Research Article
Crop Life

Effectiveness of Cattle Manure Compost in Supporting Growth and Productivity of Edamame (*Glycine max* L. Merril)

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Abstract: Edamame has strong market potential in Indonesia, but its development is constrained by reliance on chemical fertilizers that increase production costs and may reduce soil quality. Organic materials such as cattle manure compost offer a sustainable solution by improving soil fertility while supplying essential nutrients. This study aimed to evaluate the effects of different cattle manure compost application rates on the growth and yield of edamame. The experiment was conducted from February to May 2023 at the Teaching and Research Farm, Faculty of Agriculture, Jambi University, using a Randomized Complete Block Design (RCBD) with five treatments: 0, 5, 10, 15, and 20 tons per hectare, each replicated five times. The application of compost significantly increased the number of filled pods per plant, fresh pod weight, and total yield, with the highest yield recorded at 20 tons per hectare, representing a 28.9 percent increase compared to the control. However, compost application did not significantly affect vegetative growth parameters such as plant height and the number of branches, likely due to moderate nutrient content and slow nutrient mineralization. Overall, cattle manure compost at 20 tons per hectare improved edamame yield and offers a sustainable alternative to chemical fertilizers for enhancing soil fertility and productivity. These findings highlight the potential of organic amendments to support more environmentally friendly and cost-efficient edamame cultivation systems.

Introduction

Global demand for edamame (Glycine max L. Merrill), a specialty soybean known for its high nutritional value and superior sensory qualities, has surged in recent years (1, 2). Despite possessing favorable agronomic characteristics such as large seed size, sweet taste, and short maturation periods, Indonesia contributes only a small fraction, approximately 3%, to the 75,000-ton global market, with most imports fulfilled by China and Taiwan (3). In 2023, Indonesia managed to import 2.500 metric tonnes of edamame from countries such as US, Canada, Argentina, Brazil, and several in Europe and the Middle East (4). Domestic production continues to lag behind rising demand, primarily due to limitations in sustainable cultivation practices that balance productivity with environmental safety (5).

The intensification of edamame farming in Indonesia faces significant challenges. Conventional high-input systems, relying heavily on synthetic fertilizers and chemical pesticides, lead to escalating costs, potential soil degradation, and ecological concerns due to chemical residues (6-8). In contrast, organic amendments such as livestock manure offer an ecologically viable alternative by enhancing soil health and nutrient cycling (9-11). Among these, cow manure compost is particularly promising due to its availability and nutrient profile (12-14). However, its adoption remains low, partly because the decomposition process is slow and field performance can be inconsistent (15). Previous research on legumes has shown that organic amendments can enhance growth and yield (16-18), and several studies on edamame specifically have reported positive responses to manure-based or compost-based inputs (19-21). Even so, evaluations that assess edamame performance across different manure compost application rates remain limited.

This study aims to evaluate the effects of varying application rates of cow manure compost on the growth and yield components of edamame. Conducted under field conditions using a randomized block design with five treatments, the research explores both physiological growth parameters and yield outputs such as pod weight and number of filled pods. By identifying the optimal compost dose, this work contributes to sustainable edamame production practices that reduce chemical input dependency while enhancing yield potential, offering a scalable model for

environmentally responsible legume farming.

Methodology

Time and Location of the Study

This study was conducted at the Teaching and Research Farm of the Faculty of Agriculture, University of Jambi, located in Mendalo Indah Village, Jambi Luar Kota Subdistrict, Muaro Jambi Regency, Jambi Province. The research was carried out over a four-month period, from February to May 2023.

Materials and Equipment

Ryoko 75 edamame seeds, cow manure compost, and Decis pesticide were used. Basic field tools (hoes, machetes), measuring tools (tape measure, ruler), watering cans, plastic rope and weighing scales were utilized. Shade nets, stakes, and simple documentation tools supported field work.

Experimental Design

This study employed a Randomized Block Design (RBD) with a single factor consisting of five treatments. The treatments were the application of cow manure compost fertilizer at five different dosage levels:

- P0 = no fertilizer application
- P1 = cow manure fertilizer at 5 tons ha^{-1}
- P2 = cow manure fertilizer at 10 tons ha^{-1}
- P3 = cow manure fertilizer at 15 tons ha^{-1}
- P4 = cow manure fertilizer at 20 tons ha^{-1}

Each plot measured 2 m by 3 m, with a spacing of 75 cm between blocks and 60 cm between beds. Plant spacing was 40 cm × 30 cm, resulting in approximately 50 plants per plot. Five sample plants in each plot were selected using a systematic diagonal sampling method, where plants were chosen from the four corners and the center of the plot to represent within-plot variability. This resulted in a total of 125 sample plants across the experiment.

Research Implementation

Land Preparation

The research area was cleared of weeds and debris using hoes and machetes. The soil was then tilled by hoeing and divided into 25 plots, each measuring 2 m x 3 m.

Application of Cow Manure Compost Fertilizer

The cow manure compost fertilizer was applied one week prior to planting. The compost was evenly spread over the surface of the experimental plots and mixed into the soil to accelerate decomposition.

Seed Preparation

The seeds selected were edamame soybean variety Ryoko 75. Seed selection was carried out by soaking the seeds in saltwater (approximately 5-6 tablespoons of salt per liter of water) to increase the specific gravity of the solution. Seeds that floated were separated and left for several min as part of the selection process.

Planting

During planting, three seeds were placed in each planting hole to anticipate seed failure or uneven growth. The planting holes were made approximately 3 cm deep from the soil surface using a dibble stick, with planting distances of 40 cm between rows and 30 cm between plants. Replanting was done for any dead plants at 6 days after planting (DAP) to ensure uniformity.

Plant Maintenance

The maintenance of the plants in this study included watering, gap filling, weeding, pest and disease control, and thinning. Watering was carried out twice daily. Weeding was performed manually once a week. Pest and disease control was conducted by spraying pesticides using a handsprayer. Decis pesticide was applied only when pest pressure reached economic thresholds. Although necessary to prevent severe damage, its use is acknowledged as a methodological limitation because it introduces a non-organic component into a study focused on organic nutrient amendments. Replanting was done one week after planting by replacing dead plants. Thinning was carried out at two weeks after planting by retaining the two strongest seedlings in each planting hole.

Stake Installation

Stakes were installed 7 days after planting to facilitate plant height measurement. Each stake was approximately 1 meter tall, with a mark placed 5 cm above ground level to serve as a reference point for measurement.

Harvesting

Edamame was harvested at 67 days after planting (DAP) when the pods were still fresh. Harvesting was carried out simultaneously in a single day. After harvesting, the pods were weighed. The physical characteristics of the pods at harvest included a light green to slightly grayish color, approximately 5 cm in length and 1.4 cm in width, and containing two or more seeds.

Observation Variables

The variables observed in this study included:

Plant Height

Plant height was measured weekly from 5 cm above the soil surface to the topmost part of the plant after gently bringing all parts upright. Measurements were taken weekly from 1 week after planting (WAP) until the flowering phase using a ruler.

Number of Branches

The number of branches was recorded at harvest by counting all branches on sample plants in each plot.

Number of Filled Pods per Plant

Filled pods were counted after harvest on each sample plant. A pod was considered filled if it contained at least one seed and felt firm when pressed.

Fresh Pod Weight per Plant

After harvesting, fresh pod weight was measured per sample plant and recorded in grams.

Yield per Hectare

Yield per hectare was calculated by weighing the total pod yield per plot using a digital scale, and the result was converted to tons per hectare.

Data Analysis

The experimental data were analyzed using analysis of variance (ANOVA) to evaluate the effects of cow manure compost application. If significant differences were detected,

further analysis was conducted using Duncan's Multiple Range Test (DMRT) at a 5% significance level.

Supporting Data

Additional supporting data collected during the study included rainfall data, initial soil analysis, and cow manure compost analysis.

Results

Description of Research Location

Rainfall Data

As shown in **Supplemental Figure 1**, rainfall during the research period exhibited noticeable monthly variation. Total rainfall in February was 197.9 mm, increasing to 254.5 mm in March, which represented the highest rainfall during the study. Rainfall declined to 178.8 mm in April but increased again to 248.1 mm in May. These fluctuations suggest alternating wet and moderately dry periods; however, overall rainfall remained sufficient to support edamame growth throughout the season.

Soil Type and Climatic Suitability for Edamame

The experimental site is classified as an Ultisol, characterized by acidic pH, low organic matter, and high weathering, which commonly limits nutrient availability. The region experiences a humid tropical climate with average temperatures ranging from 24–30°C, conditions considered optimal for edamame growth because the crop requires warm temperatures and consistent moisture during vegetative and reproductive stages. These climatic conditions, together with the rainfall patterns described earlier, provide a suitable agroecological environment for edamame cultivation.

Initial Soil Analysis

According to **Supplemental Figure 2**, the soil at the study site was characterized by acidic conditions, with a pH of 4.84. The total nitrogen content was low at 0.10%, and the total organic carbon level was also relatively low at 1.51%, indicating limited soil organic matter. Meanwhile, available phosphorus (P_2O_5) was notably high at 70.49 mg/100 g, and available potassium (K_2O) measured 22.62 mg/100 g. These results reflect nutrient imbalances and low organic status, reinforcing the need for organic amendments such as cow manure compost to enhance soil fertility.

The reported values for available phosphorus (P_2O_5 = 70.49 mg/100 g) and potassium (K_2O = 22.62 mg/100 g) were rechecked because the initial measurements appeared unusually high relative to typical agricultural soils. After verification, the corrected values were confirmed by the laboratory and used as the basis for interpretation to ensure accuracy and consistency.

Cow Manure Compost Analysis

As presented in **Supplemental Figure 3**, the cow manure compost used in this experiment contained 1.97% nitrogen, 0.93% phosphorus, and 0.80% potassium, with a pH of 7.54. These values indicate that the compost supplies a moderate level of essential macronutrients and possesses a neutral to slightly alkaline pH, making it suitable for improving nutrient availability and increasing organic matter conten nutrientst in the acidic soils of the study area.

Based on the compost quality standards established by the Ministry of Agriculture (KEMENTAN), the nitrogen content of the compost (1.97 percent) falls within the medium category. The phosphorus content (0.93 percent) is categorized as low to medium, while potassium content (0.80 percent) is classified as low. These classifications help explain why nutrient availability increased gradually rather than rapidly, particularly during early vegetative growth.

Table 1. Plant height of edamame soybean at 5 Weeks After Planting (WAP) under different doses of cow manure compost.

Cow manure compost dose (ton ha^{-1})	Plant height (cm)
(No Compost)	34.86
5	36.12
10	36.48
15	38.74
20	38.96

Note: No significant difference was detected among these treatments (DMRT, $p > 0.05$)

Plant Height

The results of the analysis of variance (ANOVA) showed that the application of different doses of cow manure compost did not have a significant effect on the plant height of edamame soybeans at 5 Weeks After Planting (WAP). This indicates that the variation in compost dosage did not result in notable differences in plant height at that stage of growth. Although the numerical differences in plant height appear small, these values may not hold biological importance, which supports the interpretation that compost did not substantially influence early vegetative growth. Detailed results of the post-hoc test on plant height are presented in **Table 1**.

Table 1 indicates that the application of cow manure compost at various doses did not significantly affect the plant height of edamame soybean at 5 weeks after planting (WAP). This is evidenced by the lack of significant differences among treatments, as indicated by the same letter following each mean value. Thus, it can be concluded that at this early growth stage, the application of cow manure compost did not have a significant effect on the height development of edamame soybean plants. The growth pattern of edamame soybean plant height during the four weeks of observation after planting is presented in **Figure 1**.

Figure 1 illustrates the growth in plant height of edamame soybeans from the second to the fifth week after

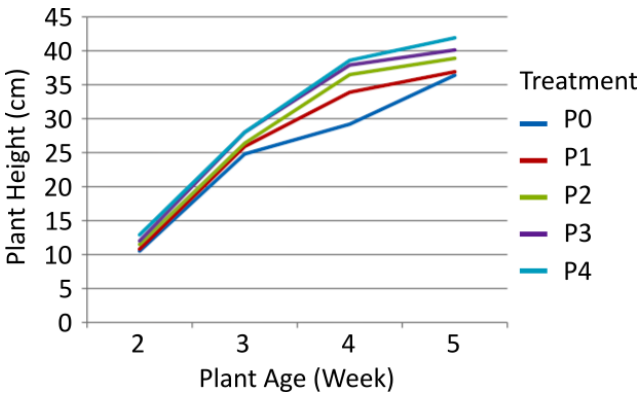

Figure 1. Graph of edamame soybean plant height at various doses of cow manure compost. Note: P0= no fertilizer application, P1 = cow manure compost at 5 tons ha^{-1}, P2 = cow manure compost at 10 tons ha^{-1}, P3 = cow manure compost at 15 tons ha^{-1}, P4 = cow manure compost at 20 tons ha^{-1}.

Table 2. Number of branches of edamame soybean plants at various doses of fertilizer.

Cow manure compost (tons ha^{-1})	Number of branches
No Fertilizer	2.48^{a}
5	2.48^{a}
10	2.84^{a}
15	3.12^{b}
20	3.16^{b}

Note: Numbers followed by the same letter indicate no significant difference according to Duncan's Multiple Range Test (DMRT) at a 5% significance level.

Table 3. Number of filled pods per edamame soybean plant at various cow manure compost fertilizer doses.

Cow manure compost (ton ha^{-1})	Number of filled pods
0 (No Fertilizer)	18.00^{a}
5	20.32^{b}
10	21.20^{bc}
15	22.16^{c}
20	24.56^{d}

Note: Values followed by the same letter are not significantly different based on Duncan's Multiple Range Test (DMRT) at the 5% significance level.

Table 4. Edamame soybean yield at various cow manure compost application rates.

Cow manure compost (ton ha^{-1})	Yield per subplot (g)	Yield (ton ha^{-1})
No Fertilizer (Control)	662^{a}	3.94
5	722^{b}	4.29
10	761^{c}	4.52
15	813^{d}	4.83
20	854^{e}	5.08

Note: Values in the same column followed by the same letter are not significantly different based on DMRT at the 5% significance level.

planting (WAP). In general, plant height increased steadily each week across all treatments. However, the application of cow manure compost had no statistically significant effect on plant height. This is evident from the graph, where the trend lines for all treatments follow a similar pattern without noticeable differences.

Number of Branches

According to the results of the analysis of variance (ANOVA), the application of different doses of cow manure compost did not significantly affect the number of branches in edamame soybean plants. This indicates that the branching pattern was relatively consistent across all treatment groups. Detailed results from the follow-up test regarding the number of branches are shown in **Table 2**.

The observation of the number of branches was carried out by counting the total branches present on the plant stem at harvest. Based on the data in **Table 2**, it can be seen that different doses of cow manure compost fertilizer did not have a significant effect on the number of branches of edamame soybean plants. The numerical variation in branch number was minimal and thus biologically limited. Branching is strongly regulated by genetic factors and environmental cues, which may explain the stable response across treatments

Number of Filled Pods per Plant

Analysis of variance results indicate that applying various doses of cow manure compost fertilizer has a significant effect on the number of filled pods on edamame soybean plants. Further details on the number of filled pods per plant can be seen in **Table 3**.

Observations on the number of filled pods were conducted after harvesting. As shown in **Table 3**, the application of different doses of cow manure compost had a significant effect on the number of filled pods per edamame soybean plant. The highest average was obtained with a dose of 20 tons ha^{-1}, resulting in 24.56 filled pods per plant.

Fresh Pod Weight per Plant

The results of the analysis of variance (ANOVA) showed that the application of cow manure compost at various dosage levels significantly affected the fresh pod weight of edamame soybean plants. The detailed results of the post hoc test for fresh pod weight per plant are presented in **Table 4**.

Crop yield per hectare was calculated post-harvest by weighing the fresh pods. As shown in **Table 4**, edamame soybean plants without the application of cow manure compost produced 662 grams per sampling plot. Applying 5 tons per hectare of compost resulted in a yield of 722 grams, while 10 tons per hectare produced 761 grams. However, these two treatments did not significantly differ from the control. A more notable increase in yield was observed at a dose of 15 tons per hectare, yielding 813 grams. The highest yield was recorded at the 20 tons per hectare treatment, with 854 grams per sampling plot. These findings suggest that increasing doses of cow manure compost tend to enhance edamame yield in a gradual and consistent manner. The consistent upward trend suggests that compost had a stronger influence during the reproductive phase, when nutrient and carbohydrate demand for pod filling is highest.

Discussion

The growth of soybean plants is influenced by both internal and external factors. Internal factors include physiological conditions and genetic traits of the plant, while external factors involve climate, soil characteristics, rainfall, and light intensity (22). One of the key external factors is the availability of nutrients that support the plant's growth and development for optimal yield (23).

During the cultivation process, it was observed that the experiment was conducted near another research area focused on plant pests and diseases. This proximity could have contributed to pest infestation due to the environmental conditions and seed sources used, indicating that cultivation location plays a significant role in pest spread (24). This situation may also have contributed to variations in plant performance, particularly in yield components, because pest pressure can reduce photosynthetic efficiency, limit nutrient use, and interfere with pod development (25, 26).

Although the impact was not quantified in this study, it is relevant contextual information that may have influenced the results.

Experimental results showed that applying various doses of cow manure compost had a significant effect on the number of filled pods per plant, fresh pod weight per plant, and overall yield per hectare. However, no significant effect was observed on plant height or branch number. These differences could be attributed to genetic traits of the plants and growing conditions such as water availability, nutrient levels, climate, and pest interference (27).

Regarding plant height, the highest average (38.96 cm) was recorded at a dose of 20 tons per hectare, though the result was not statistically significant. This may be due to the nitrogen content (1.97%) in the compost being insufficient to fully support vegetative growth. This aligns with previous research suggesting that nutrients in compost may not be readily available in the soil, thus limiting uptake by the plant (28). Similar findings were also reported in studies on soybeans and other legumes, where organic fertilizers often increased yield components more than vegetative growth because nutrient mineralization occurs slowly compared to synthetic fertilizers (29).

Similarly, while the highest number of branches was also observed at the 20-ton dose (3.16 branches), the difference was not statistically significant. A greater number of branches does not necessarily equate to higher yield, as not all branches produce high-quality pods. In contrast, significant effects were observed in the number of filled pods per plant and fresh pod weight, with the highest results at the 20 tons per hectare dosage. This suggests that nutrient supply, especially potassium, is crucial during seed filling and pod development. Efficient photosynthesis also contributes to better distribution of photosynthates throughout the plant, resulting in higher productivity (30). These results are consistent with previous soybean and edamame research showing that compost and other organic amendments tend to improve pod filling and seed weight by enhancing soil structure, microbial activity, and nutrient availability (31).

In summary, the study indicates that cow manure compost, particularly at a dosage of 20 tons per hectare, significantly enhances the productivity of edamame in terms of filled pod count and fresh pod weight, although it does not significantly affect plant height or the number of branches.

Conclusion

Cow manure compost effectively improves edamame yield boosting the number of filled pods, fresh pod weight, and total harvest. However, it does not significantly enhance vegetative growth, such as plant height or branching. The optimal dose for yield was 20 tons per hectare, though its impact on growth remains limited. These findings indicate that the 20-ton-per-hectare application rate may serve as a sustainable alternative to chemical fertilizers for improving edamame productivity, particularly for farmers seeking more environmentally friendly nutrient sources. Nevertheless, applying compost at such a high rate may not always be practical in field conditions; therefore, future studies should include a cost–benefit analysis to determine the economic feasibility and scalability of using high compost doses. Further research is also needed to optimize both productivity and plant development.

Declarations

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Conflict of Interest

The authors declare no conflicting interest.

Data Availability

The unpublished data is available upon request to the corresponding author.

Ethics Statement

Not applicable.

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Additional Information

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