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The Effectiveness of Cow Manure for Sustainable Agriculture on Purple Eggplant Plants

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Abstract
Background: Sustainable agriculture increasingly emphasizes the use of organic fertilizers to improve soil fertility and reduce environmental impact. Cow manure is widely recognized as a potential organic amendment for enhancing crop productivity. **Aim:** This study aimed to evaluate the effect of different doses of cow manure on the growth and yield of purple eggplant (*Solanum melongena* L.). **Methods:** A Randomized Complete Block Design was applied with five treatments of cow manure (0, 50, 75, 100, and 125 g/polybag) and five replications. Observed parameters included plant height, number of leaves, number of branches, flowering age, and yield components such as number of fruits, fruit length, fruit diameter, weight per fruit, and total fruit weight per plant. **Results:** The application of cow manure did not significantly affect most vegetative growth parameters. However, a dose of 100 g/polybag accelerated flowering time. Yield components such as fruit number, size, and individual fruit weight were not significantly influenced. In contrast, total fruit weight per plant showed significant differences, with the 50 g and 100 g/polybag treatments producing the highest yields (411.07 g and 409.18 g, respectively). **Conclusion:** Cow manure application at moderate doses (50–100 g/polybag) improves eggplant yield without significantly affecting vegetative growth. This finding supports the use of organic fertilizers as a sustainable alternative in eggplant cultivation.

Keywords: cow manure; purple eggplant; sustainable farming

1. Introduction

Eggplant (*Solanum melongena* L.) is a significant horticultural crop in Indonesia, prized for its nutritional benefits and culinary versatility. However, its productivity in many farming regions remains suboptimal due to declining soil fertility and the long-term reliance on inorganic fertilizers, which reduce soil health and limit sustainable production. Eggplant, a member of the Solanaceae family, is a rich source of nutrients, making it an essential component of a balanced diet. Eggplant's nutritional profile includes components such as vitamins A, B1, and C, as well as essential minerals like calcium, iron, and phosphorus (Makrogianni et al., 2017; Henry et al., 2023; Nandana et al., 2023). These nutrients play a vital role in maintaining health and preventing disease.

Although relatively low in protein, usually less than 1% of fresh weight eggplant does contain protein, which is relatively higher in seeded varieties compared to seedless varieties. This suggests that nutrient density can vary significantly among different cultivars, impacting the overall health benefits derived from eggplant consumption (Henry et al., 2023). The low protein content is offset by the vegetable's benefits as a source of dietary fibre, which is beneficial for digestive health, and its antioxidant properties, which contribute to eggplant's overall health profile (Scorsatto et al., 2017; Mieles-Gómez et al., 2021).

Nationally, eggplant production shows an increasing trend. According to data from the Central Statistics Agency (2024), eggplant production in Indonesia increased from 676,339 tons in 2021 to 699,896 tons in 2023. However, this increase has not fully met domestic market demand, which continues to grow in line with population growth and healthier consumption patterns. One of the main obstacles to increasing eggplant productivity is declining soil fertility due to the excessive use of inorganic fertilizers. This unbalanced fertilization practice can lead to degradation of soil organic matter, reduce microbial activity, and reduce the efficiency of nutrient uptake by plant roots. As a result, land productivity declines and agricultural systems become unsustainable.

To address these issues, efforts are needed to improve soil fertility through the use of organic fertilizers, which play a crucial role in improving the physical, chemical, and biological properties of the soil. In many vegetable-producing regions of Indonesia, eggplant yield remains 20–40% below its potential due to declining soil fertility and reduced soil organic matter, which has fallen by an estimated 0.5–1.0% per year in intensively cultivated lands. Long-term dependence on inorganic fertilizers has also contributed to soil compaction, nutrient imbalance, and declining cation exchange capacity, further widening the yield gap. Organic fertilizers, particularly cow manure, play a crucial role in modern agriculture by providing essential nutrients and improving soil health. The use of organic fertilizers as an alternative to chemical fertilizers has gained attention due to their benefits for ecological sustainability, particularly in improving the physical and biological properties of the soil. Cow manure is a solid organic fertilizer containing essential nutrients such as nitrogen (N), phosphorus (P_2O_5), and potassium (K_2O), which are essential for plant growth. The nutrients provided by cow manure support various plant physiological processes, increase crop yields, and encourage healthier plant development. The use of organic manure has been shown to significantly increase grain and straw yields due to the balanced supply of essential nutrients (Solanki et al., 2022; Adekiya et al., 2020).

The organic matter content in cow manure can increase the cation exchange capacity (CEC), improve porosity, and enhance the soil's water retention capacity, thus making the root environment more conducive to plant growth (Lumbanraja & Harahap, 2015; Mulyati et al., 2022). This increase in CEC and soil structure has direct implications for the efficiency of nutrient uptake by plants, improving soil water balance and ultimately increasing crop productivity. Furthermore, cow manure plays a role in improving soil physical properties that the intensive use of chemical fertilizers, such as compaction and reduced porosity, has damaged. Soil structure degradation often reflected in bulk density increases from <1.2 g cm^{-3} to >1.4 g cm^{-3} in vegetable lands further demonstrates the need for organic amendments to restore soil function and sustain crop productivity.

In addition to improving soil physical and chemical properties, cow manure also contributes significantly to increased soil biological activity. The organic matter from manure serves as an energy source for soil microorganisms, which play a crucial role in the decomposition process. Organic fertilizers, nutrient mineralization, and the formation of stable soil structures (Puspita et al., 2021; Fidiansyah et al., 2021). Increased biological activity accelerates nutrient cycling in the soil, thereby improving overall soil health. Therefore, the use of organic fertilizers, particularly cow manure, not only serves as a source of plant nutrients but also plays a role in maintaining the balance of the soil ecosystem.

Furthermore, previous research has demonstrated that the sustainable use of cow manure can enhance fertilizer efficiency by reducing dependence on inorganic fertilizers

(Sutisna et al., 2024; Hasan et al., 2024). This is highly relevant to the principles of environmentally friendly and sustainable agriculture, which emphasize efficient resource use and long-term soil health improvement. Cow manure plays a crucial role in naturally enhancing crop productivity while supporting the goals of sustainable agricultural development, which aim to achieve food security and promote farmer welfare.

Overall, the use of cow manure is an effective strategy for enhancing soil quality, boosting crop productivity, and promoting environmentally friendly agricultural systems. The use of cow manure in eggplant cultivation not only provides agronomic benefits but also strengthens the soil system. Local resource-based agriculture that is more efficient and adaptive to environmental changes. The novelty of this research lies in determining the optimal dose of cow manure that is most effective in enhancing the growth and yield of purple eggplant plants, while also naturally improving soil fertility without relying on chemical fertilizers. Therefore, this study aims to evaluate the effectiveness of various doses of cow manure on the growth and production of purple eggplant plants as a step towards a productive, efficient, and sustainable agricultural system.

2. Methods

2.1 Place and Time

This research was conducted from December 2024 to April 2025 in Cibinong Village, Gunung Sindur District, Bogor Regency, on land with an altitude of approximately 72 meters above sea level, characterized by Latosol soil type. The cow manure used in this study was obtained from a local cattle farm located approximately 2–3 km from the research site. The manure had been composted for 4–6 weeks prior to application, reaching a semi-stabilized maturity stage as indicated by its dark brown color, crumb texture, and reduced odor. The moisture content of the manure at the time of application ranged from 40–55%, which is typical for partially composted livestock manure.

Nutrient analysis was conducted before application to determine its chemical composition. The cow manure contained approximately 1.2–1.8% total nitrogen (N), 0.6–0.9% P_2O_5, and 1.5–2.0% K_2O, with an organic carbon content of 18–25%, resulting in a C: N ratio of around 15–20. This C: N ratio indicates that the manure was sufficiently decomposed to support nutrient mineralization rather than immobilization during early plant growth. These characteristics ensured that the manure could effectively contribute to improving soil nutrient availability, soil structure, and biological activity throughout the experimental period.

2.2 Research Design and Data Analysis

The research design employed a Randomized Complete Block Design (RCBD) with five treatments of cow manure doses and five replications, resulting in 25 experimental units. Each experimental unit consisted of three plants, resulting in a total of 75 purple eggplant plants observed. All treatments received inorganic fertilizers N, P, and K at 100% of the recommended dose of eggplant fertilization according to Sulardi et al. (2022), which is 0.8 g Urea + 1.5 g SP-36 + 0.88 g KCl per polybag. The cow manure dose treatments tested were: P0 (without cow manure/control), P1 (50 g/polybag), P2 (75 g/polybag; referring to (Ufairah & Sugito, 2019), P3 (100 g/polybag), and P4 (125 g/polybag).

The observation data were analyzed using analysis of variance (ANOVA) to determine the effect of treatments on plant growth. If a fundamental difference exists, the analysis is continued with the Honestly Significant Difference (HSD) test at a 5% confidence level to determine the significance of the difference between treatments. All statistical processing was done using Costat software version 6.400.

2.3 Planting and Observation

The planting medium was prepared in polybags and incubated for one week before planting, allowing for optimal decomposition of organic matter. Before incubation, the medium was watered until moist, then the polybags were covered and turned periodically. Inorganic fertilizers were applied in stages, with urea applied three times: at planting, 15 days after planting (DAP), and 30 days after planting at a dose of 0.27 g per polybag (a total of 0.8 g/polybag, equivalent to 160 kg/ha). SP-36 and KCl fertilizers were applied once at planting at doses of 1.5 g and 0.88 g per polybag (equivalent to 300 kg/ha and 175 kg/ha, respectively). Fertilizer application was carried out by digging the soil at a distance of approximately 5 cm from the plant stem. The fertilizer was then inserted into the hole and covered with soil.

Observations were conducted 9 weeks after planting (DAP), including plant height, the number of leaves, and the number of primary branches. Plant height was measured from the base of the stem to the growing point using a ruler, the number of leaves was counted overall on each plant, and the number of primary branches was counted from the main branches formed.

3. Results and Discussion

3.1 Eggplant Plant Conditions

The growth of purple eggplant plants encountered several challenges stemming from environmental factors and plant pests (OPT). Shade from two large trees and red-tipped plants around the research area reduced the light intensity received by the plants, potentially reducing photosynthetic activity and productivity (Wahyu et al., 2018). Several pests identified included leafhoppers (*Phyllium fulchrifolium*), leaf beetles (*Epilachna* sp.), mites (*Tetranychus* sp.), aphids (Aphis gossypii), and armyworms (*Acronicta* sp.). The first infestation was detected 14 days after planting, with relatively low levels of damage. Control was carried out mechanically and through the application of Decis 25 EC® insecticide (2 mL/L of water). Various forms of pest and disease attacks that emerged during the research are shown in Figure 1.

Diseases observed in purple eggplant plants included a yellow virus infection caused by the Gemini virus and leaf spot caused by Cercospora sp. at 6 weeks after planting. Symptoms include yellowing of the leaves and blackish-brown spots, which reduce photosynthetic capacity and cause physiological stress in the plants. Control was carried out by pruning infected leaves and applying the fungicide Dithane M-45 (2 g/L of water). Although some plants were infected during the generative phase, most were able to grow and produce, indicating tolerance to the infection, which was likely influenced by genetic factors and good cultivation practices.

Cercospora leaf spot is a widespread disease affecting various crops, including eggplant, peanuts, and rice, which can significantly reduce plant health and productivity by disrupting photosynthesis. Previous studies have shown that sanitation of infected leaves and fungicide application are key strategies to suppress pathogen spread (Kumar et al., 2021). Some cultivars also possess a degree of genetic resistance to this disease, acquired through selective breeding programs (Anco et al., 2020).

In addition to chemical control, developing resistant varieties through traditional breeding is a sustainable long-term strategy. Integrating tolerant varieties with Integrated Pest Management (IPM) practices can reduce reliance on fungicides and maintain ecological balance (Pretty & Bharucha, 2015). This integrated approach, when combined with fungicide application, has been shown to increase pathogen suppression and overall plant resilience (Ma et al., 2020).

Overall, the resilience of most plants despite infection suggests support from the plant's natural defence system, good agronomic practices, and optimal nutrient management. These findings confirm that appropriate disease control, supported by an understanding of limiting factors and the use of tolerant varieties, is key to the success of sustainable purple eggplant cultivation.

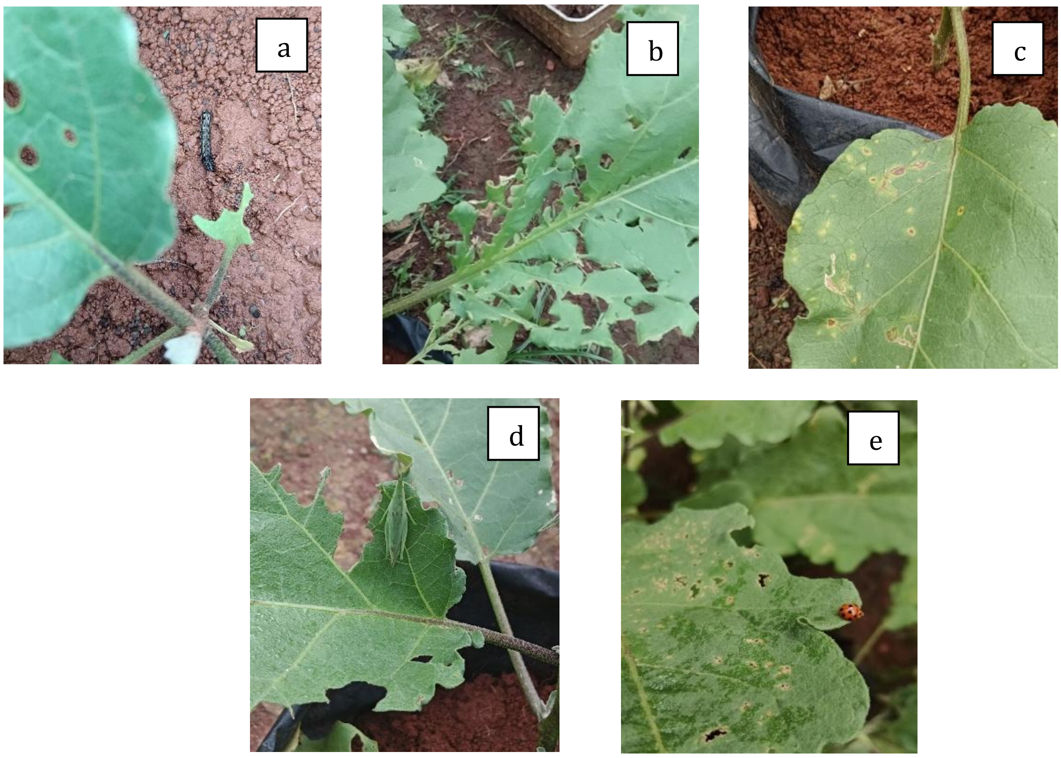

Figure 1. Pest and Disease Attacks on Eggplant Plants (a) Armyworm, (b) OPT Attacks, (c) Leaf Spots, (d) Leafhoppers, (e) Leaf Beetles

3.2 Eggplant Growth

The application of various doses of cow manure did not significantly affect most vegetative growth parameters of purple eggplant plants, such as plant height, number of leaves, and number of branches. However, the age at flowering parameter showed a significant difference between treatments based on the 5% BNJ test. Varying doses of cow manure still played a role in increasing nutrient availability and improving soil conditions, although not all parameters showed a significant response. The results of observations of average purple eggplant plant growth in each treatment are presented in Table 1.

The application of cow manure at various doses showed no significant effect on all purple eggplant production parameters, including fruit number, fruit length, fruit diameter, fruit weight, and total fruit weight per plant. This lack of difference suggests that the plant's physiological response to the treatments was uniform, likely due to the adequacy of basic nutrients from inorganic fertilizers applied evenly across all treatments. The homogeneous and relatively fertile growing medium could mask the additional contribution of organic fertilizer, making the variation between treatments less apparent.

Nevertheless, there was a trend towards an increase in the average values at doses of 50 g and 100 g per polybag, particularly for fruit number and total fruit weight per plant. This trend suggests that the application of cow manure at moderate doses still has the potential to support plant physiological processes during the generative phase. The contribution of nitrogen and potassium from manure, which play important roles in flower formation, fruit enlargement, and fruit filling efficiency, has been reported in various studies (Fadil & Sutejo, 2020; Hasnidar et al., 2022). Therefore, although the observed pattern of increase is not statistically significant, it can still be explained physiologically.

Table 1. Effect of Cow Manure Dose on Vegetative Growth of Purple Eggplant Plants

Cow Manure Dose	Plant Height (cm)	Number of Leaves (leaflets)	Number of Branches (fruits)	Flowering Age (DAP)
0 g/polybag	53.95a	48.80a	8.00a	48.47a
50 g/polybag	63.67a	55.47a	8.07a	42.27ab
75 g/polybag	55.83a	48.33a	7.07a	47.53a
100 g/polybag	64.05a	60.00a	8.13a	39.40b
125 g/polybag	55.22a	50.27a	7.33a	43.33ab

Description: Numbers followed by the same letter in the same column are not significantly different based on the BNJ test at the 5% level.

The lack of a significant effect on fruit size both length and diameter and fruit weight reinforces the hypothesis that purple eggplant varietal characteristics are more dominant in determining fruit size and morphology than the influence of additional nutrients from organic fertilizer. This finding aligns with those of Arthanawa et al. (2022) and Silvyana et al. (2023), who stated that genetic factors play a significant role in determining eggplant fruit size, while environmental influences and fertilizer treatments are often more limited. Therefore, the results of this study emphasize the importance of selecting superior varieties as a primary strategy for improving fruit quality and size.

In addition to nutritional and genetic influences, environmental conditions during the study also influenced production yield. Shading from surrounding vegetation has the potential to reduce the light intensity received by plants, thereby reducing photosynthetic capacity and biomass accumulation. On the other hand, the presence of plant pests such as grasshoppers, aphids, and mites even at low intensity can cause physiological stress that impacts fruit formation and development. The interaction between environmental factors and nutrient availability may further mask differences in response between cow manure treatments.

Overall, although no significant differences were found between treatments, the increasing trend in specific manure doses reflects agronomic potential that can be optimized under better cultivation conditions. These findings indicate that cow manure continues to contribute to improving the quality of the growing medium, gradually supporting plant physiological processes. Further research, utilizing a combination of organic and inorganic fertilizers, the cultivation of superior varieties, and more controlled environmental management, is needed to thoroughly evaluate the effectiveness of cow manure on purple eggplant yields.

3.3 Purple Eggplant Production Results

Purple eggplant yields included fruit number, fruit length, fruit diameter, fruit weight, and fruit weight per plant. Based on the statistical analysis in Table 2, only the fruit weight per plant showed a significant difference between treatments, as determined by the 5% BNJ test. At the same time, all other parameters were not significantly different.

Table 2. Average Purple Eggplant Production Components at Various Doses of Cow Manure

Cow Manure Dose	Number of Fruits (fruits)	Fruit Length (cm)	Fruit Diameter (cm)	Weight Per Fruit (g)	Fruit Weight Per Plant (g)
0 g/polybag	1.87a	23.65a	4.15a	147.41a	285.04b
50 g/polybag	2.73a	23.44a	4.21a	154.67a	411.07a
75 g/polybag	1.60a	24.15a	4.14a	151.67a	260.34b
100 g/polybag	2.60a	23.86a	4.31a	151.52a	409.18a
125 g/polybag	1.87a	22.86a	4.09a	143.83a	275.52b

Description: Numbers followed by the same letter in the same column are not significantly different based on the BNJ test at the 5% level.

The average values for fruit number, length, diameter, and weight per fruit showed a narrow range and did not form a consistent pattern of increase across treatments. This suggests that varietal genetic factors have a greater influence on fruit morphological characteristics than variations in the dosage of cow manure. This finding aligns with previous reports that fruit size and shape tend to be stable in superior varieties, despite variations in nutrient availability. Conversely, fruit weight per plant showed significant differences, with the 50 g and 100 g/polybag treatments producing the highest weights and significantly different from the other treatments. This suggests that moderate doses of cow manure can increase yield accumulation, although not directly increase fruit number or size. This increase likely stems from a combination of slightly higher fruit number and relatively stable fruit weight at these doses.

Doses that are too low (0 g) or too high (125 g) actually result in lower fruit weight per plant. This phenomenon can be explained by possible nutrient limitations at low doses and potential nutrient imbalances or inter-plant competition at high doses (Parwada & Chinyama, 2021; Adinde et al., 2021). Therefore, applying cow manure at moderate doses is the optimal point for efficiently supporting plant productivity.

Overall, the results of this study indicate that although most production parameters were not significantly affected by cow manure application, a positive response was observed in total fruit weight per plant at doses of 50–100 g/polybag. This underscores the importance of properly managing organic fertiliser doses to optimise yields without causing excess nutrients that can inhibit growth or yield.

4. Limitations and Future Directions

This study has several limitations that should be acknowledged when interpreting the findings. First, the experiment was conducted under controlled polybag conditions, which may not fully represent field-scale dynamics, particularly regarding soil heterogeneity, microbial interactions, and environmental variability such as light intensity and pest pressure, all of which were shown to influence plant performance. Second, the uniform application of full-dose inorganic fertilizers across treatments likely masked the isolated effect of cow manure, thereby limiting the ability to detect stronger treatment differences. Third, the relatively short observation period and single-location design restrict the generalizability of the results across different agroecological zones and growing seasons. Future research should therefore adopt a factorial experimental approach that integrates varying proportions of organic and inorganic fertilizers to better capture synergistic effects, alongside multi-location field trials to enhance external validity. Additionally, longer-term studies are needed to evaluate cumulative impacts on soil health, nutrient cycling, and sustainability indicators, while also incorporating different eggplant varieties to assess genotype–environment–fertilizer interactions more comprehensively.

5. Conclusion

Cow manure did not significantly affect most growth and yield parameters of purple eggplant, but doses of 50–100 g/polybag increased fruit weight and the 100 g dose accelerated flowering. Moderate applications are thus more beneficial than low or high doses. Growers may trial 50–100 g/polybag using well-decomposed manure to ensure consistent results. Future studies should include factorial nutrient experiments and field validation to confirm these findings beyond polybag conditions.

Declaration of Generative AI and AI-Assisted Technologies in the Writing Process

ChatGPT as an AI-assisted tool for language refinement, grammar checking, and improving the clarity of scientific writing. The use of this tool was limited to supporting the writing process and did not involve the generation of original research content, data analysis, or interpretation of results. After using this tool, the authors carefully reviewed, revised, and ensured the accuracy and integrity of the manuscript. The author(s) take full responsibility for the content of this publication.

Authorship Contribution Statement

Erlina Rahmayuni contributed to conceptualization, methodology, supervision, formal analysis, and writing original draft. Jelita Almas Pramudita, as a student researcher, was primarily responsible for field investigation, data collection, and data curation, as well as contributing to the initial draft preparation. Welly Herman contributed to validation, formal analysis, supervision, and writing review and editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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