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Effect of patchouli leaf waste compost on improving the growth and productivity of winged bean (*Psophocarpus tetragonolobus* L.) In Ambukha Village Lolofitu Moi Subdistrict West Nias Regency

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ABSTRACT

The results showed that patchouli leaf residue compost affected winged bean growth and productivity. Plant height was significantly affected from 3 to 6 weeks after planting, while stem diameter was significantly affected at 2, 4, 5, and 6 weeks after planting. Productivity parameters were also highly significantly affected. The number of fruits increased from 6.92 fruits per sample in P0 to 16.00 fruits per sample in P4, while fruit weight increased from 157.39 to 394.74 g per sample and from 699.78 to 1,729.55 g per plot. Treatment P4 (4 kg/plot, equivalent to 26.67 t/ha) produced the highest mean values for the measured growth and productivity parameters within the range tested. Therefore, P4 can be considered the best-performing treatment among the tested application rates under the conditions of this experiment. However, it should not be regarded as the optimum dose because application rates above 4 kg/plot were not evaluated. Practically, the results indicate that patchouli leaf residue can be utilized as a locally available compost resource for winged bean cultivation, while further research using a wider range of application rates and comprehensive soil and compost analyses is needed to determine the response beyond the tested range.

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1. INTRODUCTION

Sustainable agricultural development requires not only increased crop production but also the maintenance of soil quality and environmental sustainability. Continuous dependence on inorganic fertilizers without adequate management of organic matter may negatively affect soil quality and ecosystem balance. The utilization of locally available organic resources as organic fertilizers is one approach to support sustainable crop production because organic amendments can improve soil physical, chemical, and biological properties and contribute to nutrient availability for plants (Yuriansyah *et al*., 2020).

Winged bean (*Psophocarpus tetragonolobus* L.) is a potential food crop for supporting food diversification. The species belongs to the Fabaceae family and has multiple uses because almost all parts of the plant, including leaves, flowers, young pods, seeds, and tubers, can be utilized as food Mukhlishah & Mahi, (2023). Dried winged bean seeds contain approximately 29.8–39% protein, indicating their potential as an alternative source of plant-based protein Novianto *et al*., (2021). However, winged bean cultivation in the Nias Islands remains limited, and its productivity can still be improved. Abdirrohman, (2024) reported an average winged bean yield of approximately 2.28 tons/ha in Indonesia. Improving soil fertility and nutrient availability is therefore important to support the growth and productivity of winged bean.

One locally available organic resource with potential for agricultural utilization is the solid residue from patchouli (*Pogostemon cablin Benth*.) distillation. Patchouli is cultivated by communities in West Nias Regency, including Lolofitu Moi Subdistrict. According to BPS Kabupaten Nias Barat (2023) patchouli oil production in Lolofitu Moi Subdistrict reached 0.45 tons from an area of 11 ha. The distillation process leaves solid plant residues that still contain organic matter and can accumulate when not properly managed. Composting this residue provides an alternative method for converting agricultural waste into an organic amendment that can be returned to agricultural land (Bella *et al*., 2022).

During composting, organic materials are decomposed by microorganisms into simpler and more stable compounds, which can facilitate the availability of nutrients for plants Hazra *et al*., (2024). The potential of patchouli distillation residue as a compost material is supported by its chemical characteristics Jusriadi *et al*., (2022) reported that patchouli residue compost contained 20.08% organic carbon, 1.64% nitrogen, a C/N ratio of 12, and 0.62% phosphorus Indriani *et al*., (2025) also reported nitrogen and potassium contents of 0.52% and 1.19%, respectively, in compost derived from patchouli distillation residue. Nitrogen is important for vegetative growth, protein formation, and chlorophyll synthesis, while phosphorus contributes to energy transfer and root development, and potassium supports water regulation and various enzymatic processes. In addition to supplying nutrients, organic matter can improve soil structure, water retention, and cation exchange capacity, thereby creating more favorable conditions for root development and nutrient uptake (Erfina *et al*., 2024).

Previous studies have demonstrated that patchouli distillation residue can be utilized as a source of organic amendment and may influence crop growth and yield. However, the responses of different crops to patchouli residue compost are not necessarily comparable because crop characteristics, soil conditions, environmental conditions, and application rates may differ. Putra & Prastia, (2019) for example, reported a favorable response of leek to patchouli waste compost at 5 t/ha, but this finding was obtained from a different crop and agroecological setting. Therefore, the appropriate application range and response of winged bean to patchouli leaf residue compost remain unresolved.

In particular, information is still limited regarding the dose-dependent response of winged bean to patchouli leaf residue compost under the agroecological conditions of Ambukha Village, Lolofitu Moi Subdistrict, West Nias Regency. The present study addresses this gap by evaluating five compost application rates, ranging from 0 to 26.67 t/ha, and assessing both vegetative growth and productivity responses of winged bean. The novelty of this study lies in providing experimental evidence on the response of winged bean to different rates of locally available patchouli leaf residue compost under the specific field conditions of West Nias. This information can contribute to determining the treatment that provides the highest response within the tested application range, without assuming that the highest tested rate represents an agronomic optimum.

Based on the available evidence, the study hypothesized that different rates of patchouli leaf residue compost would produce different responses in the growth and productivity of winged bean, and that increasing compost application within the tested range would result in measurable differences in growth and productivity.

2. METHOD

2.1 Research Location and Time

The experiment was conducted in Ambukha Village, Lolofitu Moi Subdistrict, West Nias Regency, North Sumatra, Indonesia, from April to July 2026. The experimental site was located at approximately 1°3′21″ N and 97°35′22″ E. The experimental area consisted of mineral soil with an initial soil pH of 6.5, measured using a pH meter before planting. Comprehensive laboratory analysis of the initial soil physicochemical properties was not conducted in this study; therefore, data on soil

organic carbon, total nitrogen, available phosphorus, exchangeable potassium, soil texture, and other physicochemical properties were not available.

2.2 Materials and Equipment

The materials used were Anah variety winged bean (*Psophocarpus tetragonolobus* L.) seeds, 40 kg of patchouli leaf residue, 400 g of brown sugar, 400 mL of EM4, 4 L of clean water, and manure as the seedling medium. The equipment included a pH meter, hoe, machete, measuring tape, tarp, digital balance, bucket, ruler, vernier caliper, labels, raffia string, watering can, hand sprayer, camera, and observation sheets.

2.3 Experimental Design and Treatment

The experiment used a non-factorial randomized block design (RBD) with five compost application treatments and four blocks, resulting in 20 experimental plots. The treatments were P0 = 0 kg/plot P1 = 1 kg/plot, P2 = 2 kg/plot, P3 = 3 kg/plot, and P4 = 4 kg/plot. Based on the plot area of 1.5 m², these rates were equivalent to 0, 6.67, 13.33, 20.00, and 26.67 ton/ha respectively.

The use of an RBD was based on the spatial heterogeneity of the experimental field, particularly potential variation in soil fertility, soil moisture, and other environmental conditions. Blocking was used to reduce variation among experimental units caused by field heterogeneity. Within each block, the five treatments were randomly assigned to the experimental plots according to the experimental layout.

2.4 Preparation of Patchouli Leaf Compost

Patchouli leaf compost was prepared from 40 kg of patchouli leaf residue obtained from the oil distillation process. The residue was cleaned of unwanted materials and spread on a tarp. Brown sugar (400 g) was dissolved in warm water. After the solution had cooled, 400 mL of EM4 and 4 L of clean water were added and mixed uniformly.

The activator solution was gradually and evenly applied to the patchouli residue while the material was mixed until a sufficiently moist and homogeneous condition was obtained. The mixture was then placed in sacks, covered, and stored in a shaded area protected from direct sunlight and rainfall. The composting process lasted 14 days.

After 14 days, the compost was removed and evaluated based on physical characteristics. Compost considered ready for application showed a darker color, crumbly texture, reduced odor, and visible decomposition of the original material. These physical characteristics were used as indicators of compost readiness because laboratory analysis of the compost chemical properties was not conducted.

Because no laboratory analysis of compost maturity or chemical composition was conducted, compost maturity in this study was determined based on these observable physical indicators.

2.5 Land Preparation and Plot Establishment

The experimental area measured 5.5 m × 9.5 m. The land was cleared of weeds, plant residues, and other materials using a hoe and machete. The soil was then tilled until sufficiently loose to improve soil aeration and facilitate plot preparation.

Twenty experimental plots were prepared, each measuring 100 cm × 150 cm, with a plot height of 30 cm and a 50 cm distance between plots. Treatment labels were placed on each plot before compost application to ensure proper identification throughout the experiment.

2.6 Compost Application

The compost was applied once after plot preparation and before planting. The compost was weighed according to the assigned treatment and distributed evenly over the surface of each plot. The compost was then incorporated into the soil to facilitate contact between the organic amendment and the soil.

2.7 Seed Preparation and Planting

Anah variety winged bean seeds were soaked in warm water for 6 – 12 hours and subsequently sown in seedling trays containing manure-based growing media. Seedlings were maintained for approximately 10 days until they developed 1 – 2 leaves and showed healthy and relatively uniform growth.

Planting points were measured using a measuring tape before transplanting. A spacing of 60 cm × 50 cm was applied uniformly to all experimental plots. Each plot contained six plants. Seedlings were transplanted into holes approximately 5 cm deep, with one seedling per planting hole. Transplanting was conducted in the afternoon to reduce transplanting stress associated with high temperature and solar radiation.

2.8 Crop Management

Plant maintenance included watering, replanting, weeding, earthing-up, trellis installation, and pest and disease management. Watering was conducted in the morning or afternoon depending on

soil moisture conditions. Replanting was carried out up to one week after planting using seedlings of the same age to replace dead or abnormal plants.

Weeding was performed manually when weeds appeared and were considered capable of competing with the crop. Earthing-up was conducted around the plant base to improve plant support and root development. Bamboo stakes approximately 2 m high were installed beside the plants at 7 – 10 days after planting to support the stems and tendrils.

Pest and disease occurrence was monitored weekly. During the experiment, aphid infestation (*Aphis gossypii*) was observed. Pest control was carried out using Curacron according to the recommended application rate.

2.9 Observation Parameters

Three sample plants were selected from each experimental plot using a zig-zag sampling arrangement. Plant height and stem diameter were measured weekly from 2 to 6 weeks after planting (WAP).

Plant height was measured from the base of the stem to the growing point using a measuring tape. Stem diameter was measured approximately 3 cm above the soil surface using a vernier caliper.

Productivity observations included fruit number, fruit length, fruit weight per sample, and fruit weight per plot. Fruit number was determined by counting all fruits harvested from the three sample plants from the first to the third harvest. Fruit length was measured from the base to the tip of the fruit after harvest. Fruit weight per sample was obtained by weighing the total fruit harvested from the three sample plants during the first to third harvests. Fruit weight per plot was obtained by weighing the total fruit harvested from all plants in each plot during the first to third harvests.

2.10 Harvesting

Winged bean pods were first harvested at approximately 8 weeks after planting when the pods reached the appropriate size for consumption. Harvesting was conducted by carefully picking mature young pods. Harvesting was carried out successively according to pod development, and productivity data were recorded for the first three harvests.

2.11 Statistical Analysis

Data were analyzed using IBM SPSS Statistics. Before analysis of variance (ANOVA), the data were assessed for statistical assumptions, including normality and homogeneity of variance. Normality was evaluated using the Kolmogorov–Smirnov test, while homogeneity of variance was assessed using Levene's test. A significance level of $p > 0.05$ was used as the criterion for satisfying the respective assumption.

For the RBD analysis, the statistical model was:

$$Yij = \mu + \alpha i + \beta j + \varepsilon ij \quad (1)$$

where Y_{ij} is the observed response for treatment i in block j, μ is the overall mean, α_i is the treatment effect, β_j is the block effect, and ε_{ij} is the experimental error.

Plant height and stem diameter were measured repeatedly at 2, 3, 4, 5, and 6 WAP. Because treatment responses were evaluated at each observation time, ANOVA based on the RBD model was performed separately for each observation time rather than combining the measurements across times. This approach allowed the treatment effect to be evaluated independently at each growth stage.

For fruit number, fruit length, fruit weight per sample, and fruit weight per plot, ANOVA was performed according to the RBD model. Treatment effects were considered significant at $p < 0.05$ and highly significant at $p < 0.01$. When ANOVA indicated a significant or highly significant treatment effect, Tukey's honestly significant difference (HSD) test at the 5% level was used to compare treatment means.

3. RESULTS AND DISCUSSION

3.1 Plant Height

Table 1. Plant height (mean ± SD) and Tukey 5% grouping

Treatment	2 WAP	3 WAP	4 WAP	5 WAP	6 WAP
P0	15.50 ± 4.65	59.42 ± 6.73 b	142.67 ± 9.18 d	233.08 ± 26.72 b	302.42 ± 23.29 d
P1	15.08 ± 2.99	66.00 ± 5.98 b	155.08 ± 7.42 cd	246.00 ± 32.22 ab	332.00 ± 24.27 c
P2	15.84 ± 1.35	72.67 ± 15.00 ab	168.58 ± 7.31 bc	259.25 ± 26.57 ab	341.58 ± 20.14 bc
P3	16.25 ± 3.76	74.67 ± 10.07 ab	176.67 ± 12.13 ab	267.08 ± 10.46 ab	361.00 ± 9.98 ab
P4	22.84 ± 4.56	82.84 ± 9.29 a	188.67 ± 1.65 a	272.00 ± 9.30 a	369.67 ± 8.39 a

Note: Values are mean ± SD (n = 4). Letters are Tukey 5% groups.

Analysis of variance showed that the application of patchouli leaf residue compost had no significant effect on plant height at 2 weeks after planting (WAP), but significantly affected plant height at 3 – 6 WAP. At 2 WAP, the numerical means ranged from 15.08 to 22.84 cm, with P4 recording the highest mean. However, because the ANOVA result was not significant, this numerical difference should not be interpreted as a confirmed treatment effect. At 3 WAP, P4 recorded the highest mean at 82.84 cm and differed significantly from P0, whereas P2 and P3 were statistically comparable with P4. At 4 WAP, P4 produced the highest mean (188.67 cm) and differed from P0 and P1 but was statistically comparable with P3. At 5 WAP, P4 had the highest mean (272.00 cm), although it shared a statistical group with P1, P2, and P3. At 6 WAP, P4 recorded the highest mean (369.67 cm) and differed significantly from P0, P1, and P2, but not from P3 (361.00 cm).

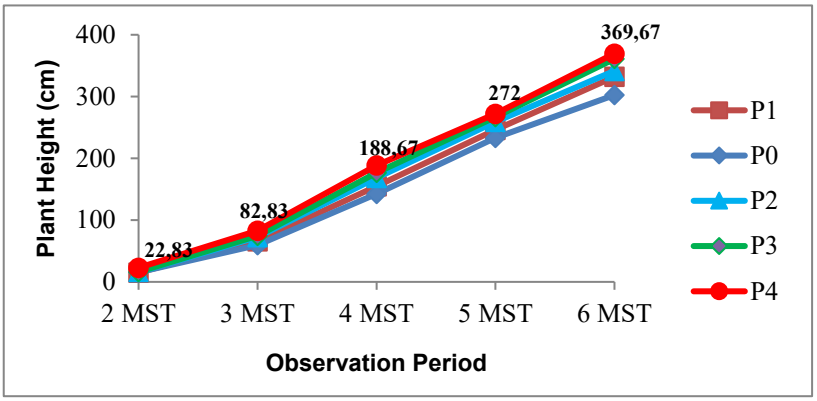


Figure 1. Graph of average winged bean plant height

Based on Figure 1, plant height increased from 2 to 6 WAP in all treatments. Treatment P4 generally recorded the highest numerical mean at each observation time. The statistical results, however, show that the treatment effect was not significant at 2 WAP, whereas significant differences were detected from 3 to 6 WAP. At 6 WAP, P4 recorded the highest mean plant height (369.67 cm), while P0 recorded the lowest mean (302.42 cm). The differences among treatments indicate that the response to compost application became more evident at later observation stages.

This result is broadly consistent with previous studies reporting that compost application can influence crop growth. Widowati *et al*., (2022) reported differences in plant growth following the application of compost derived from different raw materials,while Bella *et al*., (2022) reported that patchouli waste compost affected soil chemical properties. However, these studies involved different crops, compost materials, and experimental conditions. Therefore, they provide comparative evidence rather than direct evidence of the physiological mechanism responsible for the response observed in the present winged bean experiment.

Because soil nutrient availability, nutrient uptake, root development, and photosynthetic activity were not measured in this study, the observed differences in plant height should be interpreted as treatment responses under the experimental conditions rather than as evidence of a specific physiological mechanism.

3.2 Stem Diameter

Table 2. Stem diameter (mean ± SD) and Tukey 5% grouping

Treatment	2 WAP	3 WAP	4 WAP	5 WAP	6 WAP
P0	1.28 ± 0.22 b	2.27 ± 0.26	2.37 ± 0.19 b	3.25 ± 0.35 b	3.68 ± 0.45 b
P1	1.86 ± 0.31 ab	2.52 ± 0.39	2.92 ± 0.43 ab	4.00 ± 0.61 ab	4.52 ± 0.66 a
P2	1.87 ± 0.52 ab	2.87 ± 0.67	3.12 ± 0.43 ab	3.96 ± 0.15 ab	4.58 ± 0.32 a
P3	2.11 ± 0.20 a	3.08 ± 0.49	3.06 ± 0.35 ab	4.17 ± 0.34 a	4.62 ± 0.15 a
P4	2.34 ± 0.37 a	2.99 ± 0.30	3.54 ± 0.40 a	4.36 ± 0.30 a	4.98 ± 0.46 a

Note: Values are mean ± SD (n = 4). No letters are shown at 3 WAP because the ANOVA was not significant at that observation time.

Analysis of variance showed that patchouli leaf residue compost significantly affected stem diameter at 2, 4, and 5 WAP and highly significantly affected stem diameter at 6 WAP, whereas the effect at 3 WAP was not significant. At 2 WAP, P4 produced the largest mean stem diameter (2.34 mm), while P0 had the smallest mean (1.28 mm). At 3 WAP, P3 had the highest numerical mean (3.08 mm), but the difference among treatments was not statistically significant. At 4 WAP, P4 recorded the highest mean (3.54 mm) and differed significantly from P0. At 5 WAP, P4 produced the highest mean stem diameter (4.36 mm) and was statistically comparable with P1, P2, and P3, while P0 differed significantly from P3 and P4. At 6 WAP, P4 recorded the largest mean stem diameter

(4.98 mm), while P0 had the lowest mean (3.68 mm); P1 – P4 were statistically comparable, whereas P0 differed significantly from the compost treatments.

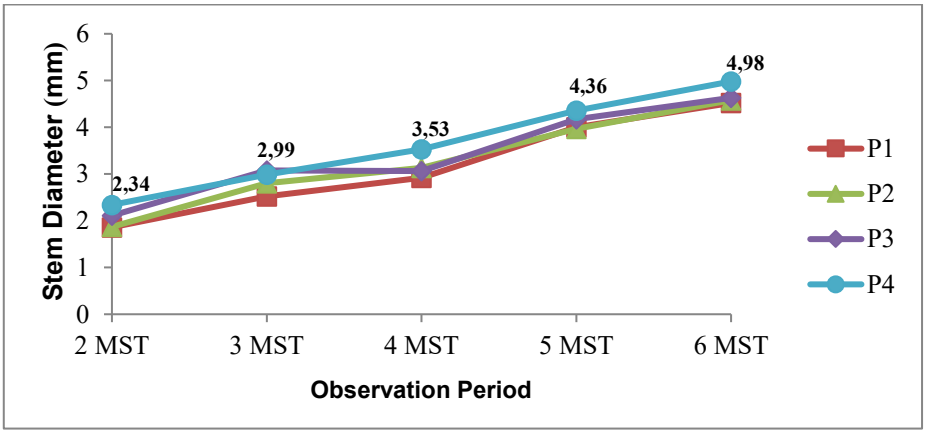


Figure 2. Graph of the average stem diameter of winged bean plants

The observed differences in stem diameter across several observation times are consistent with previous studies reporting changes in crop growth following compost application. Widowati *et al.*, (2022). reported responses in plant growth following compost application, while Bella *et al.*, (2022) found that patchouli waste compost could alter soil chemical properties. These studies provide relevant support for the observed growth response, although they do not establish the specific physiological mechanism operating in the present winged bean experiment.

The present study did not directly measure soil properties, nutrient uptake, or root development. Therefore, these factors should not be presented as demonstrated mechanisms for the increase in stem diameter.

3.3 Number of Fruits per Sample

Table 3. Number of fruits per sample (mean ± SD) and Tukey 5% grouping

Treatment	Fruits sample
P0	6.92 ± 0.57 e
P1	8.67 ± 1.25 d
P2	10.50 ± 1.10 c
P3	12.83 ± 1.23 b
P4	16.00 ± 0.90 a

Analysis of variance showed that patchouli leaf residue compost had a highly significant effect on the number of fruits per sample. The mean number of fruits increased from 6.92 fruits in P0 to 16.00 fruits in P4. Tukey's test at the 5% level placed the treatments into five different groups: P0 (e), P1 (d), P2 (c), P3 (b), and P4 (a). Thus, each increase in compost dose within the tested range was accompanied by a statistically significant increase in the number of fruits per sample.

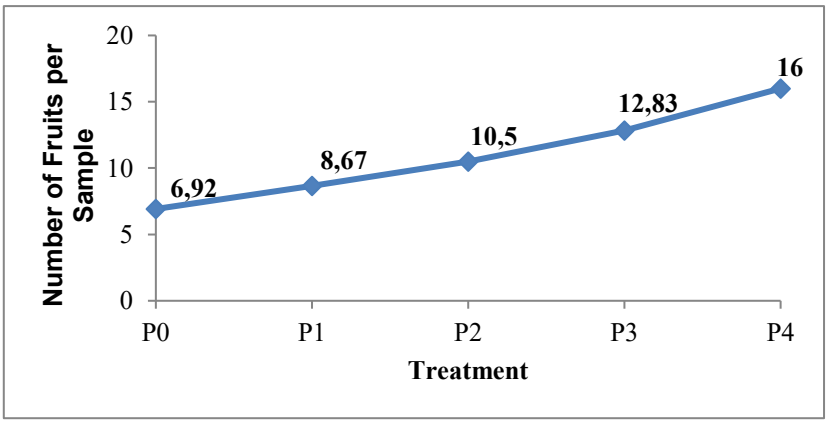


Figure 3. Graph of the average number of fruits per sample of winged bean plants

Based on Figure 3. the number of fruits increased progressively from P0 to P4. The mean number of fruits increased from 6.92 fruits per sample in P0 to 16.00 fruits per sample in P4. The Tukey 5% test placed all five treatments into different statistical groups, namely P0 (e), P1 (d), P2 (c), P3 (b), and P4 (a). Thus, the numerical increase from one treatment to the next was accompanied by a statistically significant difference within the tested treatment range.

The observed increase in fruit number is consistent with previous research showing that organic fertilizer or compost application can affect crop production parameters. Armaniar et al., (2024) reported changes in growth and production characteristics following organic amendment application, while Hervina *et al*., (2024) reported responses of crop growth to organic fertilizer application. Although these studies involved different crops and organic materials, they provide comparative evidence that organic amendments may influence measurable production characteristics.

In the present study, however, flowering intensity, pollination success, nutrient availability, nutrient uptake, and photosynthetic activity were not measured. Therefore, the increase in fruit number is interpreted only as a measurable response to the compost treatments under the experimental conditions and is not attributed to a specific physiological mechanism.

3.4 Fruit Length per Sample

Table 4. Fruit length per sample (mean ± SD) and Tukey 5% grouping

Treatment	Fruit length (cm)
P0	17.26 ± 0.93 c
P1	19.31 ± 0.61 b
P2	20.09 ± 0.81 ab
P3	20.17 ± 0.61 ab
P4	21.08 ± 0.73 a

Analysis of variance showed a highly significant effect of patchouli leaf residue compost on fruit length per sample. The mean fruit length increased from 17.26 cm in P0 to 21.08 cm in P4. Tukey's test showed that P0 differed significantly from P2, P3, and P4, whereas P2, P3, and P4 were statistically comparable. P1 showed an intermediate response. Therefore, although P4 had the highest numerical mean, it was not statistically different from P2 or P3.

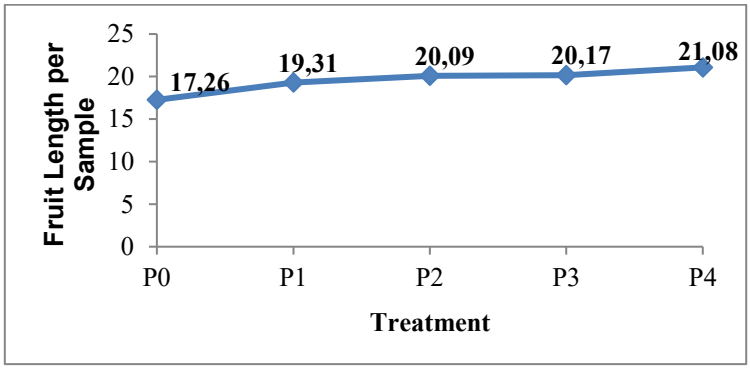


Figure 4. Graph of the average fruit length per sample of winged bean plants

Based on Figure 4, the average fruit length increased from P0 to P4. P0 recorded the lowest mean fruit length of 17.26 cm, while P4 recorded the highest mean of 21.08 cm. P1, P2, and P3 recorded mean fruit lengths of 19.31, 20.09, and 20.17 cm, respectively.

Although P4 recorded the highest numerical mean fruit length (21.08 cm), it was statistically comparable with P2 (20.09 cm) and P3 (20.17 cm) based on the Tukey 5% test. Therefore, the numerical superiority of P4 should not be interpreted as a statistically greater response than P2 and P3.

The observed response is broadly consistent with previous studies reporting positive crop responses to organic amendments. Juniati *et al*.,(2023) reported that agricultural-waste mulch and compost affected crop responses, while Armaniar *et al*., (2024) reported effects of organic amendments on production-related characteristics of Japanese cucumber. These studies provide supporting evidence for the potential contribution of organic amendments to crop production, although direct numerical comparisons are not appropriate because of differences in crop species, organic materials, and experimental conditions.

Because fruit developmental physiology, nutrient uptake, and water status were not measured, the mechanism underlying the differences in fruit length cannot be determined directly. The appropriate interpretation is therefore that compost application was associated with differences in fruit length under the conditions of this experiment.

3.5 Fruit Weight per Sample

Table 5. Fruit weight per sample (mean ± SD) and Tukey 5% grouping

Treatment	Fruit weight (g/sample)
P0	157.39 ± 24.98 d
P1	202.11 ± 39.81 cd
P2	250.63 ± 33.16 c
P3	309.31 ± 45.08 b
P4	394.74 ± 31.10 a

Analysis of variance showed a highly significant effect of patchouli leaf residue compost on fruit weight per sample. Mean fruit weight increased from 157.39 g in P0 to 394.74 g in P4. Tukey's test at the 5% level showed that P4 differed significantly from all other treatments. P3 was also significantly higher than P0, P1, and P2, whereas P0 and P1 were statistically comparable.

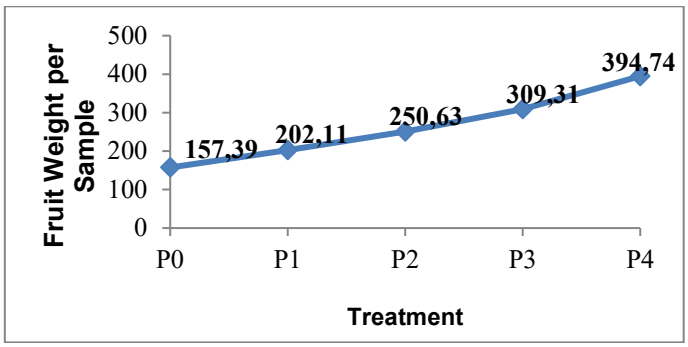


Figure 5. Graph of the average fruit weight per sample of winged bean plants

The increase in fruit weight is consistent with previous studies showing that organic amendments can influence crop production Juniati *et al*., (2023) reported crop responses to agricultural-waste mulch and compost, while Madyaratri & Suntari, (2023) reported effects of compost application on crop growth and yield-related characteristics of okra. These studies support the general interpretation that organic amendments can affect measurable yield components, although the different crops and amendment materials mean that the results cannot be compared directly in numerical terms.

P4 produced the highest fruit weight per sample and was significantly different from all other treatments. Nevertheless, chlorophyll concentration, photosynthetic rate, nutrient uptake, root development, and source–sink relationships were not measured. Therefore, the higher fruit weight should not be attributed directly to these physiological mechanisms.

3.6 Fruit Weight per Plot

Table 6. Fruit weight per plot (mean ± SD) and Tukey 5% grouping

Treatment	Fruit weight (g/plot)
P0	699.78 ± 58.30 d
P1	1,063.82 ± 152.72 c
P2	1,173.45 ± 89.22 c
P3	1,439.73 ± 182.66 b
P4	1,729.55 ± 119.05 a

Analysis of variance showed a highly significant effect of patchouli leaf residue compost on fruit weight per plot. Mean fruit weight per plot increased from 699.78 g in P0 to 1,729.55 g in P4. Tukey's test showed that P4 differed significantly from all other treatments, while P3 also differed significantly from P0, P1, and P2. P1 and P2 were statistically comparable despite their numerical difference.

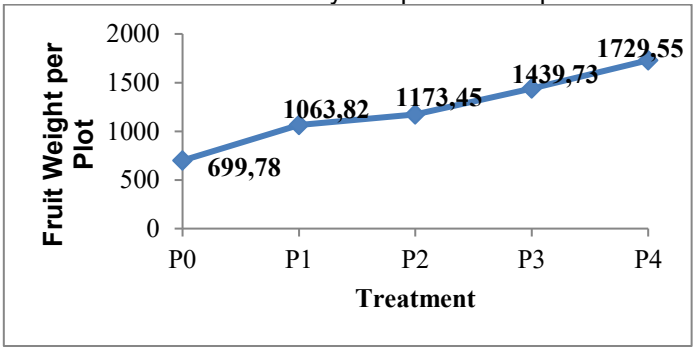


Figure 6. Graph of average fruit weight per plot of winged bean plants

The increase in fruit weight per plot is consistent with previous findings that organic amendments can improve crop yield responses. Juniati *et al*., (2023) reported yield responses following the application of agricultural-waste mulch and compost. In addition, Bella *et al*., (2022) demonstrated that patchouli waste compost can affect soil chemical properties, providing relevant context for the use of patchouli residue as an organic amendment. However, differences in crop species, soil conditions, and application rates should be considered when comparing these studies with the present experiment.

Fruit weight per plot represents an aggregate yield measurement and is influenced by the production of fruits across the plants within a plot. In the present experiment, both fruit number and fruit weight per sample were significantly affected by the compost treatments. However, because physiological variables such as nutrient uptake and photosynthetic rate were not measured, the observed increase in plot-level fruit weight cannot be assigned to a specific physiological mechanism.

A limitation of this study is that comprehensive laboratory analysis of the initial soil physicochemical properties was not conducted. Consequently, the interpretation of treatment responses is limited to the measured variables and the experimental conditions, including the initial soil pH. Further research should include comprehensive soil analysis before planting to better characterize the relationship between soil properties and crop responses to patchouli leaf residue compost.

4. CONCLUSION

Based on the experimental results, the application of patchouli leaf residue compost affected the growth and productivity of winged bean (*Psophocarpus tetragonolobus* L.). Treatment effects on plant height were detected at 3 – 6 weeks after planting (WAP), while effects on stem diameter were detected at 2, 4, 5, and 6 WAP. Treatment P4 (4 kg/plot) consistently produced the highest numerical vegetative growth response within the range of treatments tested. Patchouli leaf residue compost also had a highly significant effect on the productivity parameters measured, namely the number of fruits per sample, fruit length per sample, fruit weight per sample, and fruit weight per plot. Treatment P4 produced the highest mean values for all observed productivity parameters. For fruit weight, P4 reached 394.74 g/sample and 1,729.55 g/plot. Therefore, P4 (4 kg/plot) produced the highest overall measured response for growth and productivity within the treatment range evaluated. However, this result should not be interpreted as evidence that 4 kg/plot is the optimum dose, because doses above 4 kg/plot were not evaluated. The conclusion is limited to the experimental conditions and the range of treatments tested. The observed differences describe treatment responses in the measured variables only. Mechanisms involving root development, nutrient uptake, chlorophyll concentration, photosynthetic rate, microbial activity, or source–sink relationships were not directly measured and therefore are not concluded from this experiment.

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