboratory analysis of soil moisture content, some of this water may be stored in the micro-pores or fibers of the cocopeat, so it is not entirely measured as free soil moisture, resulting in a lower soil moisture content value [15].

3.6. Results of the Statistical Analysis of the Fresh Weight of Mung Bean Plants

In the next stage, a DMRT analysis was conducted on the treatments involving several types of growing media, where different sample variations had a highly significant effect on the fresh weight of mung bean seeds. Consequently, a further analysis using the Duncan Multiple Range Test (DMRT) was required, as shown in Table 6.

Table 6. Results of Statistical Analysis on the Effects of Various Types of Growing Media on Plant Fresh Weight

Treatment	Average wet weight of crops (g)	Level	
		5 %	1 %
M1	31.37	a	A
M2	50.83	b	B
M3	15.32	c	C

Note: Numbers followed by different letters in the 5% and 1% significance level columns indicate significant differences based on the results of the Duncan Multiple Range Test (DMRT).

In Table 6, the high wet weight in the M2 treatment is thought to be related to soil physical properties that influence root development and the plants' ability to utilize available water. The M2 treatment had the highest bulk density, the lowest porosity, and relatively high field capacity, organic matter content, and available water, enabling it to supply water and nutrients more optimally to the plants. These conditions support more efficient water and nutrient uptake, resulting in greater plant biomass formation [16].

In treatment M2 (a mixture of organic matter and cow manure), the highest fresh plant weight, with an average of 50.83 g, indicating that a growing medium rich in organic matter, such as cattle manure, can have a significant effect on plant height, stem diameter, number of productive branches, number of pods per plant and seed weight per plant [17].

The results of the analysis in Table 6 show the effect of different types of growing media on plant fresh weight. Statistical analysis using Duncan's Multiple Range Test (DMRT) at the 5% and 1% significance levels revealed highly significant differences among the three treatments in terms of maintaining plant fresh weight. These differences indicate that the type and composition of the growing media have a significant effect on the fresh weight of mung beans. Different symbols in the 5% and 1% significance level columns indicate that these differences are significant at all levels of significance.

In the M3 treatment (a mixture of organic cocopeat), the lowest average fresh weight of plants was recorded at 15.32 g. The reason for the poor growth response of plants treated with added cocopeat is the presence of tannins contained in coconut coir powder. Tannins are compounds that inhibit gibberellin hormone activity and disrupt the transport of P and K nutrients. If P and K are available in limited quantities and cannot meet the plant's growth needs, the plant will experience stunted growth of roots, stems, and leaves [18].

During the study, all plants were maintained and cared for under the same treatment in each experiment. Maintenance activities included regular watering to keep the moisture content of the medium close to field capacity, weeding of unwanted plants, and pest control if signs of infestation were observed. Uniform maintenance played an important role in supporting plant growth and improving nutrient uptake efficiency.

Based on the results presented in Tables 1–6, each growing medium produced different soil physical characteristics, which consequently affected mung bean growth. Treatment M2, consisting of Ultisol soil mixed with cattle manure, produced the highest fresh plant weight (50.83 g), whereas treatment M3, consisting of Ultisol soil mixed with cocopeat, resulted in the lowest fresh weight (15.32 g). These findings indicate that plant growth was influenced not by a single soil property but by the combined effects of field capacity, available water, soil organic matter, bulk density, particle density, porosity, and soil texture.

Table 1 shows that treatment M3 had the highest field capacity moisture content (79.58%) and available water (51.38%). However, these favorable moisture characteristics did not result in the highest fresh plant weight. This finding suggests that high water retention alone is insufficient to promote optimal plant growth when nutrient availability is limited. Although cocopeat has excellent water-holding capacity, it contains relatively low nutrient levels and a high C/N ratio, which slows organic matter decomposition and nutrient mineralization. Consequently, nutrient availability for plant uptake remains limited.

In contrast, treatment M2 provided a better balance between water availability and nutrient supply. Although its field capacity and available water were lower than those of M3, it had the highest final soil organic matter content (2.40%) (Table 3). The addition of cattle manure likely enhanced microbial activity, improved soil structure, and increased nutrient availability, thereby promoting more efficient water and nutrient uptake. These conditions supported greater biomass accumulation and resulted in the highest fresh plant weight.

Overall, the findings demonstrate that the best growing medium is not necessarily the one with the greatest water-holding capacity but rather the one that provides a balanced combination of water availability, soil aeration, organic matter, and nutrient supply. This balance was achieved in treatment M2, resulting in the highest fresh plant weight. Therefore, cattle manure was more effective than rice husk charcoal and cocopeat as an organic amendment for improving Ultisol conditions and promoting mung bean growth.

4. Conclusion

According to the research findings, adding organic matter to Ultisol soil has been shown to improve the physical properties of the growing medium by reducing bulk density and particle density and increasing porosity. The treatment of Ultisol soil mixed with rice husk charcoal (M1) resulted in the highest porosity and moderate organic matter content, indicating that rice husk charcoal is effective in improving aeration and increasing nutrient content, which plays a role in improving the physical properties of the growing medium. The Ultisol soil treated with cocopeat (M3) yielded the lowest plant growth, which is believed to be due to the presence of tannins and the high C/N ratio in the cocopeat, resulting in lower nutrient availability for the plants. The treatment involving Ultisol soil mixed with cow manure (M2) yielded the best growth and harvest results, as evidenced by the highest plant height, number of leaves, and fresh plant weight compared to the other treatments. This indicates that cattle manure not only improves the physical properties of the growing medium but also provides sufficient nutrients to support plant growth. Overall, differences in growing media had a significant effect on the yield of mung beans, and Ultisol soil mixed with cow manure (M2) was the best treatment for promoting the growth of mung beans in polybag cultivation.

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