

Effect of Various Organic Fertilizer Treatments on Soil Bulk Density and Soil Color in Yardlong Bean (*Vigna sinensis* L.)

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Abstract

*Yardlong bean (*Vigna sinensis* L.) is one of the secondary food crops with considerable potential as a food source; therefore, improvements in cultivation practices are required to enhance its productivity. One effort to increase yardlong bean production is through the application of organic fertilizers, such as chicken manure and cattle manure. This study aimed (1) to evaluate the effects of chicken manure and cattle manure application on soil bulk density (BD) and soil color in yardlong bean cultivation, and (2) to determine the optimal dosage of these organic fertilizers for improving BD and soil color. The study was conducted from September to January 2026 in Tunggulo Village, Tilong Kabila Subdistrict, Bone Bolango Regency, Gorontalo Province, Indonesia. The experiment employed a Randomized Block Design (RBD) consisting of five treatments: P0 (control, without fertilizer), P1 (chicken manure at 10 t ha⁻¹), P2 (chicken manure at 20 t ha⁻¹), P3 (cattle manure at 10 t ha⁻¹), and P4 (cattle manure at 20 t ha⁻¹). Data were analyzed using analysis of variance (ANOVA) followed by the Honestly Significant Difference (HSD) test, and correlation analysis was conducted to examine the relationship between BD and the growth and yield of yardlong bean. The results indicated that the application of chicken manure and cattle manure had no significant effect on soil bulk density and soil color.*

Keywords: Chicken Manure Fertilizer, Canle Manure Fertilizer. Long Bean

INTRODUCTION

Soil functions as the primary medium supporting plant growth by providing essential nutrients, water, and air required for physiological processes and crop production. Soil tillage alters soil physical properties, particularly pore space, which is influenced by soil texture, organic

matter content, and bulk density (Afrianti et al., 2023). Soil physical fertility is closely related to its capacity to provide adequate aeration and water availability, both of which are strongly governed by soil structure and bulk density.

Bulk density is an important indicator of soil compaction, reflecting the arrangement and packing of soil particles. It is widely used to estimate soil mass, fertilizer requirements, and water needs per unit area (Anti et al., 2023). High bulk density restricts water movement and limits root penetration, thereby negatively affecting plant growth and productivity (Anggraini & Kamal, 2024).

Soil color is one of the most visually distinguishable soil characteristics and serves as an indicator of soil condition. Although soil color does not directly influence soil function, darker soils are generally associated with higher organic matter content and greater fertility, while grayish colors often indicate advanced weathering or poor drainage conditions (Fitriani et al., 2022). Variations in soil color are strongly influenced by organic matter content, which affects soil temperature and moisture regimes and indirectly impacts plant growth (Marlinae & Biyatmoko, 2021).

Organic fertilizers derived from plant residues and animal waste, such as manure, compost, and green manure, play an important role in sustainable soil management. Manure-based fertilizers supply essential macro- and micronutrients and improve soil physical structure, enhance microbial activity, increase cation exchange capacity, and improve soil resistance to drought (Panataria et al., 2025). The application of solid organic fertilizers also contributes to improving soil physical, chemical, and biological properties while reducing dependence on chemical fertilizers (Ashari & Purwaningsih, 2024).

Yardlong bean (*Vigna sinensis* L.) is a widely cultivated vegetable crop in tropical regions and is valued for its nutritional content and economic importance. Despite its potential, yardlong bean production in Bone Bolango Regency has declined sharply in recent years. Production decreased from 61.25 tons in 2021 to 17.60 tons in 2023, with only a slight increase recorded in 2024 (BPS, 2025). This decline is partly attributed to increased soil compaction resulting from continuous use of inorganic fertilizers, intensive tillage practices, and insufficient organic matter inputs.

Soil compaction reduces pore space, restricts root growth, and limits water and air availability, thereby suppressing crop productivity. The application of organic fertilizers is considered an environmentally friendly approach to restoring soil physical quality. Lower bulk density and higher soil porosity are generally associated with improved water infiltration, aeration, and crop yield (Waruwu & Buulolo, 2024).

Previous studies reported that the application of cattle manure at 20 t ha⁻¹ produced optimal growth and yield of yardlong bean, while higher application rates did not provide additional benefits and may reduce growth performance (Nariswari et al., 2024). The application rates of 10 and 20 t ha⁻¹ represent practical and scientifically relevant dosages commonly used by farmers and recommended for improving soil physical properties without causing nutrient imbalance.

Therefore, this study aimed to evaluate the effects of chicken manure and cattle manure applied at rates of 10 and 20 t ha⁻¹ on soil bulk density and soil color in yardlong bean cultivation. The findings of this study are expected to contribute to sustainable soil management practices and provide scientific evidence for the use of organic fertilizers to improve soil physical quality and crop productivity.

METHOD

This study was conducted from September 2025 to January 2026 in Tunggulo Village, Tilongkabila District, Bone Bolango Regency, Gorontalo Province, Indonesia. The research aimed to evaluate the effect of different types and application rates of organic fertilizers on soil bulk density (BD) and soil color in long bean (*Vigna sinensis* L.) cultivation.

The experiment employed a Randomized Block Design (RBD) with five treatments and three replications. The treatments consisted of:

- P0 = control (without fertilizer),
- P1 = chicken manure at 10 tons ha⁻¹,
- P2 = chicken manure at 20 tons ha⁻¹,
- P3 = cattle manure at 10 tons ha⁻¹, and
- P4 = cattle manure at 20 tons ha⁻¹.

Organic fertilizers were applied uniformly to each plot prior to planting and incorporated into the soil. Long bean seeds were planted according to standard agronomic practices, and crop management, including watering and weed control, was carried out uniformly across all treatments.

Soil bulk density was determined using the core sampling method. Bulk density was calculated using the following equation:

$$BD = \frac{W_d}{V}$$

where BD is soil bulk density (g cm⁻³), W_d is the oven-dry weight of soil (g), and V is the volume of the soil core (cm³).

Soil color was identified using the Munsell Soil Color Chart under field conditions. The collected data were analyzed using Analysis of Variance (ANOVA) to determine treatment effects. When significant differences were observed, mean separation was performed using Tukey's Honestly Significant Difference (HSD) test at a 5% significance level. In addition, correlation analysis was conducted to assess the relationship between soil bulk density and the growth and yield of long bean plants.

RESULTS AND DISCUSSION

Soil bulk density (BD) is a key physical indicator used to assess soil compaction and porosity, representing the ratio between soil solid mass and total soil volume. The results showed that the application of chicken manure and cattle manure at different rates did not significantly affect soil bulk density after long bean harvest. Bulk density values ranged from 1.33 to 1.49 g cm⁻³ across all treatments (Table 1). The lowest BD value was observed in the control treatment (P0), while the highest value occurred in the cattle manure treatment at 20 t ha⁻¹ (P4).

Table 1. Average bulk density values under organic fertilizer treatments

Treatment	Bulk density (g cm ⁻³)
P0 (Control)	1.33
P1 (Chicken manure 10 t ha ⁻¹)	1.36
P2 (Chicken manure 20 t ha ⁻¹)	1.43
P3 (Cattle manure 10 t ha ⁻¹)	1.35
P4 (Cattle manure 20 t ha ⁻¹)	1.49

Increasing organic fertilizer dosage was not followed by a decrease in bulk density; instead, a slight increase was observed. This indicates that the applied organic materials had not yet functioned effectively as soil conditioners. Incomplete decomposition of organic matter likely limited soil aggregation and pore space development, causing soil mass to increase without a proportional increase in porosity (Ibrahim, Robbo, & Nasrullah, 2023). According to Schad (2023), bulk density values exceeding 1.30 g cm⁻³ indicate moderate soil compaction, which may reduce soil porosity and restrict root penetration. The bulk density values obtained in this study therefore classify the soil as moderately compacted.

Previous studies reported that cattle manure often contains excessive moisture and relatively high C/N ratios, indicating incomplete decomposition and reduced effectiveness in

improving soil physical properties (Lumbanraja et al., 2024). Organic fertilizer performance in improving soil structure depends not only on application rate but also on material type and decomposition level. Longer incubation periods or repeated applications are required to enhance soil aggregation and reduce compaction. Sri et al. (2024) demonstrated that organic fertilizer incubation for 8–12 weeks significantly improves soil physical properties, including reduced bulk density and increased porosity.

Soil color observations revealed uniform results across all treatments, with all samples classified as 7.5YR according to the Munsell Soil Color Chart (Table 2). This brownish-yellow color indicates relatively low organic matter content and high iron oxidation levels (Hardjowigeno, 2015). The absence of color variation suggests that organic fertilizer application during the study period was insufficient to induce changes in soil organic matter composition and humus formation. Similar findings were reported by Kautsar et al. (2024), who noted that short-term organic amendments rarely result in noticeable soil color changes when assessed using MSCC.

Table 2. Soil color under organic fertilizer treatments

Treatment	Soil color
P0 (Control)	7.5YR
P1 (Chicken manure 10 t ha ⁻¹)	7.5YR
P2 (Chicken manure 20 t ha ⁻¹)	7.5YR
P3 (Cattle manure 10 t ha ⁻¹)	7.5YR
P4 (Cattle manure 20 t ha ⁻¹)	7.5YR

Regression analysis indicated a negative linear relationship between soil bulk density and long bean pod yield per hectare (Figure 1), expressed by the equation:

$$y = -2.3824x + 9.2482$$

An increase of 0.1 g cm⁻³ in bulk density was associated with a decrease of 0.23824 t ha⁻¹ in pod yield. However, the coefficient of determination ($R^2 = 0.0185$) and correlation coefficient ($R = -0.1360$) indicate a very weak relationship, suggesting that bulk density contributed minimally to yield variation in this study. Nevertheless, similar research has reported that increasing soil compaction negatively affects legume yield by restricting root growth and nutrient uptake (Amit & Amit, 2015), highlighting the importance of maintaining favorable soil physical conditions for optimal crop productivity (Xiukang & Adnan, 2025).

Mitigation strategies such as deep tillage, cover cropping, improved soil aeration, and optimized planting density have been suggested to reduce the negative effects of high bulk density on crop growth (Wenxu et al., 2022; R. et al., 2019). Overall, these findings emphasize the importance of proper soil management in sustainable agricultural systems and the need for long-term studies to evaluate the cumulative effects of organic fertilizer applications on soil physical properties (Lynch, 2022).

CONCLUSION

The application of chicken manure and cattle manure at rates of 10 and 20 t ha⁻¹ did not result in a significant effect on soil bulk density or soil color in long bean (*Vigna sinensis* L.) cultivation. Across all treatments, soil bulk density values ranged from 1.33 to 1.49 g cm⁻³, indicating a moderately compacted soil condition, while soil color remained uniform at 7.5YR (yellowish brown). These findings suggest that short-term application of organic manure was insufficient to induce measurable improvements in soil physical properties.

Furthermore, no optimal dosage or manure type was identified for reducing soil bulk density or altering soil color, as all organic fertilizer treatments exhibited responses comparable to the control. This indicates that the effectiveness of organic manure in improving soil physical characteristics may require longer decomposition periods, repeated applications, or integration with complementary soil management practices to achieve significant changes.

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