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The Effect of Growth and Root Nodules of *Mucuna Bracteata* on Various Planting Media Compositions

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Abstract
This study aims to determine the effect of growth and root nodules of *Mucuna bracteata* plants on various planting media compositions. This research was conducted at the Kebun Pendidikan dan Penelitian (KP2) INSTIPER, Maguwoharjo, Depok District, Sleman Regency, from December 2022 to April 2023. This research method is an experimental study arranged in a Completely Randomized Design (CRD). The research treatment consists of 12 treatments consisting of sand+clay+manure, sand+clay+green manure, sand+clay+bioslurry, sand+manure, sand+green manure, sand+bioslurry, clay+manure, clay+green manure, clay+bioslurry, sand, and clay. Each media mixture uses the same volume ratio. The research data were analyzed using ANOVA (Analysis of Variance) at a significance level of 5%, and the real effect was further tested using DMRT at a level of 5%. The results of the study showed that the composition of sand with manure gave the highest fresh root weight results of *Mucuna bracteata*, namely 8.59 grams, compared with other compositions, such as clay soil, which gave the lowest root weight results, namely 2.07 grams. The sand and bioslurry mixture produced the highest number of root nodules, root nodule weight, and number of effective root nodules in *Mucuna bracteata*, with figures of 28.40 nodules, 1.05 grams, and 14.80 nodules, respectively. The sand and bioslurry mixture results showed significant differences from those of other planting media mixtures.

Keywords— *Mucuna Bracteata*; Organic Fertilizer; Palm Oil; Planting Media

Introduction

Ground cover crops, especially from the legume family are very important in the management of oil palm plantations, especially at the age of young or immature plants with the condition of the branches that are still wide open due to the plant canopy has not closed each other so that it can be used to control erosion, maintain soil moisture, increase organic matter and soil nutrient content, control weed growth, and increase soil nitrogen content from the results of symbiosis of Rhizobium bacteria with legume plant roots in fixing nitrogen (Tarigan et al., 2020). One widely used ground cover crop is *Mucuna bracteata* (Mb), due to its rapid biomass growth, making it highly effective as a cover crop. Due to its rapid, dense, and spreading growth, it suppresses weeds that interfere with oil palm plantations and produces high levels of organic matter (Husaini & Iswahyudi, 2019). Furthermore, Mb is considered highly effective as an intercropping crop to control soil erosion in oil palm plantations (Satriawan et al., 2015, 2017). Mb's dense roots bind soil particles and provide better slope stabilization (Nasir Ahmad et al., 2020). Another reason for choosing Mb as a ground cover crop in oil palm plantations is that its leaves contain high levels of phenols, making them unpalatable to livestock (Madusari et al., 2013).

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Mb growth is not only influenced by genetic factors but also by environmental factors, such as good planting media that provide the basic needs of plants, namely water and nutrients needed for metabolic processes in plants, as well as good soil air circulation that supports smooth root respiration. Sandy soil has good aeration, which supports smooth root respiration. However, its limitations include low water holding and storage capacity, high infiltration and evaporation, low fertility and organic matter content, and low water use efficiency, affecting the root system, root depth, nutrients, and pH (Hasibuan, 2015). Unlike clay soil, which can store and provide relatively high amounts of water and nutrients, it has low permeability, high capillary water rise, low bearing capacity against high water table conditions, and high shrinkage and swelling properties (Uddin, 2017), which in turn can inhibit the smooth absorption of nutrients in the soil.

Organic fertilizer is an organic material with good chemical and physical properties for the soil, increasing its water absorption capacity and cation exchange capacity, ultimately increasing crop yields (Fallah et al., 2013; Schlegel et al., 2015). Cow manure contains 3% N, 2% P2O5, and 1% K2O, all nutrients required by plants (Gilroyed et al., 2015; Sanni, 2016). Bioslurry is a byproduct of biogas production rich in chelating compounds that have the potential to stabilize metal-contaminated soil (García-Sánchez et al., 2016; Groot & Bogdanski, 2013). The impact of bioslurry application on soil is increased fertility, friability, water-holding capacity, and microbiological properties (Himawan & Darwanta, 2022). Bioslurry is highly beneficial as a nutrient source for plants, containing nitrogen, phosphorus, potassium, and additional (micro) nutrients such as magnesium (Mg), calcium (Ca), and sulfur (S). The resulting biogas residue undergoes anaerobic fermentation and can be used as plant fertilizer. This study was conducted to observe the growth response of *Mucuna bracteata* to various growing media compositions.

Literature Review

Mucuna bracteata is a type of legume plant that is often used in oil palm plantations as a ground cover that can fix nitrogen, grows quickly, competes with weeds (Wikka Sasvita et al., 2023), and has a high biomass (Sebayang et al., 2015). Mb can be used as a green manure because it can bind nitrogen due to symbiotic rhizobium bacteria, resulting in a higher N content than other plants (Rahayu et al., 2014). Roots are an important structure for plant growth, where the system continuously provides water and nutrients for other parts of the plant, so the roots must grow and develop to support plant growth (Hanum, 2021). Adding organic matter to the soil has a more powerful effect on improving soil properties, not just increasing nutrient content. Returning crop residues will improve the soil's biological, chemical, and physical properties, increasing its water absorption capacity, management, and soil fertility (Jeki Daisa et al., 2024). Using cow dung as a source of plant nutrients is very popular worldwide to improve soil fertility and increase crop yields (Jokela, 1992; Kapkiyai et al., 1999).

Nduka et al. (2019) stated that using compost fertilizer significantly increases the absorption of K and N nutrients. Bioslurry is a type of organic fertilizer derived from the anaerobic process of organic waste in producing flammable methane gas (Nasir et al., 2012; Shaheb et al., 2017). Bioslurry consists of 93% water and 7% dry matter, of which 4.5% is organic and 2.5% is inorganic (Kumar et al., 2015). The application of bioslurry to the soil can help increase soil pH (Geremew et al., 2019), the physicochemical and biological properties of the soil, thus supplying some nutrients needed by plants (Chappa, 2023). Research by Alhammad et al. (2023) and Sarwar et al. (2010) showed that an increase in plant height was observed in the treatment of bioslurry fertilizer. This is associated with bioslurry, which contains various important macro and micronutrients for healthy plant growth. In addition, bioslurry can provide nutrients plants need, improving overall growth performance and plant health (Shao et al., 2023).

Research Method

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This research was conducted at the Kebun Pendidikan dan Penelitian (KP2) INSTIPER, Depok District, Sleman Regency, from December 2022 to April 2023. The tools used in this study were analytical scales, ovens, sieves, nail clippers, and leaf area meters. The materials used in this study were *Mucuna bracteata* seeds, polybags, paranet, regosol sand soil, latosol soil, cow manure, green manure from LCC leaves, and bioslurry. This research method is an experimental study arranged in a Completely Randomized Design (CRD).

The research treatment consists of 12 treatments consisting of sand+clay+manure, sand+clay+green manure, sand+clay+bioslurry, sand+manure, sand+green manure, sand+bioslurry, clay+manure, clay+green manure, clay+bioslurry, sand, and clay. Each media mixture uses the same volume ratio. Each composition of the planting media was repeated 5 times, so there were 60. The research data was analyzed (Analysis of Variance) with a real level of 5%. If there is a real difference, proceed with Duncan's multiple range test (DMRT) with a real level of 5%.

Results and Discussion

Based on the analysis results, the composition of planting media affected the growth of *Mucuna bracteata*, likely the fresh weight of leaves, number of root nodules, weight of the root nodules, and number of effective root nodules (Table 1).

Table 1. The effect of the composition of planting media on the growth of *Mucuna bracteata*

Treatment	Plant Growth Parameters			
	Fresh weight of roots (gram)	Number of root nodules (nodule)	Weight of the root nodules (gram)	Number of effective root nodules (nodule)
Sand + Clay + Manure	5.31 bc	12.00 bc	0.60 b	6.60 b
Sand + Clay + Green manure	3.35 bc	9.20 bc	0.50 b	7.20 b
Sand + Clay + Bioslurry	4.98 bc	7.60 bc	0.29 b	5.00 b
Sand + Manure	8.59 a	13.40 bc	0.19 b	7.80 ab
Sand + Green manure	3.70 bc	8.80 bc	0.31 b	4.60 b
Sand + Bioslurry	4.75 bc	28.40 a	1.05 a	14.80 a
Clay + Manure	5.86 ab	7.60 bc	0.38 b	5.20 b
Clay + Green manure	4.09 bc	13.20 bc	0.57 b	5.60 b
Clay + Bioslurry	4.47 bc	6.20 bc	0.29 b	3.20 b
Sand + Clay	3.49 bc	3.20 c	0.11 b	0.80 b
Sand	3.22 bc	8.20 bc	0.31 b	3.60 b
Clay	2.07 c	5.00 bc	0.21b	1.60 b

Information: The average number followed by the same letter in the same column shows a significant difference based on the DMRT test at a significance level of 5%.

Table 1 shows that the planting media composition significantly affected several parameters, including root fresh weight, root nodule number, root nodule weight, and effective root nodule number. The use of sand and manure as a planting media resulted in the highest root fresh weight. This is in line with previous research, which shows that the combination of sand and compost significantly affects the fresh weight of wheat plant roots during the seedling stage (Fatima et al., 2025) and in corn plants (Zhou et al., 2012). Manure can improve the properties of sandy soil by increasing water retention, the rate of groundwater infiltration, and enriching the soil with essential nutrients such as nitrogen (N), phosphorus (P), potassium (K), and sulfur (S), which are very important for maintaining soil moisture and supporting plant growth (Liu et al., 2020; Ozlu et al., 2019). The nutrient content of cow manure is as follows: 0.3% N; 0.2% P_2O_5; and 0.3% K_2O (Novizan, 2007). Support from manure on sandy soil in the form of improved nutrients and

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physical properties of sandy soil impacts the growth of wider roots.

It was also observed that using sand and bioslurry as a planting media results in root nodule weight and a higher number of effective root nodules compared to other growing media compositions. Bio-slurry improves the hydro-physical properties of sandy soil, which is usually poor in water retention, by reducing soil bulk density and increasing soil moisture content, thus aiding in the development of root nodules (Abdo, 2021; Yuan et al., 2022). Bio-slurry is a biogas waste product in solid and liquid form (Addis et al., 2024; Islam et al., 2019; Sun et al., 2023), yet it still contains high levels of nutrients that are beneficial to the soil. The nutrient content of Bio-Slurry is as follows: Total N = 0.54%; P2O5 = 0.74%; K2O = 0.96%; Total Ca = 0.15%; Total Mg = 0.57%; Total Na = 0.18%; Total Fe = 0.49%; Total Mn = 0.08%; Total Zn = 0.02%; and Total Cu = 0.002% (Fitriyah et al., 2024). In addition, bio slurry provides a source of easily degradable carbon and nitrogen, thereby increasing nitrogen availability in the soil, which supports rhizobia growth and enhances root nodule formation (Fangueiro et al., 2012). Root nodules are interesting structures found in the roots of certain plants that enable a unique and mutually beneficial symbiotic relationship between the plants and rhizobia bacteria (Gilbert, 2023). The weight of root nodules affects the biomass and nutrient content of *Mucuna bracteata*, particularly nitrogen (N), calcium (Ca), and magnesium (Mg). Heavier root nodules contribute to nitrogen fixation and more effective nutrient circulation, influencing the growth and yield of related plants (Boateng & Tetteh, 2020; Mohd Noor et al., 2021). The number of active root nodules plays a role in the nitrogen fixation process, where an increase in the number of effective root nodules will increase the amount of nitrogen available in the soil (Wahyuni et al., 2019). Furthermore, the number of root nodules contributes to better soil structure and organic matter content (Wawan et al., 2019).

Organic matter plays a role in improving the soil's physical, biological and chemical properties. The physical condition of the soil is good if it can ensure plant roots' growth and provide oxygen and water in the soil. The greatest role of organic matter on soil physical properties includes: structure, consistency, porosity, water-binding power, and increased resistance to erosion. Organic matter is one of the materials forming soil aggregates, which acts as an adhesive between soil particles to unite them into soil aggregates. Organic fertilizers are the best and most natural soil-improving agents compared to artificial/synthetic soil-improving agents. Organic matter affects the soil's physical, chemical, and biological properties and social conditions. The application of organic matter increases the nutrient content of the soil based on the decomposition process of organic matter and cation exchange capacity, which is an indicator of soil chemical fertility. The addition of organic matter improves aeration and drainage of loams. At the same time, clay soil still maintains the ability to provide water for plants. Applying organic matter increases the sand soil's ability to provide water and nutrients. In addition, organic matter will increase the activity of microorganisms in the soil, both on clay and sand soils (Sutanto, 2002).

Conclusion

This study concluded that the planting media composition influences *Mucuna bracteata*'s growth. The composition of the sand with manure gave the highest fresh root weight results compared to other compositions. Meanwhile, the composition of the sand with bioslurry gave the highest influence and results on the number of root nodules, root nodule weight, and the number of effective root nodules of *Mucuna bracteata* plants. The use of organic materials affected the presence of root nodules in *Mucuna bracteata* plants.

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