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# Growth and Yield Response of Kailan Plants (*Brassica Oleraceae* L.) to Various Doses of Guano Fertilizer

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**ABSTRACT**

Kailan is a vegetable plant from the cabbage family that has promising potential due to its high economic value and the high nutritional content contained in kailan. However, kailan production is still unstable due to the continuous use of inorganic fertilizers, resulting in a decrease in soil quality in terms of physical, chemical, and biological properties. Actions that can be taken to stabilize kailan production can be done by adding organic guano fertilizer to kailan plant cultivation. The purpose of this study was to determine the effect of various doses of guano fertilizer on the growth and yield of kailan plants (*Brassica oleraceae* L.). The method used in this study was a randomized block design (RAK) with 5 treatments and 5 replications, namely A: Control, B: 5 tons ha-1, C: 10 tons ha-1, D: 15 tons ha-1, and E: 20 tons ha-1. The results showed that the administration of various doses of guano fertilizer affected the parameters of plant height 35 HST, number of leaves 35 HST, leaf size, leaf area, and fresh weight of plants. However, it did not affect the harvest index parameters. In treatment D, the application of guano fertilizer dose of 15 tons ha-1 was able to provide the best results for the growth and yield of kale plants in the parameters of plant height 35 HST, number of leaves 35 HST, leaf size, leaf area, fresh weight of plants, and dry weight of plants. Therefore, the dose of 15 tons ha-1 is the recommended dose for kale plant cultivation.

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## 1. INTRODUCTION

Kailan (*Brassica oleraceae* L.) is a vegetable crop belonging to the cabbage family, of which the stems and leaves are consumed (Abror & Harjo, 2017). This plant is rich in nutrients and has a high economic value. Generally, kailan is marketed to upper-middle-class consumers, such as those in international-standard restaurants, star-rated hotels, and cafés (Krisnawati et al., 2014). The increasing demand for kailan requires enhanced production efforts. However, according to the Central Statistics Agency (2023), the production of cruciferous vegetables in West Java Province decreased from approximately 236 thousand tons in 2022 to 211 thousand tons in 2023. This decline is likely due to soil quality degradation, affecting its physical, chemical, and biological properties, which leads to nutrient depletion (Rudiyanto et al., 2023). Continuous use of inorganic fertilizers without the addition of organic matter exacerbates this problem. Maghfoer (2018) reported that prolonged and improper use of inorganic fertilizers degrades soil fertility and alters its properties. Similarly, Murnita and Taher (2021) stated that exclusive reliance on inorganic fertilizers leads to nutrient imbalances, soil structure damage, and reduced soil microbial diversity. To address these issues, integrating organic fertilizers into cultivation practices is recommended.

One potential component for organic fertilizer production is animal manure. Guano, composed of urine and solid excreta from bats or seabirds, is commonly found in natural caves (Tangguda et al., 2022). Rich in essential nutrients, particularly nitrogen and phosphorus, guano effectively enhances soil fertility, making it suitable as an organic fertilizer (Azai et al., 2018). According to Syofiani and Oktabriana (2017), guano contains 7–17% N, 8–15% P, and 1.5–2.5% K, contributing to improved soil fertility. Suhartono et al. (2020) reported that applying guano at 15 tons $ha^{-1}$ produced optimal results for plant height, leaf number, leaf area, fresh weight, and total dry weight in Andrographis paniculata. Based on these findings, this study aims to investigate the response of growth and yield of kailan (Brassica oleracea L.) to various guano fertilizer dosages.

## 2. METHOD

This research was conducted at the Food Crops, Horticulture, and Livestock Seed Center (UPT), located on Cigagak Street, Palasari Village, Cibiru District, Bandung City, at an altitude of approximately 791 m above sea level (6°54'39''S, 107°43'29''E). Materials used included kailan seeds (Nova variety), Nafos guano fertilizer, urea fertilizer, dolomite lime, herbicides, pesticides, soil, and water. The tools used were 35 cm × 35 cm polybags, hoes, shovels, analytical balance, thermohygrometer, measuring tape, buckets, dippers, labels, raffia string, wooden stakes, camera, stationery, and an oven. A Randomized Complete Block Design (RCBD) was used, consisting of five treatment levels with five replications, resulting in 25 plots. Each plot contained three sample plants, yielding a total of 75 plants. The treatments were as follows: A = Control B = 5 tons $ha^{-1}$ C = 10 tons $ha^{-1}$ D = 15 tons $ha^{-1}$ E = 20 tons $ha^{-1}$

**Research Procedure**

1. Soil Preparation
   The soil was loosened to a depth of 20–30 cm and cleared of weeds, plant residues, and stones. One month before transplanting, dolomite was applied to adjust soil pH by mixing it thoroughly with the soil.
2. Planting Media Preparation and Guano Application
   The prepared soil was placed into 35 cm × 35 cm polybags. According to the designated treatment doses, Guano fertilizer was applied by spreading it evenly on the soil surface, two weeks before transplanting. This timing allowed sufficient decomposition of organic matter by soil microorganisms, improving soil structure and fertility.
3. Seedling Preparation
   The nursery medium consisted of manure, burnt husk, soil, and cocopeat at a 3:3:1:1 ratio. The mixture was placed into seed trays, moistened, and one kailan seed was sown per hole. The trays were covered with black plastic for three days to promote rapid germination, then uncovered and placed in a shaded, well-lit area. Watering was done daily to maintain moisture.
4. Transplanting
   After 14 days, seedlings with 3–4 true leaves were transplanted into the prepared polybags. Watering was carried out immediately after transplanting.
5. Maintenance
   Maintenance included additional fertilization, watering, replanting, weeding, and pest and disease control. Supplementary fertilization using NPK 16:16:16 at a rate of 6 g per polybag was applied two weeks after transplanting. Watering was performed twice daily, from planting until harvest.
6. Harvesting
   Kailan was harvested at five weeks after transplanting (WAT). Plants were carefully uprooted to avoid root damage. Harvest-ready kailan was characterized by dark green, wavy-edged leaves.

## 3. RESULT AND DISCUSSION

### 1. General Condition

The soil used in this study had a clay texture, consisting of 11% sand, 9% silt, and 80% clay, with an acidic pH of 5.0. These conditions do not meet the optimal requirements for kailan growth, which prefers a soil pH of 5.5–6.5 (Mulyana et al., 2012) and sandy loam texture (Mulyono, 2011). The average daily temperature during the study was 26°C, with a range of 19°C to 32°C. Relative humidity averaged 75%, ranging from 55% to 97%. The temperature was slightly above the optimal range of 15–25°C for kailan growth, while humidity was within the ideal range of 60–80% (Silvester et al., 2013).

### 2. Plant Pests

Observed pests included grasshoppers, white grubs, and cabbage loopers. Grasshoppers appeared at 7 days after transplanting (DAT) with a 2.8% infestation rate, decreasing to 1.3% at 14 DAT, causing leaf tears and holes. Control was performed using profenofos 500 g $L^{-1}$ at a concentration of 0.5 mL $L^{-1}$ water. White grubs attacked at 7 DAT with a 1.3% infestation rate, causing basal stem cutting and plant death, requiring replanting. Mechanical control by hand removal was applied. Cabbage loopers infested plants at 28 DAT with 2.4% severity, decreasing to 1.3% at 35 DAT. Chemical control using profenofos 500 g $L^{-1}$ at 1 mL $L^{-1}$ water was conducted.

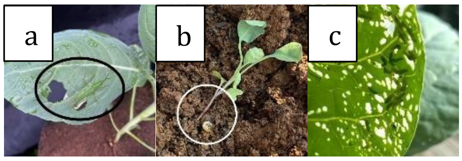


Figure 1. a) Leaves damaged by grasshoppers; b) Plants attacked by white grubs; c) Leaves damaged by cabbage loopers.

### 3. Plant Height

Plant height was measured at 7, 14, 21, 28, and 35 DAT. Based on variance analysis, guano fertilizer doses did not significantly affect plant height at 7, 14, 21, and 28 DAT but showed a significant effect at 35 DAT (Appendix 8). This was likely due to the slow-release nature of guano fertilizer, which requires decomposition time before nutrients become available (Charlos & Kesumaningwati, 2021). Consequently, nutrient uptake was delayed, requiring time for plants to adapt and absorb the nutrients from guano.

Table 1. Effect of Guano Fertilizer Dosage on Kailan Plant Height

| Treatments | Average (cm) | | | | |
|---|---|---|---|---|---|
| | 7 DAS | 14 DAS | 21 DAS | 28 DAS | 35 DAS |
| A (control) | 6,23 a | 10,56 a | 15,10 a | 23,03 a | 27,46 a |
| B (5 ton $ha^{-1}$) | 6,43 a | 10,96 a | 16,83 a | 25,96 a | 32,53 ab |
| C (10 ton $ha^{-1}$) | 6,23 a | 9,76 a | 15,76 a | 24,33 a | 30,76 ab |
| D (15 ton $ha^{-1}$) | 6,40 a | 11,10 a | 18,33 a | 27,63 a | 34,95 b |
| E (20 ton $ha^{-1}$) | 6,83 a | 11,43 a | 17,60 a | 27,23 a | 35,66 b |

**Note:** The mean values in each column followed by the same letter indicate no significant difference based on Duncan's Multiple Range Test at the 5% significance level.

Based on Duncan's test at a 5% significance level, the highest average plant height was observed in treatment D (15 tons $ha^{-1}$), reaching 34.95 cm. Treatment D did not differ significantly from treatment E (20 tons $ha^{-1}$) but was significantly higher than the control (A) (Table 4). This is likely because the control treatment did not receive guano fertilizer, resulting in a lack of essential nutrients needed for plant height growth. Similarly, Suhartono et al. (2020) reported that applying guano fertilizer at 15 tons $ha^{-1}$ significantly increased plant height in sambiloto compared to other dosages. This can be attributed to the nitrogen content in guano (3.85%), which is crucial for promoting plant growth. Nitrogen stimulates vegetative growth and plant height by serving as a key component in amino acids, proteins, and chlorophyll, which are essential for photosynthesis (Lutfiah et al., 2021).

### 4. Leaf Color

Leaf color observation using the Munsell Plant Tissue Color Charts showed that all treatments resulted in a leaf color code of 5GY 5/4 (green-yellow). This indicates that kailan leaves had a moderately bright green color, consistent with the description of the 'nita' variety, which has medium green, waxy leaves. This coloration suggests that nitrogen levels from the soil and guano fertilizer were sufficient to meet the plant’s nitrogen requirements. Nitrogen promotes chlorophyll formation, which gives leaves their green color and plays a key role in photosynthesis, especially during the vegetative phase. A nitrogen deficiency can cause leaf yellowing and reduced photosynthesis efficiency, while excess nitrogen can lead to dark green foliage (Nugroho, 2015).

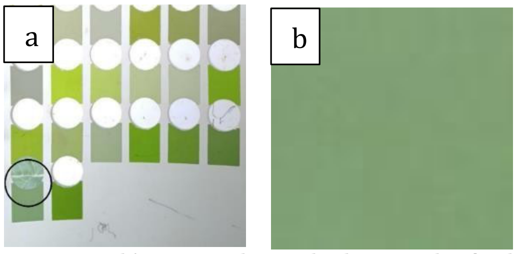


Figure 2. a) Observation process; b) Research result showing leaf color code 5GY 5/4

### 5. Number of Leaves

Leaves play a crucial role in plant growth as the primary site for photosynthesis, providing energy for development (Pamungkas & Supijatno, 2017). The analysis of variance showed that guano fertilizer application had no significant effect on the number of kailan leaves at 7, 14, 21, and 28 days after transplanting (DAT). However, a significant effect was observed at 35 DAT. This is attributed to the slow-release nature of guano fertilizer, which gradually releases nutrients over time (Suhartono et al., 2020). The highest number of leaves at 35 DAT was recorded in treatment D (15 tons $ha^{-1}$), which significantly differed from the control (A). Treatment D consistently produced the highest leaf counts at 21, 28, and 35 DAT, while at 7 and 14 DAT, treatment E (20 tons $ha^{-1}$) showed slightly higher leaf counts (Table 5). The excessive nitrogen supply from both guano and the supplemental NPK fertilizer applied at 14 DAT likely caused nutrient imbalance in treatment E, leading to reduced nitrogen uptake efficiency, as noted by Priambodo (2021). Similarly, Nugrahini (2013) reported that guano application increased the number of lettuce leaves compared to untreated plants, due to the improved nitrogen availability during the vegetative phase. With 3.85% nitrogen content, guano meets the kailan crop’s N requirements. Proper nutrient availability supports organ development such as leaf formation (Putri & Kristanto, 2023). Nitrogen is essential for chlorophyll synthesis, thus promoting photosynthesis and subsequent translocation of photosynthates to vegetative organs, including new leaves (Pramitasari et al., 2016). Additionally, nitrogen contributes to protoplasm formation, stimulating meristematic activity at growth points, which enhances stem internode development and increases leaf production (Indriyani et al., 2018).

Table 2. Effect of Guano Fertilizer Dosage on Kailan Number of Leaves

| Treatments | Average (cm) | | | | |
|---|---|---|---|---|---|
| | 7 DAS | 14 DAS | 21 DAS | 28 DAS | 35 DAS |
| A (control) | 4,63 a | 5,60 a | 7,13 a | 7,66 a | 8,00 a |
| B (5 ton $ha^{-1}$) | 4,76 a | 5,76 a | 7,66 a | 7,87 a | 8,33 abc |
| C (10 ton $ha^{-1}$) | 4,93 a | 5,59 a | 7,26 a | 7,53 a | 8,26 ab |
| D (15 ton $ha^{-1}$) | 5,00 a | 6,00 a | 7,86 a | 8,07 a | 9,06 c |
| E (20 ton $ha^{-1}$) | 5,26 a | 6,33 a | 7,46 a | 7,80 a | 8,93 bc |

**Note:** The mean values in each column followed by the same letter indicate no significant difference based on Duncan's Multiple Range Test at the 5% significance level.

### 6. Leaf Size

The analysis of variance indicated that guano fertilizer application had a highly significant effect on both leaf length and width of kailan (Appendix 18). The highest average leaf length and width were recorded in treatment D (15 tons $ha^{-1}$), which differed significantly from the control (A) (Table 3). This outcome is attributed to the nitrogen content in guano, which supports the expansion of leaf dimensions in kailan. Nitrogen plays a critical role in the formation of chlorophyll, proteins, and amino acids, all of which contribute to leaf enlargement. When essential nutrients are adequately supplied, the plant's physiological processes function optimally, enhancing both growth and development (Nurhasana et al., 2015).

Table 3. Effect of Guano Fertilizer Dosage on Kailan Leaf Size

| Treatments | Length Leaf | Width Leaf |
|---|---|---|
| A (control) | 12,92 a | 9,73 a |
| B (5 ton $ha^{-1}$) | 15,51 b | 11,01 b |
| C (10 ton $ha^{-1}$) | 15,56 b | 11,60 bc |
| D (15 ton $ha^{-1}$) | 15,82 b | 11,86 c |
| E (20 ton $ha^{-1}$) | 15,76 b | 11,71 bc |

**Note:** The mean values in each column followed by the same letter indicate no significant difference based on Duncan's Multiple Range Test at the 5% significance level.

However, the leaf size of kailan in this study did not reach the standard size described for the Nita variety, which is characterized by a leaf length of 35 cm and a width of 22 cm. This discrepancy is likely due to suboptimal environmental conditions that did not fully support leaf size development in kailan. This finding is consistent with the statement by Ramadhan et al. (2022), who noted that each crop variety will only reach its optimal performance when cultivated under suitable land and environmental conditions.

### 7. Leaf Area

Leaf area measurement was conducted at harvest time, which occurred at 35 days after transplanting (DAT). The analysis of variance revealed that the application of guano fertilizer had a significant effect on the leaf area of kailan plants.

Table 4. Effect of Guano Fertilizer Dosage on Kailan Leaf area

| Treatments | Leaf area |
|---|---|
| A (kontrol) | 102,53 a |
| B (5 ton $ha^{-1}$) | 118,24 ab |
| C (10 ton $ha^{1}$) | 149,57 abc |
| D (15 ton $ha^{-1}$) | 173,47 c |
| E (20 ton $ha^{-1}$) | 168,15 bc |

**Note:** The mean values in each column followed by the same letter indicate no significant difference based on Duncan's Multiple Range Test at the 5% significance level.

Based on the results of the Duncan test at the 5% significance level, the highest average leaf area was obtained in treatment D (15 tons $ha^{-1}$), which reached 173.47 $cm^2$. Treatment D showed a significantly higher value compared to the control (treatment A), but it was not significantly different from treatments C and E.

This result is supported by the findings of Siregar et al. (2018), who reported that the application of guano fertilizer at a dose of 12 tons $ha^{-1}$ had a significant effect on the leaf area of mustard greens, producing the largest leaf area compared to other treatments and the control, at 171.50 $cm^2$.

This result is comparable to the leaf area obtained in the present study. The positive effect is attributed to the nitrogen content in guano fertilizer, which can enhance total nitrogen availability in the soil, thereby promoting plant growth, especially when applied at an adequate dose.

According to Pramitasari et al. (2016), nitrogen plays an essential role in increasing leaf area because it is a key component in chlorophyll formation, which is crucial for photosynthesis. Higher nitrogen application, up to its optimal level, enhances chlorophyll content, thus increasing the rate of photosynthesis. The photosynthates produced from this process subsequently support plant growth, resulting in a larger leaf area.

### 8. Harvest Index

The harvest index represents the ratio between the dry weight of the economically valuable plant parts and the total dry weight of the plant. The results of the analysis of variance indicated that guano fertilizer application at various doses did not significantly affect the harvest index of kailan. This lack of effect may be due to the low C/N ratio of the soil, recorded at 10%, which may not have been sufficient to influence the harvest index. Microorganisms require both carbon and nitrogen for their metabolic activities; when the soil C/N ratio is low, microorganisms cannot assimilate the nutrients efficiently, resulting in nutrient loss (Purnomo et al., 2017).

Table 5. Effect of Guano Fertilizer Dosage on Kailan Plant harvest index

| Treatments | harvest index |
|---|---|
| A (control) | 0,80 a |
| B (5 ton $ha^{-1}$) | 0,84 a |
| C (10 ton $ha^{-1}$) | 0,82 a |
| D (15 ton $ha^{-1}$) | 0,88 a |
| E (20 ton $ha^{-1}$) | 0,81 a |

**Note:** The mean values in each column followed by the same letter indicate no significant difference based on Duncan's Multiple Range Test at the 5% significance level.

Furthermore, the harvest index can also be influenced by other factors that support plant growth, including adequate sunlight, water availability, and sufficient nutrient uptake by the plant. The utilization of sunlight absorbed by the plant for photosynthesis leads to the production of abundant photosynthates, which is reflected in the harvest index (Raditya et al., 2017).

The harvest index serves as an indicator of crop productivity. A high harvest index signifies a greater proportion of the plant's biomass being allocated to economically valuable parts. In this study, kailan plants exhibited relatively high harvest index values, ranging from 0.81 to 0.86. This finding aligns with the statement by Hariyadi et al. (2012), who noted that a harvest index below 0.40 indicates low productivity, while a value exceeding 0.40 reflects high productivity.

### 9. Fresh Weight of Plants

The analysis of variance showed that guano fertilizer application had a significant effect on the fresh weight of kailan plants. Based on the Duncan test at the 5% level, treatment D (15 tons $ha^{-1}$) produced the highest average fresh weight of 70.79 g, which was not significantly different from treatment E but was significantly different from the control (treatment A) (Table 6). Thus, the dose of 15 tons $ha^{-1}$ was identified as the most effective for promoting the growth of kailan plants. This result is consistent with the findings of Suhartono et al. (2020), who reported that applying guano fertilizer at 15 tons $ha^{-1}$ produced the highest average fresh weight and had a significant effect on the fresh weight of sambiloto plants. The application of guano fertilizer enhances soil microbial activity, which optimizes nutrient availability for plant uptake. When the supply of nutrients is adequate and balanced, it supports increased plant biomass and contributes to higher fresh weight yields.

Table 6. Effect of Guano Fertilizer Dosage on Kailan Plant Fresh Weight

| Treatments | Fresh Weight |
|---|---|
| A (control) | 40,03 a |
| B (5 ton ha | 56,78 ab |

| | |
|---|---|
| C (10 ton ha$^{-1}$) | 53,26 ab |
| D (15 ton ha$^{-1}$) | 70,79 b |
| E (20 ton ha$^{-1}$) | 67,57 b |

**Note:** The mean values in each column followed by the same letter indicate no significant difference based on Duncan's Multiple Range Test at the 5% significance level.

However, treatment D has not yet met the fresh weight standard per kailan plant as stipulated by the Ministry of Agriculture Decree, which is set at 250 g. The relatively low fresh weight observed may be attributed to the thin leaves of the kailan plants, which affects the fresh weight. According to Wahyuningtyas et al. (2022), thin leaves indicate a lower water content. Therefore, even though the kailan plants have large leaf areas, the resulting fresh weight remains low. The fresh weight of a plant depends on the nutrients and water absorbed by the plant. However, the clayey soil texture in this study hindered root absorption of water due to smaller soil pores, thus reducing water uptake by the roots. Rahmah et al. (2014) stated that increased nutrient and water absorption leads to higher plant biomass. Nutrients stimulate the growth of plant organs such as roots, enabling the plant to absorb more nutrients and water, which are utilized to enhance photosynthetic activity. This ultimately results in increased fresh and dry weights of the plant. Moreover, nutrient and water absorption via roots also influence plant growth parameters such as plant height, leaf number, and leaf area. The combination of these parameters collectively affects the fresh weight of kailan plants (Maisarah & Fithria, 2022).

### 10. Dry Weight of Plants

Dry weight is a measure of plant growth and development as it reflects the accumulation of organic compounds synthesized by the plant. It also serves as an indicator of the plant's nutritional status, closely related to nutrient availability (Sitorus et al., 2014). The analysis of variance showed that guano fertilizer doses significantly influenced the dry weight of kailan plants.

Table 7. Effect of Guano Fertilizer Dosage on Kailan Plant Dry weight

| Treatments | Dry weight |
|---|---|
| A (Control) | 4,92 a |
| B (5 ton ha$^{-1}$) | 7,38 b |
| C (10 ton ha$^{-1}$) | 6,03 ab |
| D (15 ton ha$^{-1}$) | 8,09 b |
| E (20 ton ha$^{-1}$) | 7,81 b |

**Note:** The mean values in each column followed by the same letter indicate no significant difference based on Duncan's Multiple Range Test at the 5% significance level.

Based on the results of Duncan's test at the 5% significance level, treatment D (15 tons ha$^{-1}$) produced the highest average plant dry weight of 8.09 g (Table 10). The dry weight obtained in treatment D was not significantly different from treatments B, C, and E, but was significantly different from treatment A (control). These results are consistent with the findings of Suhartono et al. (2020), who reported that the application of guano fertilizer at a dose of 15 tons ha$^{-1}$ had a significant effect on the dry weight of sambiloto plants, resulting in the highest average dry weight of 21.33 g. This indicates that the application of guano fertilizer can supply optimal nutrients for kailan plants, leading to higher average dry weight compared to the control treatment. According to Amsya et al. (2017), higher plant dry weight can be achieved through fertilizer application, as it ensures stable and adequate nutrient availability that supports photosynthesis and promotes plant growth. Dry weight is produced through the process of photosynthesis, followed by biosynthesis, which is facilitated by the uptake of nutrients by the plant. Therefore, higher dry weight reflects better vegetative growth performance in plants.

## 4. CONCLUSION

The application of guano fertilizer had a significant effect on the growth and yield of kailan plants. Among the various doses applied, the treatment with a dose of 15 tons ha$^{-1}$ showed the most optimal results in terms of both vegetative growth and yield. This dose was able to enhance growth parameters such as plant height, number of leaves, leaf area, as well as produce higher fresh and dry weight of the plants compared to other treatments. These results indicate that the application of guano fertilizer at a dose of 15 tons $ha^{-1}$ is the most effective dose in supporting the growth and yield of kailan plants..

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