



Response of Cocoa (*Theobroma cacao* L.) Seedlings to the Application of Various Types of Manure on *Latosol*

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Abstract

This study aimed to determine the effect of various types of manure on the growth of cocoa (*Theobroma cacao* L.) seedlings on latosol soil media. The research was conducted in August 2025 at the Experimental Farm of the State Polytechnic of Agriculture Payakumbuh using a Completely Randomized Design (CRD) with four treatments and six replications: P1 = cow manure, P2 = goat manure, P3 = chicken manure, and P4 = duck manure. Parameters observed included seedling height, stem diameter, number of leaves, fresh weight, and dry weight. Data were analyzed using ANOVA followed by Duncan's New Multiple Range Test (DNMRT) at 5% significance level. The results showed that manure application significantly affected seedling height but had no significant effect on stem diameter and number of leaves. Goat manure (P2) resulted in the highest fresh and dry weights. Therefore, goat manure is recommended as the best organic fertilizer source for cocoa seedling growth on latosol soil.

Keywords: cocoa; manure; latosol soil; seedling growth.

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1. Introduction

Cocoa (*Theobroma cacao* L.) is one of Indonesia's leading plantation commodities with high economic value. It plays an important role in supporting smallholder plantations, the chocolate processing industry, and national non-oil exports. Indonesia is among the world's top three cocoa-producing countries after Côte d'Ivoire and Ghana [1]. However, national cocoa productivity remains relatively low compared to the genetic potential of the crop, which can reach 2–3 tons of dry beans per hectare per year. One of the main factors contributing to low productivity is the limited availability of high-quality seedlings and suboptimal nursery management practices Reference [2]. The success of seedling production is strongly influenced by the quality of the growing medium, which serves as physical support and a source of nutrients for early plant growth. Latosol soil is widely distributed in tropical regions, including West Sumatra. This soil type is generally characterized by acidic pH, clay to silty clay texture, and low organic matter content, which limits its capacity to support optimal seedling growth [3]. Therefore, improving the physical and chemical properties of latosol soil through organic matter application, such as manure, is essential.

Manure is an easily accessible and relatively inexpensive source of organic fertilizer that can improve soil structure, enhance cation exchange capacity, and supply essential macro- and micronutrients for plant growth. Different types of manure have varying nutrient compositions depending on their animal sources. Chicken manure generally contains high nitrogen levels and releases nutrients rapidly, while cow manure is rich in organic matter that improves soil physical properties [4]. Goat and duck manure are known to contribute to increased phosphorus and potassium availability. These differences in nutrient composition may influence the early growth of cocoa seedlings. Several previous studies have reported that manure application enhances the growth of plantation crop seedlings such as oil palm, coffee, and cocoa [5]. However, specific information regarding the comparative effects of various manure types on cocoa seedling growth in latosol soil, particularly in West Sumatra, remains limited. Therefore, this study aimed to determine the most suitable type of manure for promoting the growth of cocoa seedlings cultivated on latosol soil. The research was conducted at the Experimental Farm of the State Polytechnic of Agriculture Payakumbuh as part of efforts to develop environmentally friendly and sustainable cocoa nursery technologies based on locally available organic materials.

2. Materials and Methods

2.1 Location and Time

This research was conducted at the Experimental Farm of Payakumbuh State Polytechnic of Agriculture, West Sumatra, in September 2025. The research site has latosol soil with clay texture and acidic pH, which is commonly found in tropical highland areas. The location was selected based on soil characteristics that have low organic matter content, thus suitable for testing the effectiveness of various types of manure on cocoa seedling growth.

2.2 Materials and Tools

The equipment used in the cocoa seedling nursery study included polybags measuring 20 × 25 cm as planting containers, shovels and small hoes for processing and mixing latosol soil with cow, goat, chicken, and duck manure, as well as soil sieves to obtain a homogeneous growing medium. Seedling growth measurements were conducted using a ruler to measure plant height and a vernier caliper to measure stem diameter. An analytical balance was used to measure seedling fresh and dry weights, while a drying oven was used to dry samples to a constant weight. Other supporting equipment included buckets, a sprayer for irrigation, treatment labels, and stationery for data recording.

2.3 Research Design

This research used a Completely Randomized Design (CRD) with four treatments and six replications, resulting in 24 experimental units. The treatments tested were as follows:

- P1: Cattle manure
- P2: Goat manure
- P3: Chicken manure
- P4: Duck manure

Each treatment was applied to growing media with uniform ratio of manure to latosol soil per polybag. Planting was conducted using one cocoa seedling per polybag, and maintenance was performed uniformly, including watering, weeding, and mechanical pest and disease control.

2.4 Observation Parameters

Growth parameters observed included:

1. Seedling height (cm): measured from the base of the stem to the highest growing point
2. Stem diameter (mm): measured at 1 cm height above the media surface
3. Number of leaves (pieces): counted for all fully opened leaves
4. Fresh weight (g): measured after seedlings were uprooted and cleaned of soil
5. Dry weight (g): determined after seedlings were dried in an oven at 70°C until constant weight

2.5 Data Analysis

Observation data were analyzed using Analysis of Variance (ANOVA) at 95% confidence level to determine the effect of treatments on each cocoa seedling growth parameter. If analysis showed significant differences, further analysis was conducted using Duncan's New Multiple Range Test (DNMRT) at 5% significance level for pairwise treatment comparisons.

3. Results

3.1 Seedling Height

Results of variance analysis showed that application of various types of manure significantly affected cocoa seedling height (*Theobroma cacao* L.) grown on latosol soil media ($P < 0.05$). Average cocoa seedling height as affected by manure treatments is presented in Table 1.

Table 1: Mean height of cocoa seedlings under various manure types

Treatment	Mean Height (cm)	Notation
P1 (Cattle manure)	28.32	a
P2 (Goat manure)	24.91	b
P3 (Chicken manure)	26.80	ab
P4 (Duck manure)	24.13	b

Figures followed by the same letter show no significant difference based on DNMRT at 5% significance level.

Cattle manure (P1) resulted in the highest seedling height (28.32 cm) and was significantly different compared to goat and duck manure, but not significantly different from chicken manure. This indicates that cattle manure provides more balanced and sustained nutrient availability for vegetative growth of cocoa seedlings.

Plant height growth reflects cell division and elongation activities, which depend greatly on the availability of macronutrients such as nitrogen (N), phosphorus (P), and potassium (K). Cattle manure is known to have high organic matter content that improves soil structure, increases cation exchange capacity, and enhances soil aeration and water-holding capacity. In addition, cattle manure decomposes more slowly than chicken manure, allowing nutrients to be released gradually and continuously, thereby supporting stable vegetative growth over longer periods [6].

Chicken manure also provided relatively good seedling height and was not significantly different from cattle manure. This manure type contains high levels of nitrogen that are readily available to plants, thus stimulating leaf and stem growth during the early nursery stage. However, because of its rapid decomposition rate, nutrient availability from chicken manure tends to decline earlier compared to cattle manure [5].

Conversely, goat and duck manure treatments resulted in lower seedling heights. This is likely due to their higher lignin and crude fiber content, which slows the decomposition process and reduces nutrient release during the early growth period. Duck manure is also reported to have high moisture content and a relatively large C/N ratio, which may inhibit nitrogen mineralization and limit nutrient uptake by plants. These findings are consistent with previous studies reporting that cattle manure generally provides better effects on seedling growth of plantation crops such as cocoa, coffee, and oil palm compared to other manure types, particularly

when applied to acidic tropical soils such as latosols [7].

3.2 Stem Diameter

Observations on stem diameter of cocoa seedlings under various manure types showed that there were no significant differences among treatments (Table 2). Mean stem diameter values ranged from 6.71–6.82 mm.

Table 2: Effect of manure type on stem diameter of cocoa seedlings

Treatment	Mean Stem Diameter (mm)
P1 (Cattle manure)	6.71
P2 (Goat manure)	6.82
P3 (Chicken manure)	6.76
P4 (Duck manure)	6.79

The highest stem diameter was observed in the goat manure treatment (P2) at 6.82 mm, followed by duck manure (6.79 mm), chicken manure (6.76 mm), and cattle manure (6.71 mm). The non-significant difference among treatments indicates that all four manure types provided relatively balanced nutrients for stem tissue formation in cocoa seedlings.

The absence of significant differences among treatments indicates that all four types of manure were able to provide relatively balanced nutrients to support stem tissue development of cocoa seedlings grown on latosol soil. Major nutrients such as nitrogen, phosphorus, and potassium contained in manure play important roles in stem cell division and elongation; however, their effects tend to be similar when the applied dosage and the degree of organic matter decomposition are relatively comparable [8]Goat manure, which showed the highest mean stem diameter, is presumed to have a lower C/N ratio than the other manure types, resulting in faster nutrient mineralization and improved nutrient availability for plant uptake [9]. This finding is consistent with the study by Sari, who reported that goat manure positively affected the stem diameter of cocoa seedlings due to its relatively high nitrogen and phosphorus contents and finer texture, which facilitates nutrient absorption by plants [10]

In addition to manure type, the condition of latosol soil also influences the effectiveness of organic fertilizers. Latosol soils, which are generally low in organic matter, tend to show a stronger plant response to manure application. However, when soil fertility is already adequate, increases in stem growth may not be statistically significant [7] Therefore, although no significant differences were observed among treatments, goat manure is still recommended because it produced the highest average stem diameter.

3.3 Number of Leaves

The observation of the number of leaves of cocoa seedlings showed that the application of different types of

manure resulted in varying responses; however, no statistically significant differences were observed among treatments (Table 3). The mean number of leaves ranged from 14.89 to 16.22 leaves per seedling. The highest mean number of leaves was recorded in the goat manure treatment (P2) at 16.22 leaves, while the lowest number was observed in the chicken manure treatment (P3) at 14.89 leaves.

Table 3: Effect of manure type on the number of leaves of cocoa seedlings

Treatment	Mean Number of Leaves (pieces)
P1 (Cattle manure)	15.45
P2 (Goat manure)	16.22
P3 (Chicken manure)	14.89
P4 (Duck manure)	15.33

The number of leaves is an important indicator of vegetative growth and is strongly influenced by nutrient availability, particularly nitrogen (N), as this element plays a crucial role in chlorophyll formation and leaf tissue development [11]. Although no significant differences were detected, the tendency toward a higher number of leaves under the goat manure treatment suggests that this manure type is capable of supplying nitrogen in a form that is more readily absorbed by plants.

Goat manure generally contains higher nitrogen levels than cow or duck manure, thereby promoting more optimal leaf development [12]. In addition, the more friable physical structure of goat manure improves soil aeration and enhances the structure of latosol soils, which are typically compact. Improved soil conditions support better root system development of cocoa seedlings and subsequently stimulate the formation of new leaves [7].

These results are consistent with the findings [13], who reported that the application of goat manure in cocoa nurseries resulted in the highest number of leaves compared to other manure types. Goat manure also contributes phosphorus (P) and potassium (K), which are essential for photosynthesis and vegetative organ development. Therefore, although the differences were not statistically significant, goat manure still exhibited a positive effect on increasing the number of leaves of cocoa seedlings.

3.4 Fresh Weight and Dry Weight

Research results showed that application of various manure types affected fresh weight and dry weight of cocoa seedlings, although statistically did not show significant differences among treatments. Mean fresh weight and dry weight values are presented in Table 4.

Table 4: Effect of manure type on fresh weight and dry weight of cocoa seedlings

Treatment	Fresh Weight (g)	Dry Weight (g)
P1 (Cattle manure)	24.67	5.67
P2 (Goat manure)	31.83	7.08
P3 (Chicken manure)	25.50	6.35
P4 (Duck manure)	27.00	5.99

The results indicate that goat manure (P2) produced the highest values for both fresh weight (31.83 g) and dry weight (7.08 g) of cocoa seedlings. This suggests that goat manure contains nutrients that are more readily decomposed and available for plant uptake compared to other manure types. Goat manure generally has a lower C/N ratio than cow or duck manure, resulting in faster nutrient mineralization. In addition, the relatively balanced contents of nitrogen (N), phosphorus (P), and potassium (K) in goat manure support vegetative growth, such as leaf and stem development, which contributes to increased plant biomass [12]. Fresh weight reflects the accumulation of photosynthates that still contain water, while dry weight represents the total biomass produced through net assimilation. The increases in both parameters under the goat manure treatment indicate that cocoa seedlings were able to absorb nutrients effectively and utilize them efficiently for the formation of permanent tissues [11].

These findings are consistent with previous studies [10], which reported that goat manure resulted in the highest fresh and dry weights of cocoa seedlings compared to other manure types. Furthermore, [7] noted that the organic matter content of goat manure can improve the physical properties of latosol soils, enhance soil aeration and cation exchange capacity, and thereby increase nutrient uptake efficiency. Therefore, although the differences were not statistically significant, goat manure is still recommended as the most suitable organic matter source to support growth and biomass accumulation of cocoa seedlings grown on latosol soil.

4. Conclusion

This research demonstrates that application of various manure types significantly affects cocoa seedling growth on latosol soil. Although cattle manure promoted maximum height growth, goat manure was superior in promoting biomass accumulation as indicated by higher fresh and dry weights. Given that biomass accumulation is a critical indicator of seedling vigor and transplant success, goat manure is recommended as the optimal organic fertilizer source for cocoa seedling production on latosol soil in West Sumatra and similar tropical highland environments with comparable soil characteristics.

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