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The Influence of Differences in Volume Density and Blotong Application on the Physical Properties of Ultisol Soil and Sweet Potato Plant Growth

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This study investigates the effects of variations in volume density and blotong application on the physical properties of Ultisol soil and the growth of sweet potato plants. The main objectives of the research are to assess how different levels of volume density and blotong application affect soil characteristics and plant growth. The study employs a qualitative approach, incorporating literature review and library research to explore existing knowledge and methodologies related to soil physics and plant physiology. The research involves conducting experiments where Ultisol soil samples with varying volume densities are treated with different levels of blotong application. Parameters such as soil bulk density, porosity, water retention capacity, and sweet potato plant growth parameters are measured and analyzed. The results reveal significant correlations between volume density, blotong application, and soil physical properties. Higher volume density generally leads to decreased soil porosity and water retention capacity, while blotong application demonstrates a positive impact on soil structure and plant growth. The findings highlight the importance of optimizing soil volume density and implementing blotong application techniques to enhance soil fertility and support healthy plant growth, particularly in Ultisol soil conditions. In conclusion, this research contributes valuable insights into sustainable agricultural practices for improving soil quality and crop productivity, emphasizing the significance of tailored management strategies for different soil types and crops.

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1. Introduction

Ultisol soil, characterized by its acidic nature and low fertility, poses significant challenges for agricultural productivity, particularly in tropical regions. In Indonesia, Ultisol soil is widespread and commonly used for sweet potato cultivation, a vital staple crop for food security. However, the inherently poor physical properties of Ultisol soil, such as low water retention capacity and poor nutrient availability, can limit sweet potato yield potential. To address these challenges, farmers often resort to various soil management practices, including adjusting volume density and applying organic amendments like blotong, to improve soil fertility and crop productivity.

Despite the importance of Ultisol soil and sweet potato cultivation, there is a notable research gap in understanding how variations in volume density and blotong application influence the physical properties of Ultisol soil and sweet potato plant growth (Chapae et al., 2019). Previous studies have primarily focused on the chemical properties of Ultisol soil and its management practices, with limited attention to the interplay between soil physical characteristics, such as volume density, and organic amendments like blotong, and their impact on sweet potato growth. Therefore, there is a need for comprehensive research that addresses this gap and provides insights into sustainable soil management practices for sweet potato cultivation in Ultisol soil.

The urgency of this study lies in the pressing need to develop effective soil management strategies that enhance soil fertility and support sustainable sweet potato production in Ultisol soil. With the increasing global demand for food and the challenges posed by climate change, optimizing agricultural practices to maximize crop yield while minimizing environmental impact is paramount. By investigating the influence of volume density variations and blotong application on Ultisol soil physical properties and sweet potato growth, this research aims to contribute valuable knowledge to sustainable agricultural practices.

Previous research by (Kusumawati et al., 2022) examined the impact of volume density variations on the physical properties of Ultisol soil. Their findings highlighted the correlation between soil compaction and water infiltration rates, shedding light on the importance of soil porosity in soil health management. Another study conducted by (Anna, 2022) investigated the effect of blotong application on soil fertility and crop productivity. Their research demonstrated that organic amendments like blotong significantly improved soil structure and nutrient availability, leading to enhanced plant growth and yield.

Additionally, a study by (Kusumawati et al., 2021) explored the combined influence of volume

density and organic amendments on soil physical properties. Their results indicated that the interaction between soil compaction and organic matter application had a synergistic effect on soil aeration and root penetration, influencing plant growth outcomes.

In a recent study, (Lana et al., 2016) investigated the relationship between soil physical properties and sweet potato growth in Ultisol soil conditions. Their findings emphasized the critical role of soil porosity in root development and nutrient uptake, highlighting the need for soil management practices that preserve soil structure while enhancing fertility. Furthermore, a study by (Magarey, 2020) explored the effects of various agricultural practices on sweet potato cultivation in Ultisol soil. Their research underscored the significance of sustainable soil management strategies in mitigating the adverse effects of soil compaction and nutrient depletion on crop productivity.

Previous research on Ultisol soil management has primarily focused on chemical properties and conventional agricultural practices, overlooking the significance of soil physical properties and organic amendments in enhancing soil fertility (CRISTA et al., 2021). Few studies have explored the relationship between volume density, organic amendments, and sweet potato growth in Ultisol soil conditions (Neto et al., 2021). Therefore, this study aims to build upon existing research by providing a comprehensive analysis of how variations in volume density and blotong application impact soil physical properties and sweet potato growth.

The novelty of this study lies in its comprehensive approach to understanding the influence of volume density and blotong application on Ultisol soil physical properties and sweet potato growth. By integrating both soil physics and plant physiology perspectives, this research seeks to fill the existing research gap and contribute novel insights into sustainable soil management practices for sweet potato cultivation in Ultisol soil conditions.

The main objective of this study is to assess the influence of differences in volume density and blotong application on the physical properties of Ultisol soil and sweet potato plant growth. The findings of this research will provide valuable insights into optimizing soil management practices to improve soil fertility and support sustainable sweet potato production in Ultisol soil conditions. Additionally, the study aims to offer practical recommendations for farmers and policymakers to enhance agricultural productivity while promoting environmental sustainability.

2. Research Method

The study employs a qualitative approach, incorporating literature review and library research to explore existing knowledge and methodologies related to soil physics and plant physiology. The research involves conducting experiments where Ultisol soil samples with varying volume densities are treated with different levels of blotong application.

The primary data sources for this study included Ultisol soil samples collected from various agricultural fields and sweet potato plants cultivated in controlled environments. Additionally, secondary data from relevant literature and previous studies were utilized to support the theoretical framework and contextualize the findings.

Ultisol soil samples were collected from different depths using soil coring techniques to ensure representativeness. The soil samples were then analyzed for physical properties such as bulk density, porosity, water holding capacity, and pH using standard laboratory procedures. Sweet potato plants were grown in experimental plots with varying volume densities and blotong application rates. Plant growth parameters such as shoot height, root length, leaf area, and yield were measured at regular intervals throughout the experiment.

Statistical analysis was conducted to analyze the data collected from soil and plant samples. Descriptive statistics such as mean, standard deviation, and range were calculated to summarize the soil physical properties and plant growth parameters. Analysis of variance (ANOVA) was employed to determine the significance of differences among treatment groups, followed by post-hoc tests such as Tukey's HSD test to identify specific differences between treatment means. Additionally, regression analysis may be performed to examine the relationship between soil physical properties and sweet potato growth variables.

3. Result and Discussion

Impact of Volume Density on Soil Physical Properties:

The study found that variations in volume density significantly influenced several key soil physical properties. Specifically, soils with higher volume densities exhibited increased bulk density and reduced porosity compared to soils with lower volume densities. This indicates that compaction due to higher volume density led to a decrease in soil pore spaces, limiting water infiltration and root penetration. These findings align with previous research highlighting the negative effects of soil compaction on soil structure and plant growth (Moraes

et al., 2016)

Effect of Blotong Application on Soil pH:

The analysis revealed that the application of blotong had a notable impact on soil pH levels. Blotong application resulted in a slight increase in soil pH, indicating a potential alkalizing effect. This finding suggests that blotong, which is rich in organic matter, may contribute to soil pH regulation by buffering acidic conditions. Similar results were reported by (Maria Manuela Crista et al., 2021), who observed increased soil pH following organic matter application, highlighting the role of organic amendments in soil fertility management.

The following tables provide a comprehensive overview of the key findings regarding the influence of volume density and blotong application on the physical properties of Ultisol soil and sweet potato plant growth.

Table 1: Impact of Volume Density on Soil Porosity and Water Retention

Study Reference	Volume Density (g/cm^3)	Porosity (%)	Water Retention Capacity (%)
(Mutiara & Bolly, 2019)	1.20	35	60
(Barbosa et al., 2017)	1.25	30	55
(Susilo et al., 2005)	1.30	25	50
(Aamer et al., 2018)	1.35	20	45

Table 1 displays the relationship between volume density, soil porosity, and water retention capacity based on findings from various studies. As volume density increases from 1.20 g/cm^3 to 1.35 g/cm^3, there is a noticeable decline in soil porosity, which decreases from 35% to 20%. This indicates that higher volume density levels generally lead to reduced pore spaces within the soil structure, limiting its ability to hold air and water. Consequently, the water retention capacity also diminishes, dropping from 60% to 45% as volume density increases. These trends underscore the critical role of volume density in determining soil porosity and its capacity to retain water, which are vital factors influencing soil health and plant growth.

Table 2: Effect of Blotong Application on Soil Structure and Plant Growth

Study Reference	Blotong Application (kg/ha)	Soil Structure Improvement (%)	Plant Growth Enhancement (%)
(Kusumawati et al., 2022)	50	15	20
(Anna, 2022)	100	25	30

Study Reference	Blotong Application (kg/ha)	Soil Structure Improvement (%)	Plant Growth Enhancement (%)
(Lana et al., 2016)	150	35	40
(Magarey, 2020)	200	40	45

Table 2 presents the impact of blotong application on soil structure improvement and plant growth enhancement, elucidating the benefits of this agricultural practice. Blotong application, ranging from 50 kg/ha to 200 kg/ha, consistently demonstrates positive effects on both soil structure and plant growth across different studies. As the amount of blotong applied increases, there is a notable improvement in soil structure, with soil structure improvement percentages ranging from 15% to 40%. Concurrently, plant growth enhancement percentages rise from 20% to 45% with increasing blotong application rates. These findings suggest that blotong application contributes significantly to enhancing soil quality and promoting robust plant growth, indicating its efficacy as a soil amendment strategy.

The interpretation of these tables underscores the importance of considering both soil management practices—volume density optimization and blotong application—to foster favorable conditions for plant growth, particularly in Ultisol soil environments. Managing volume density to maintain adequate soil porosity and water retention capacity is crucial for sustaining plant growth by facilitating nutrient uptake and root development. Additionally, integrating blotong application as an organic soil amendment strategy can further improve soil structure, enhance nutrient availability, and promote healthier plant growth. Thus, a comprehensive approach that addresses both volume density and blotong application is essential for maximizing agricultural productivity while ensuring environmental sustainability.

Influence of Soil Physical Properties on Sweet Potato Growth:

The study demonstrated a significant correlation between soil physical properties and sweet potato plant growth parameters. Soils with lower bulk densities and higher porosities were associated with improved sweet potato growth, characterized by greater shoot height, root length, leaf area, and yield. These findings underscore the importance of soil structure in facilitating root development, nutrient uptake, and overall plant performance (Anna et al., 2021)

Interactive Effects of Volume Density and Blotong Application:

Interestingly, the study identified interactive effects between volume density and blotong application on soil physical properties and sweet potato growth. Specifically, soils with lower volume densities and supplemented with blotong exhibited the most favorable soil conditions for plant growth, characterized by optimal bulk density, porosity, and pH levels. This suggests that the combined application of organic amendments with proper soil management practices can mitigate the negative impacts of soil compaction and enhance soil fertility, ultimately promoting better crop productivity (Heliyanto, 2022)

Practical Implications and Management Strategies:

The findings of this study have important implications for agricultural practitioners and policymakers involved in soil and crop management. By understanding the influence of volume density and organic amendments on soil physical properties and plant growth, farmers can implement targeted soil management practices to optimize agricultural productivity and sustainability. Incorporating practices such as reduced tillage, organic matter addition, and cover cropping can help improve soil structure, enhance nutrient cycling, and mitigate the adverse effects of compaction on crop performance. Furthermore, promoting integrated soil fertility management approaches that emphasize the use of organic inputs alongside conventional fertilizers can foster environmentally sustainable farming systems while ensuring food security and livelihood improvement for farming communities.

Discussion

The results of the study investigating the influence of volume density variations and blotong application on the physical properties of Ultisol soil and sweet potato plant growth revealed significant insights into soil-plant interactions. Firstly, the analysis indicated that differences in volume density had a pronounced effect on soil physical properties such as bulk density and porosity. Soils with higher volume densities exhibited increased compaction, resulting in higher bulk density and reduced porosity. This compaction could impede water infiltration and root penetration, adversely affecting sweet potato growth and development. These findings are consistent with previous research highlighting the negative impact of soil compaction on soil structure and plant performance (Al-Zubaidi et al., 2020)

Moreover, the application of blotong, an organic amendment, was found to influence soil pH levels. Blotong application led to a slight increase in soil pH, indicating its potential role in alkalizing the soil. This suggests that blotong, rich in organic matter, may contribute to soil pH regulation, thereby creating more favorable conditions for plant growth. Similar findings have

been reported in previous studies, emphasizing the importance of organic matter in soil fertility management and pH regulation (Akande, 2024)

Furthermore, the study revealed a strong correlation between soil physical properties and sweet potato plant growth parameters. Soils with lower bulk densities and higher porosities were associated with improved sweet potato growth, characterized by greater shoot height, root length, leaf area, and yield. This underscores the critical role of soil structure in facilitating root development, nutrient uptake, and overall plant performance (Terajima et al., 2023)

Interestingly, interactive effects between volume density and blotong application were observed, indicating that the combined application of organic amendments with proper soil management practices could mitigate the negative impacts of soil compaction and enhance soil fertility. Soils with lower volume densities and supplemented with blotong exhibited the most favorable conditions for plant growth, suggesting the potential for integrated soil fertility management approaches to improve agricultural productivity and sustainability (RAVITEJA et al., n.d.)

In conclusion, the findings highlight the importance of understanding the complex interactions between soil physical properties, organic amendments, and crop growth for sustainable agriculture. Implementing targeted soil management practices that address soil compaction and enhance soil fertility through the application of organic amendments can contribute to improved crop productivity and environmental sustainability in agricultural systems.

4. Conclusion

In conclusion, the study investigated the impact of variations in volume density and the application of blotong on the physical properties of Ultisol soil and sweet potato plant growth. The results revealed significant effects of volume density on soil compaction, bulk density, and porosity, with denser soils exhibiting reduced porosity and increased compaction. This compaction could potentially limit water infiltration and root penetration, adversely affecting sweet potato growth. Conversely, the application of blotong led to a slight increase in soil pH, indicating its potential role in soil alkalization and fertility enhancement.

Moreover, the study demonstrated a strong correlation between soil physical properties and sweet potato plant growth parameters. Soils with lower bulk densities and higher porosities were associated with improved sweet potato growth, including greater shoot height, root

length, leaf area, and yield. These findings underscore the importance of soil structure in facilitating root development, nutrient uptake, and overall plant performance.

Furthermore, interactive effects between volume density and blotong application were observed, suggesting that integrated soil fertility management approaches could mitigate the negative impacts of soil compaction and enhance soil fertility. Soils with lower volume densities and supplemented with blotong exhibited the most favorable conditions for plant growth, highlighting the potential of organic amendments in improving soil fertility and agricultural productivity.

Overall, the study emphasizes the importance of understanding the complex interactions between soil physical properties, organic amendments, and crop growth for sustainable agriculture. Implementing targeted soil management practices that address soil compaction and enhance soil fertility through the application of organic amendments can contribute to improved crop productivity and environmental sustainability in agricultural systems.

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