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Effects of Different Compost Types on the Growth and Yield of Amaranth (*Amaranthus* spp.)

Akhmad Hamam Nasirudin[1]*, Rennanti Lunnadiyah Aprilia[2]
[1,2] Fakultas Pertanian dan Peternakan, Universitas Ma'arif Nahdlatul Ulama Kebumen, Indonesia

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Corresponding author*:
renantihadeejah@gmail.com

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Abstract: Vegetable amaranth is a fast-growing leafy vegetable with high nutritional value and strong potential for sustainable cultivation. Livestock-manure compost is increasingly used as an environmentally friendly nutrient source to improve crop growth and reduce dependence on inorganic fertilizers. **Objective:** This study aimed to evaluate the effects of different livestock-manure composts on the growth and yield of several vegetable amaranth varieties under polybag cultivation and to identify the most effective treatment combination. **Method:** The study was conducted in Jatisari Village, Kebumen District, Central Java, Indonesia, from January to February 2026. A quantitative experimental approach was applied using a 3 × 4 factorial randomized complete block design with nine effective blocks. The first factor was compost type, namely chicken-, goat-, and cow-manure compost, while the second factor was amaranth variety, namely green, uproot, red, and batik amaranth. Data were collected through direct plant measurements and analyzed using ANOVA followed by DMRT at the 5% level. **Findings:** The interaction between compost type and variety significantly affected plant height, number of leaves, leaf area, fresh plant weight, dry plant weight, fresh root weight, and dry root weight, but did not significantly affect root length. The best overall performance was obtained from cow-manure compost combined with green amaranth (P3V1). **Implications:** Cow-manure compost is a promising organic input for improving vegetable amaranth productivity under polybag cultivation. **Originality:** This study provides comparative evidence on three livestock-manure composts across four amaranth varieties under local cultivation conditions.

Keywords: Amaranth; Compost; Cow Manure; Growth; Yield

INTRODUCTION

Vegetable amaranth (*Amaranthus spp.*) is an important leafy vegetable widely cultivated in tropical and subtropical regions due to its rapid growth, short harvest period, and high nutritional value. The leaves are rich in essential minerals, vitamin C, phenolic compounds, flavonoids, and antioxidant substances, making amaranth valuable not only for daily consumption but also for supporting dietary diversification and food security. Previous studies have also reported considerable variation among amaranth genotypes in terms of micronutrient composition, yield potential, and agronomic performance, indicating that varietal selection is an important factor in improving amaranth production (Jahan et al., 2023; Jiménez-Aguilar & Grusak, 2017; Sarker et al., 2022).

In vegetable cultivation, nutrient management is one of the main determinants of plant growth, yield, and soil productivity. Although inorganic fertilizers are commonly used because of their rapid nutrient release, their continuous and excessive use may negatively affect soil quality and environmental sustainability. For this reason, the application of organic inputs has received increasing attention as part of sustainable agricultural practices. Compost is one of the most widely used organic amendments because it can improve soil physical, chemical, and biological properties. Previous studies have shown that compost application contributes to increased soil organic matter, nutrient availability, microbial biomass, and soil functionality, which in turn support better crop growth and long-term soil fertility (Aprilia & Sukur, 2022; Ho et al., 2022; Liu et al., 2023)

Among the available organic materials, livestock manure is an accessible and abundant resource in rural farming systems. In many agricultural areas, cattle, goat, and chicken manure are produced continuously and can be utilized as valuable inputs for crop production rather than being treated merely as waste. Through composting, livestock waste can be transformed into a more stable and environmentally friendly fertilizer source for agricultural use. This process reduces the negative effects of raw manure application, such as unstable nutrient release and potential phytotoxicity, while improving the agronomic value of the material. As a result, manure compost has increasingly been considered an important component of sustainable nutrient management in vegetable cultivation (Ho et al., 2022; Liu et al., 2023)

Several studies have demonstrated that manure-based compost can improve the growth and biomass production of leafy vegetables. Composted cattle manure, for example, has been reported to increase leaf number, leaf area, fresh weight, and dry weight in spinach. Other manure-derived organic fertilizers have also shown positive effects on nutrient uptake, soil quality, and plant productivity. These improvements are associated with enhanced soil structure, increased water-holding capacity, and stimulated microbial activity in the root zone, which collectively improve nutrient availability and plant uptake efficiency. This indicates that manure-based compost has considerable potential to support vegetable production under sustainable cultivation systems (Anwar et al., 2017; Namah & Abineno, 2024; Xu & Mou, 2016).

Despite these benefits, the effectiveness of manure-based compost may vary depending on manure source, compost quality, and crop genotype. Chicken, goat, and cow manure differ in nutrient composition and decomposition characteristics, which may lead to different plant growth responses. In addition, recent studies have confirmed that amaranth exhibits considerable genotypic variation in growth performance, yield attributes, and environmental adaptability, suggesting that plant response to nutrient inputs may differ among varieties (Ayenan et al., 2025; Sefasi et al., 2025)Therefore, comparative evaluation among different livestock-manure composts across several amaranth varieties remains necessary to identify the most suitable combination for improving productivity under local cultivation conditions.

Based on this research gap, the present study was conducted to evaluate the effects of chicken-, goat-, and cow-manure composts on the growth and yield of several vegetable amaranth varieties grown under polybag conditions in Jatisari Village, Kebumen District, Central Java, Indonesia. The novelty of this study lies in the comparative evaluation of three livestock-based compost types across four amaranth varieties under local cultivation conditions. The findings are expected to provide practical recommendations for the use of locally available organic fertilizers to support more sustainable amaranth production.

RESEARCH METHOD

The unit of analysis in this study was the growth and yield performance of vegetable amaranth cultivated under different compost treatments and varietal combinations. Specifically, the study focused on individual amaranth plants grown in polybags as experimental units. Each polybag contained one final healthy plant and represented one unit of observation. The variables observed included plant height, number of leaves, leaf area, root length, fresh plant weight, dry plant weight, fresh root weight, and dry root weight. Thus, the research examined how different types of livestock-manure compost affected the vegetative growth and biomass production of several amaranth varieties under local cultivation conditions.

This study employed a quantitative experimental approach because the objective was to test the effect of treatment combinations on measurable plant growth and yield variables. The experiment was arranged using a 3 × 4 factorial Randomized Complete Block Design (RCBD), which was selected to improve the precision of treatment comparison by controlling environmental heterogeneity within the experimental area. The first factor was compost type, consisting of chicken-manure compost (P1), goat-manure compost (P2), and cow-manure compost (P3). The second factor was amaranth variety, consisting of green amaranth (V1), uproot amaranth (V2), red amaranth (V3), and batik amaranth (V4). These two factors produced 12 treatment combinations. Although the field layout was initially divided into three main block areas, each area contained three independent replicate positions, so the data were analyzed as nine effective blocks, resulting in a total of 108 experimental units.

The data used in this study were primary quantitative data obtained directly from experimental observations conducted in Jatisari Village, Kebumen District, Central Java, Indonesia, from December 2025 to February 2026. The sources of information consisted of plants grown under controlled treatment combinations in a polybag-based cultivation system. The compost materials used in the experiment included chicken-, goat-, and cow-manure compost obtained from local compost farmers in the study area. The growing medium consisted of soil and rice husk charcoal mixed in a ratio of 1:1 (w/w), with each polybag measuring 25 cm × 25 cm and containing 2 kg of medium. The initial pH of the growing medium was 6.2. Compost was applied at a dose of 250 g plant^{-1} in two split applications, namely at planting and 15 days after planting. Environmental supporting data, such as ambient temperature and relative humidity, were also recorded during the study using a hygrometer.

Data collection was carried out through direct observation and measurement of plant growth during the cultivation period. Seeds of the four amaranth varieties were first established in a nursery, then two seedlings were transplanted into each polybag and later thinned to one healthy plant per polybag. Routine crop maintenance included watering, replacement of dead seedlings when necessary, and regular field monitoring until harvest. Plant height and number of leaves were recorded periodically at 7, 14, 21, 28, and 35 days after planting (DAP). Plant height was measured from the stem base to the tip of the highest leaf, while the number of leaves was counted based on fully expanded leaves. At harvest (35 DAP), leaf area, root length, fresh plant weight, dry plant weight, fresh root weight, and dry root weight were measured. Leaf area was determined using millimeter block paper, root length was measured from the stem base to the tip of the longest root, and dry weights were obtained after oven-drying at 70°C until constant weight.

The data were analyzed using analysis of variance (ANOVA) at the 5% significance level to determine the effects of compost type, amaranth variety, and their interaction on the observed variables. When the ANOVA results showed significant differences among treatments, mean separation was conducted using Duncan's Multiple Range Test (DMRT) at the 5% level. If the interaction effect between factors was significant, the interpretation of treatment effects was based on the interaction means. This statistical procedure was chosen because it was appropriate for factorial experimental data arranged in an RCBD and allowed a more precise comparison of treatment combinations under relatively homogeneous block conditions.

RESULT

At 35 DAP, the interaction between compost type and amaranth variety significantly affected most of the observed variables. Analysis of variance showed significant treatment effects on root dry weight, root fresh weight, plant dry weight, plant fresh weight, leaf area, number of leaves, and plant height at the 5% significance level. In contrast, root length was not significantly affected by the tested treatment combinations. These results indicate that the response of vegetable amaranth to the applied treatments was more pronounced in shoot growth and biomass accumulation than in root elongation.

Table 1. Summary of ANOVA for growth and yield variables of vegetable amaranth at 35 DAP

Variable	df (treatment)	df (error)	F value	p value	Remark
Root dry weight (g)	11	88	4.392	0.000031	Significant
Root fresh weight (g)	11	88	2.948	0.002301	Significant
Root length (cm)	11	88	1.497	0.147048	ns
Plant dry weight (g)	11	88	4.002	0.000097	Significant
Plant fresh weight (g)	11	88	3.583	0.000340	Significant
Leaf area (cm^2)	11	88	4.838	0.000008	Significant
Number of leaves (leaves)	11	88	2.692	0.004951	Significant
Plant height (cm)	11	88	2.180	0.022438	Significant

Note: ns = not significant at the 5% level.

Growth response at 35 DAP

The treatment combinations significantly affected plant height and number of leaves at 35 DAP (Table 2). Plant height ranged from 10.000 to 23.111 cm. The tallest plants were obtained under treatment P3V1 (cow-manure compost + green amaranth), with a mean value of 23.111 cm, whereas the lowest plant height was observed in P3V2 (cow-manure compost + uproot amaranth), with a mean value of 10.000 cm.

The number of leaves also differed significantly among treatments. The highest number of leaves was recorded in P3V1, with a mean of 12.889 leaves, followed by P3V4 with 12.222 leaves. The lowest number of leaves was observed in P2V2, with a mean of 7.222 leaves.

Table 2. Effects of compost type × amaranth variety interaction on plant height and number of leaves at 35 DAP

Treatment Code	Treatment Combination	Plant Height (cm)	Number of Leaves
P1V1	Chicken-manure compost + green amaranth	13.333 bc	8.111 bd
P1V2	Chicken-manure compost + uproot amaranth	13.556 bc	7.556 bd
P1V3	Chicken-manure compost + red amaranth	21.333 ac	9.667 ab
P1V4	Chicken-manure compost + batik amaranth	13.556 bc	11.111 ab
P2V1	Goat-manure compost + green amaranth	14.111 bc	8.444 bc
P2V2	Goat-manure compost + uproot amaranth	11.333 bd	7.222 b
P2V3	Goat-manure compost + red amaranth	19.778 acd	11.000 ab
P2V4	Goat-manure compost + batik amaranth	15.667 ab	11.333 acd
P3V1	Cow-manure compost + green amaranth	23.111 a	12.889 a
P3V2	Cow-manure compost + uproot amaranth	10.000 b	7.667 bd
P3V3	Cow-manure compost + red amaranth	12.333 bc	9.222 ab
P3V4	Cow-manure compost + batik amaranth	17.111 ab	12.222 ac

Note: Means followed by the same letter within the same column are not significantly different according to DMRT at the 5% level.

Yield and root-related traits at 35 DAP

At harvest, the treatment combinations significantly affected leaf area, fresh plant weight, dry plant weight, fresh root weight, and dry root weight, whereas root length did not differ significantly among treatments (Table 3). Leaf area ranged from 8.667 to 35.556 cm². The highest leaf area was recorded in P3V1, while the lowest was observed in P1V1. Fresh plant weight ranged from 1.667 to 10.556 g, with the highest value also found in P3V1. Dry plant weight ranged from 0.354 to 2.639 g, and again P3V1 showed the highest value.

Fresh root weight ranged from 1.000 to 3.667 g. The highest fresh root weight was observed in P3V4, while the lowest was recorded in P3V2. Root dry weight ranged from 0.108 to 1.230 g, with the highest value obtained in P3V1 and the lowest in P2V2.

Table 3. Effects of compost type × amaranth variety interaction on leaf area, root length, and biomass components at 35 DAP

Treatment code	Leaf area (cm²)	Root length (cm)	Fresh plant weight (g)	Dry plant weight (g)	Fresh root weight (g)	Dry root weight (g)
P1V1	8.667 c	10.000 a	2.000 b	0.718 bd	1.111 b	0.437 bc
P1V2	11.556 bc	6.667 a	2.222 bd	1.012 bd	1.333 b	0.387 bc
P1V3	25.556 ad	10.889 a	8.222 ac	2.218 ac	1.977 bc	0.879 acd

Treatment code	Leaf area (cm^2)	Root length (cm)	Fresh plant weight (g)	Dry plant weight (g)	Fresh root weight (g)	Dry root weight (g)
P1V4	12.778 bc	7.889 a	4.222 bc	1.176 bc	1.556 b	0.201 b
P2V1	15.333 bcd	10.111 a	3.000 bd	0.927 bd	1.333 b	0.354 bd
P2V2	10.889 bc	9.333 a	2.556 bd	0.354 b	1.222 b	0.108 b
P2V3	22.667 bd	11.444 a	7.111 acd	1.877 acd	2.556 ab	0.970 ac
P2V4	16.333 bcd	10.000 a	4.556 bc	0.992 bd	1.889 bc	0.471 bc
P3V1	35.556 a	13.778 a	10.556 a	2.639 a	3.222 b	1.230 a
P3V2	11.889 bc	9.333 a	1.667 b	0.380 b	1.000 b	0.214 b
P3V3	11.778 bc	11.889 a	2.444 bd	0.553 be	1.333 b	0.267 b
P3V4	22.778 bd	12.889 a	6.667 ab	1.720 acde	3.667 a	0.267 b

Note: Means followed by the same letter within the same column are not significantly different according to DMRT at the 5% level.

DISCUSSION

The results of this study showed that the interaction between compost type and amaranth variety significantly affected most growth and yield variables, particularly plant height, number of leaves, leaf area, fresh plant weight, dry plant weight, fresh root weight, and dry root weight. Among all treatment combinations, P3V1 (cow-manure compost + green amaranth) consistently produced the best performance in most observed parameters, indicating that this combination was the most effective in promoting vegetative growth and biomass accumulation. In contrast, root length was not significantly affected by the treatments, although root fresh and dry weights showed significant differences. These findings indicate that treatment responses were more clearly expressed in shoot growth and biomass formation than in root elongation.

The superior performance of P3V1 may be explained by the capacity of cow-manure compost to provide a more favorable root-zone environment for plant growth. Composted cattle manure likely released nutrients more gradually and steadily, thereby supporting continuous nutrient uptake throughout the vegetative phase. In addition, organic compost can improve soil aggregation, increase water-holding capacity, and stimulate microbial activity, all of which contribute to better nutrient cycling and root functioning. These conditions are especially important in leafy vegetables such as amaranth, which require adequate nutrient supply for rapid canopy development, leaf initiation, and biomass production. The higher plant height and number of leaves observed in P3V1 suggest stronger shoot development, most likely due to improved nitrogen availability and more efficient nutrient uptake. Similarly, the greater leaf area and plant biomass under this treatment indicate a more efficient photosynthetic system, allowing higher assimilate production and dry matter accumulation.

The findings of this study are generally consistent with previous studies reporting the positive role of manure-based compost in improving leafy vegetable growth. (Xu & Mou, 2016) found that composted cattle manure increased leaf number, leaf area, fresh weight, and dry weight in spinach, which is in line with the present findings for green amaranth. Likewise, (Liu et al., 2023; Ouyang et al., 2022) emphasized that organic amendments enhance microbial activity and nutrient cycling, thereby improving soil functionality and plant nutrient uptake. The present study also supports the general view that manure-based compost can improve vegetable productivity, as reported by (Anwar et al., 2017; Namah & Abineno, 2024). However, the novelty of this study lies in the comparative evaluation of three livestock-manure composts across four amaranth varieties under local polybag cultivation conditions. This broader comparison shows that not all compost sources produce the same response, and that varietal background plays an important role in determining treatment effectiveness.

An important finding of this study is that root length was not significantly affected, even though root biomass differed significantly among treatments. This suggests that the treatments influenced root development more in terms of thickness, density, or branching rather than elongation. The highest fresh root weight recorded in P3V4 further indicates that belowground response may vary depending on varietal characteristics. This result strengthens the interpretation that genotype is an important determinant of amaranth performance under organic fertilization. Previous studies have also shown considerable genotypic variability in agronomic traits, biomass yield, and environmental adaptability in vegetable amaranth (Ayenan et al., 2025; Sefasi et al., 2025). Therefore, the strong performance of green amaranth under cow-manure compost in this study likely reflects the combined effect of favorable compost quality and higher varietal adaptability to local cultivation conditions.

From a broader perspective, the findings have important practical and agronomic implications. The study demonstrates that locally available livestock waste, particularly cow manure, can be transformed into a productive and environmentally friendly organic input for vegetable cultivation. This has a positive function in reducing dependence on inorganic fertilizers, improving the utilization of local agricultural waste, and supporting more sustainable small-scale farming systems. However, one possible limitation is that the effectiveness of compost may vary depending on local compost quality, manure maturity, and varietal differences, so the results may not always be directly generalized to all production settings. For this reason, farmers and local agricultural practitioners are encouraged to prioritize the use of well-matured cow-manure compost, especially for green amaranth cultivation in polybag systems. Future action should include further testing under open-field conditions, chemical characterization of compost quality, and economic feasibility analysis to strengthen recommendations for wider adoption in sustainable vegetable production.

CONCLUSION

The present study demonstrated that the interaction between compost type and amaranth variety significantly influenced most growth and yield parameters of vegetable amaranth at 35 DAP. The treatment combinations significantly affected plant height, number of leaves, leaf area, fresh plant weight, dry plant weight, fresh root weight, and dry root weight, but did not significantly affect root length. Among all treatments, the combination of cow-manure compost and green amaranth (P3V1) consistently produced the best overall response, indicating that this treatment was the most effective in promoting vegetative growth and biomass accumulation under the polybag cultivation system.

This study contributes to the scientific understanding of organic fertilization in vegetable amaranth by providing comparative evidence on the performance of three livestock-manure compost types across four amaranth varieties under local cultivation conditions. The findings confirm that plant response to organic fertilization is influenced not only by compost source but also by varietal characteristics. Therefore, the study offers both practical and scientific value in identifying cow-manure compost combined with green amaranth as the most promising option for sustainable amaranth production.

However, this study was limited to a polybag-based cultivation system and a relatively short observation period up to 35 days after planting. In addition, the chemical characteristics of the composts were not analyzed in detail, which limits the explanation of nutrient-specific treatment effects. Future studies are recommended to evaluate these treatment combinations under open-field conditions, include detailed compost nutrient analysis, and assess productivity over a longer growth period to generate more comprehensive recommendations.

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