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Effect of different types of manure on the growth and yield of green amaranth (*Amaranthus viridis* L.)

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Abstract

Green amaranth (*Amaranthus viridis* L.) is a nutritious leafy vegetable, and the demand for organically grown vegetables keeps rising. Manure is a non-chemical fertilizer option, but crop response may differ among manure types. This study evaluated the effects of chicken, cow, and goat manure on the growth and yield of green amaranth. The experiment was conducted from July to August 2023 in Nagari Tanjung, Koto VII District, Sijunjung Regency, West Sumatra, Indonesia, using a randomized complete block design with four treatments and five blocks: control without manure (P0), chicken manure (P1), cow manure (P2), and goat manure (P3). Manure was applied at 20 tons/ha, equivalent to 80 g per polybag containing 5 kg of soil. Plant height, number of leaves, and net plant weight were measured, and the data were analyzed with analysis of variance followed by Duncan's multiple range test (DMRT). The treatments did not significantly affect plant height (12.87-13.12 cm) or number of leaves (5.79-5.80), but significantly affected net plant weight ($P < 0.01$). Chicken manure gave the highest net weight (3.68 g), about 18% higher than the control (3.12 g), and differed significantly from all other treatments. Under the conditions tested, chicken manure is recommended to increase green amaranth yield.

Keywords: Amaranthus viridis, chicken manure, cow manure, goat manure, organic fertilizer

1. Introduction

Amaranth is a leafy vegetable widely consumed for its relatively high vitamin and mineral content, including calcium, iron, and vitamins A and C [1]. Market demand is high because of population growth and rising nutritional awareness, while the crop has a short life cycle and is mostly grown by smallholders [1]. Green amaranth (*Amaranthus viridis* L.), locally known as *bayam cabut*, is one of the amaranth types whose leaves are eaten as a vegetable. As public concern for health grows, so does the demand for organic vegetables produced without chemical fertilizers.

Fertilization is a key practice for raising crop production because it supplies the nutrients that plants require [2]. Nitrogen (N) is a constituent of proteins and chlorophyll and therefore supports photosynthesis and vegetative growth [3]. Manure can serve as a nutrient source in organic farming while improving the physical, chemical, and biological properties of the soil [1].

However, manures differ in nutrient content and decomposition rate depending on the animal source, and previous studies on amaranth have reported inconsistent rankings of manure types [2], [4], [5], [6]. The most suitable manure therefore needs to be tested under local conditions. This study aimed to determine the effect of chicken, cow, and goat manure on the growth and yield of green amaranth (*A. viridis*). It was hypothesized that the type of manure affects the growth and yield of the plant.

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2. Literature Review

2.1. Characteristics of chicken, cow, and goat manure

Chicken manure generally has higher N and P contents than other manures, together with lower moisture and a lower C/N ratio, so its nutrients mineralize faster [1], [7]. Analysis of composted chicken manure reported pH 6.8, organic C 12.23%, total N 1.77%, P_2O_5 27.45 mg/100 g, and K_2O 3.21 mg/100 g [8]. Goat manure has been reported to contain 0.60% N, 0.30% P, 0.17% K, and 85% water [9], and to be richer in nutrients than cow manure [10]. These values come from different studies and units, so they are not directly comparable.

In pot and field experiments on *Amaranthus cruentus*, the response to cow manure was lower than the response to goat and poultry manure, which was attributed to differences in total N, total P, and the C/N and C/P ratios; responses also increased over successive crop cycles as organic N and P mineralized [4].

2.2. Previous studies on amaranth

Results of earlier studies on amaranth are not uniform. Chicken manure gave the best plant height in red amaranth (*A. tricolor*) [5], and the response order poultry > goat > cow was found in *A. cruentus* [4]. In contrast, goat manure gave the highest plant weight in amaranth grown on marginal soil [2] and the best results in red amaranth on Entisol and Inceptisol soils [6]. Goat manure at 8 t/ha also significantly increased the number and yield of leaves of *A. cruentus* [11]. These differences suggest that the best manure depends on soil conditions, manure maturity, and application rate.

3. Methodology

3.1. Time and location

The experiment was conducted from July to August 2023, starting on 15 July 2023, in Nagari Tanjung, Koto VII District, Sijunjung Regency, West Sumatra, Indonesia.

3.2. Experimental design and treatments

The experiment used a randomized complete block design (RCBD) with four treatments and five blocks, giving 20 experimental units. The treatments were P0, control (no manure); P1, chicken manure; P2, cow manure; and P3, goat manure. Each polybag (20 cm × 20 cm) was filled with 5 kg of soil. Treatments P1-P3 received manure at 20 tons/ha, equivalent to 80 g per polybag. This rate follows the standard rate of chicken manure for amaranth [1] and is consistent with the best rate of chicken manure reported for amaranth [7].

3.3. Procedure

The soil was loosened, leveled, placed in polybags, mixed with manure according to the treatment, and labeled. Seeds were soaked for 1-2 hours to help break dormancy and were then sown in the polybags. Dead plants were replaced when necessary. Plants were watered in the morning and in the afternoon, weeds were removed, and pests and diseases were controlled when attacks occurred. Plants were harvested 30-35 days after sowing or when they were about 20 cm tall, by pulling up the whole plant with its roots. This height criterion is in line with [1], where amaranth was harvested at 28 days after planting at a height of 15-20 cm before flowering.

3.4. Observed variables

Observations began 7 days after planting and were repeated at 7-day intervals using five samples per treatment. Plant height (cm) was measured from the soil surface to the highest canopy with a ruler or measuring tape. The number of leaves was counted on fully opened leaves. Net plant weight (g) was measured after harvest by weighing the whole plant after soil was cleaned off the roots.

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3.5. Data analysis

Data were subjected to analysis of variance for RCBD at the 5% and 1% levels [12]. Where the treatment effect was significant, means were compared with Duncan's multiple range test (DMRT) [13].

4. Results and Discussion

4.1. Analysis of variance

Manure type did not significantly affect plant height or the number of leaves, but it had a highly significant effect on net plant weight (Table 1). Mean values are presented in Table 2 and Figure 1.

Table 1. Summary of analysis of variance for the effect of manure type (df treatment = 3; df error = 12)

Variable	F-value	F-table 5%	F-table 1%	Remark
Plant height	0.82	3.49	5.95	Not significant
Number of leaves	0.01	3.49	5.95	Not significant
Net plant weight	10.68	3.49	5.95	Highly significant (**)

**Significant at P < 0.01.

Table 2. Mean plant height, number of leaves, and net plant weight of green amaranth

Treatment	Plant height (cm)	Number of leaves	Net plant weight (g)
P0 (control)	12.87	5.80	3.12 ab
P1 (chicken manure)	12.97	5.80	3.68 c
P2 (cow manure)	13.12	5.79	2.80 a
P3 (goat manure)	12.90	5.80	3.28 b
Standard error of the mean	0.121	0.045	0.112

Means followed by different letters in the same column differ significantly according to DMRT at 5%.

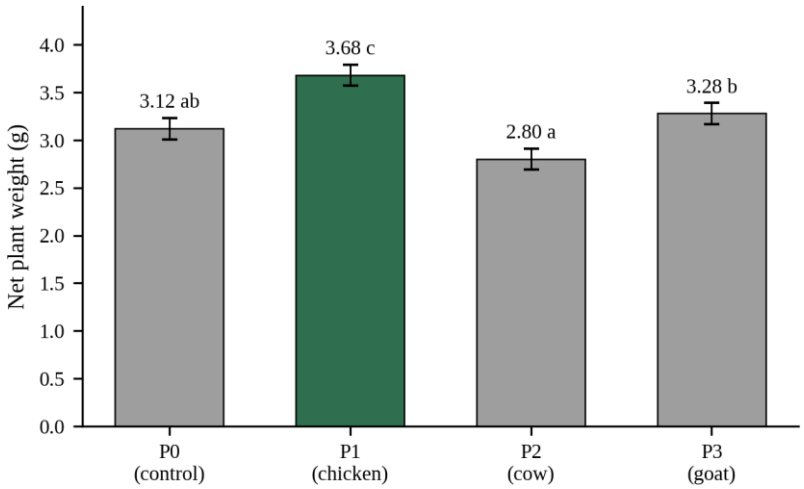


Figure 1. Mean net plant weight (g) of green amaranth under different manure types. Bars show the mean ± standard error of the mean (n = 5); means followed by different letters differ significantly according to DMRT at 5%.

4.2. Plant height

Mean plant height ranged from 12.87 to 13.12 cm and did not differ significantly among treatments, including the control. A likely reason is that the nutrients in the manure had not yet fully mineralized during the short observation

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period, because mineralization of organic N and P from animal manure increases with time [4]. In addition, the nutrients already present in the growth medium appear to have been sufficient for early vegetative growth. In contrast, [1] obtained a significant response to chicken manure on an acidic soil with low organic C and low organic N, so whether a response occurs probably depends on the initial fertility of the soil. Initial soil analysis was not performed in this study.

4.3. Number of leaves

The number of leaves was also not significantly affected by the treatments (5.79-5.80 leaves). This agrees with the plant height result and supports the view that the soil medium supplied enough nutrients during the vegetative phase while the manure nutrients were not yet fully released. When soil nutrients are adequate in all treatments, leaf number tends to be uniform. This differs from [5], who reported that manure type significantly affected the number of leaves of red amaranth, so differences in soil conditions and observation time should be considered.

4.4. Net plant weight

Net plant weight was highly significantly affected by manure type ($P < 0.01$). The DMRT showed that chicken manure (P1) gave the highest net weight (3.68 g) and differed significantly from P0, P2, and P3 (Table 2). The least significant ranges at the 5% level were 0.345 ($p = 2$), 0.362 ($p = 3$), and 0.373 ($p = 4$); the differences between P1 and P3 (0.40 g), P0 (0.56 g), and P2 (0.88 g) all exceeded these values. Cow manure (P2) gave the lowest weight (2.80 g) and did not differ significantly from the control, whereas P3 differed from P2 but not from P0.

The advantage of chicken manure is probably related to its higher N content (1.77% in composted chicken manure compared with 0.60% in goat manure [8], [9]). Nitrogen is involved in chlorophyll and protein formation and promotes vegetative growth [3], which matters for amaranth because the leaves and stems are the harvested product. Chicken manure also has low moisture and a low C/N ratio, so its nutrients mineralize faster [1]. The order chicken > goat > cow in this study is consistent with the order found in *A. cruentus* [4] and with the superiority of chicken manure for the height of red amaranth [5].

The P and K contents of the three manures cannot be compared directly here because the data come from different sources and units (mg/100 g for chicken manure and % for the others). The weight difference is therefore better associated with N than with P or K.

The low weight under cow manure (P2) is consistent with the finding that cow manure gave the lowest response among the three manures, attributed to lower total N and P and higher C/N and C/P ratios [4]. Goat manure, which is richer in nutrients than cow manure [10], performed better than cow manure. However, the superiority of chicken over goat manure differs from the results of [2] and [6], who found goat manure superior on marginal soil and on Entisol and Inceptisol soils. Reference [6] also noted that chicken manure is suitable when it is mature or composted. Because the decomposition rate, manure maturity, and soil properties were not measured here, these explanations remain tentative.

4.5. Limitations

Nutrient contents of the soil and manures were not analyzed, so the nutrient data discussed come from the literature. Only one rate (20 tons/ha) was tested, although the optimum response may differ with rate; for example, significant increases in the leaf number and leaf yield of *A. cruentus* were reported at 8 t/ha of goat dung [11]. The short observation period and the small sample size (five blocks) also limit generalization.

5. Conclusion

Manure type (chicken, cow, and goat) did not significantly affect plant height or number of leaves of green amaranth, but it had a highly significant effect on net plant weight. Chicken manure at 20 tons/ha (80 g per polybag) produced

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the highest net weight (3.68 g) and differed significantly from the control, cow manure, and goat manure. Future studies should analyze the nutrient content of the soil and manures before treatment, test several rates of mature manure, extend the observation period, and consider plant spacing and the timing of fertilization.

6. Declarations

6.1. Author Contributions

Conceptualization: A.R.; Methodology: A.R; Validation: A.R.; Formal Analysis: A.R.; Investigation: A.R.; Data Curation: A.R.; Writing Original Draft Preparation: A.R.; Writing Review and Editing: A.R; and A.R.; Supervision: H.D.T.

*A.R. is the abbreviation of "Aulia Ramadhani"

6.2. Data Availability Statement

The data presented in this study are available on request from the corresponding author.

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The authors received no financial support for the research, authorship, and/or publication of this article.

6.4. Institutional Review Board Statement

Not applicable.

6.5. Informed Consent Statement

Not applicable.

6.6. 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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