Formosa Journal of Science and Technology (FJST)
Vol. 5, No. 6, 2026: 1641-1654

Growth and Production Response of Pakcoy (*Brassica rapa* L.) Plants to the Application of Cow Manure and Liquid Organic Fertilizer (POC) from Rabbit Urine

Pantas Simanjuntak[1*], Efbertias Sitorus[2], Lince Romauli Panataria[3], Meylin Kristina Saragih[4], Arie Bagus Lase[5]
Faculty of Agriculture, Universitas Methodist Indonesia
Corresponding Author: Pantas Simanjuntak, simanjuntak.pantas@gmail.com

A R T I C L E I N F O

Keywords: Cow Manure, Growth, Pakcoy, POC, Production, Rabbit Urine.

Received : 27, April
Revised : 29, May
Accepted: 30, June

A B S T R A C T

Pakcoy (*Brassica rapa* L.) is an economically valuable horticultural crop whose growth can be improved with organic fertilizers. This study examined the effects of cow manure and liquid organic fertilizer from rabbit urine on pakcoy growth and yield. The research was using a factorial randomized block design. Cow manure was applied at 0, 1, 2, and 3 kg per plot, while rabbit urine fertilizer was applied at 40, 50, and 60 ml per plot. Observed variables were plant height, leaf number, and plant weight per plot. Results showed that cow manure significantly affected all variables. The 2 kg per plot treatment gave the best results, while rabbit urine fertilizer and interaction effects were not significant

ISSN-E: 2964-6804
DOI: https://doi.org/10.55927/fjst.v5i6.97
https: https://journalfjst.my.id/index.php/fjst

INTRODUCTION

Pakchoy (Brassica rapa L.) is a vegetable from the Brassicaceae family. Pakchoy originated in China and has been widely cultivated in South and Central China and Taiwan since the 5th century. The largest centers of pakchoy cultivation are in Thailand, the Philippines, Malaysia, and Indonesia (Pyngrope et al., 2023)

Pakcoy mustard greens (Brassica rapa L.) are a popular horticultural crop widely consumed by the public, including green, white, and pakcoy mustard greens. Of these three, pakcoy mustard greens are among the varieties most widely cultivated by farmers today (Ernanda, 2017). Their broad stems and leaves, which are greener than regular mustard greens, make this type more commonly used in various dishes. Pakcoy is excellent for relieving itchy throats in cough sufferers. It is a cure for headaches, a blood purifier, and improves kidney function and facilitates digestion. Its seeds are used as oil and a food flavoring. Pakcoy contains calories, protein, fat, carbohydrates, and Ca, P, Fe, Vitamin A, Vitamin B, and Vitamin C, all of which are excellent for health, have high nutritional content, and have good prospects as an economically valuable commodity (Nurawalia, 2022; Ompusunggu & Daeli, 2024).

Based on data from the Central Statistics Agency (2023), mustard greens production in North Sumatra tended to increase from 2020 to 2023. In 2020, mustard greens production reached 75,424 tons per year, decreased to 74,908 tons per year in 2021, and decreased slightly to 74,370 tons per year in 2022. Meanwhile, in 2023, it increased to 77,970 tons per year. These data indicate that mustard greens production in North Sumatra is increasing every year (Utara, 2021). According to (Nurhasanah et al., 2021), mustard greens are a very popular crop among Indonesians, including pak choy mustard greens, due to their various benefits. Therefore, production needs to be increased to meet the demand for mustard greens for the Indonesian people.

In general, bok choy (bok choy) productivity is still very low, caused by several factors, including less intensive cultivation techniques, climate factors, and low soil fertility (Bi et al., 2024; Kumpanalaisatit et al., 2022). One way to increase crop production is through fertilizer application. Fertilization is carried out to meet the Plant's nutrient needs, thus achieving high yields. An effective solution to address soil fertility is switching to organic fertilizers, which can improve soil structure, increase water absorption, enhance soil conditions, and provide nutrients for plants (Ishfaq et al., 2023; Zhou et al., 2022).

Fertilization is one of the practices that should be considered to increase bok choy (Brassica rapa L.) production through fertilizer use (Mohamad et al., 2022). Organic and inorganic fertilizers are materials that meet plants' nutrient needs. The use of organic fertilizers can be an alternative solution to reduce dependence on chemical fertilizers and can increase crop production (Verma et al., 2019). Cultivating bok choy (Brassica rapa L.) is influenced by the availability of nitrogen (N), which plays a role in the growth and development of bok choy (Sumiahadi & Putri, 2025). The use of cow dung fertilizer aims to utilize the accumulated cow dung as a good organic fertilizer for plants (Mukhuba et al., 2018). Furthermore, if cow dung continues to accumulate and is not utilized, it will cause environmental pollution, producing an unpleasant odor that can disrupt human activities. The use of cow dung fertilizer can help overcome the scarcity of subsidized chemical fertilizers.

Liquid organic fertilizers contain higher levels of nitrogen and potassium than solid fertilizers. Liquid rabbit manure can be used as a liquid organic fertilizer, offering numerous benefits for plants (Azeez et al., 2025; Rahmatika & Andayani, 2024). Plants more readily utilize nutrients in liquid form because the elements in the nutrients break down more readily, allowing them to be absorbed by the roots (Bhatla & Kathpalia, 2023; Kathpalia & Bhatla, 2018).

Based on the description above, the researcher is interested in assessing the extent of growth and production responses of Packcoy (Brassica rapa L.) plants when provided with organic cow manure fertilizer and liquid organic rabbit urine fertilizer.

THEORETICAL REVIEW

Pakcoy (*Brassica rapa* L.) is a hybrid vegetable that is good to plant in lowland and highland areas, because pak choy can easily adapt to the environment quite easily (Kusnia*et al*.., 2022). Pakcoy (*Brassica rapa* L.) can usually be harvested when it reaches 30-45 days after planting, when the bok choy leaves are already wide and the bok choy stalks appear greenish-white. However, harvesting can also be done when the bok choy plant reaches its maximum height, which is between 20-25 cm (Mardilla and Pratiwi, 2021). Pakcoy (*Brassica rapa* L.) has various good contents for those who consume it, starting from protein, fat, fiber, carbohydrates, calcium, phosphorus, potassium, iron, and also various vitamins in the pakcoy plant, namely vitamins A, B, and B6 which are needed (Riansyah et al., 2022). Pakcoy contains quite a high-water content of 80%-90%, which is considered high so it will affect the weight of the pakcoy plant. Pakcoy also has a high chlorophyll content compared to other mustard plants according to (Sari, 2020), the chlorophyll content in pakcoy plants is 86.76 mg/g, because if the nutrients for pakcoy plants are met, the photosynthesis process can take place properly and result in optimal chlorophyll content in pakcoy.

Continuous use of inorganic fertilizers will have a negative impact on soil productivity and over time it will become hard Currently, many farmers still use inorganic fertilizers whose application and dosage are not in accordance with the recommended rules or exceed the recommended dosage. Excessive and continuous use of organic fertilizers in large quantities will result in a decrease in soil quality and negative impacts on soil health and the environment. Organic fertilizers are fertilizers that consist mostly or entirely of organic materials derived from plants and/or animals that have gone through an engineering process, can form solids or liquids that are used to supply organic materials, improve the physical, chemical and biological properties of the soil. Liquid organic fertilizers from animal or plant waste (POC) have not been widely used even though in addition to being useful for increasing soil fertility, they are also more easily absorbed by plants so that their efficiency is higher, but the right dosage for vegetable plants still needs to be studied further. Liquid organic fertilizers derived from rabbit urine have a relatively higher nutrient content, namely 2.72% N, 2.8% $P_2THE_5$and 1.2% K_2O, in cow urine is 1.21% N, 0.65% P_2THE_5, 1,16% K_2O and goats amounted to 1.45% N, 0.05% P_2O_5, 1,96% K_2O. The

benefits of organic fertilizer from rabbit urine include helping to improve soil fertility and increasing plant productivity (Rahmatika et al., 2022).

Cow manure is a fertilizer made from livestock waste because it plays a role in plant growth. Cow manure is usually referred to as organic fertilizer, where organic fertilizer is used to restore nutrients to the soil because it acts as a nutrient provider for cultivated plants so they can produce optimally (Amini et al., 2021). Cow manure fertilizer is usually placed in a designated area and left for a certain period of time before being applied to plants (Astiti et al., 2022). The application of organic fertilizer, namely cow manure, aims to fertilize the soil. Therefore, applying cow manure will restore the soil's fertility and have an impact on plant growth. By utilizing cow manure, farmers can save costs on fertilizing plants and can maintain soil fertility. It can also reduce chemical fertilizers that can leave residues in the soil (Ratriyanto et al., 2019)

METHODOLOGY

This research was conducted on Jalan Sukarame, Tanjung Selamat, Sunggal District, at an altitude of approximately 30 meters above sea level. The materials used in this study were pak choy (Brassica rapa L.) seeds of the Nauli F1 variety, cow manure, rabbit urine, EM4, and molasses. The tools used included hoes, machetes, sample boards, measuring instruments, analytical scales, hand sprayers, watering cans, 5-liter jerry cans, cameras, stationery, and other supporting equipment.

This study used a Factorial Randomized Block Design with two treatment factors. The first factor was the dose of cow manure consisting of four levels, namely S0 = without cow manure, S1 = 1 kg/plot equivalent to 10 tons/ha, S2 = 2 kg/plot equivalent to 20 tons/ha, and S3 = 3 kg/plot equivalent to 30 tons/ha. The second factor was the concentration of liquid organic fertilizer from rabbit urine, with three levels: K1 = 40 ml/plot (equivalent to 0.4 l/ha), K2 = 50 ml/plot (equivalent to 0.5 l/ha), and K3 = 60 ml/plot (equivalent to 0.6 l/ha).

Twelve treatment combinations were obtained, each replicated three times, resulting in 36 experimental plots. Each plot measured 100 cm × 100 cm with a planting distance of 25 cm × 25 cm. There were 16 plants per plot, for a total of 576. Seven sample plants were used in each plot.

The research began with land preparation. The land was cleared of weeds, debris, remaining plant roots, and stones, then leveled, and a 100 cm × 100 cm experimental plot was created. Cow manure was applied 1 week before planting at the specified dosage. Pakcoy seeds were sown in the nursery medium and grown until the seedlings were ready to be transferred to the research plot, 2 weeks after sowing. The rabbit urine liquid organic fertilizer was made through a fermentation process. The ingredients used were 4 liters of rabbit urine, 40 ml of EM4, and 40 ml of molasses. All ingredients were mixed in a 5-liter jerry can, then shaken thoroughly and fermented for 7–8 days in a shaded area. During fermentation, the jerry can lid was opened occasionally to release gas. The rabbit urine POC was applied at 2 and 3 weeks after planting, depending on the treatment level. Plant maintenance included watering, weeding, replanting, and pest and disease control. Watering was done twice daily, in the morning and evening, except when it rained. Weeding was performed if weeds were found around the experimental plot. Replanting was performed on dead or abnormally growing plants within 2 weeks of planting. Pest and disease control was

performed manually or, if necessary, with pesticides. Harvesting was carried out 35 days after transplanting or before the plants flowered. Harvesting was done by carefully uprooting the plants or cutting the base of the plants to ensure a good yield.

The parameters observed in this study included plant height, leaf number, and plant weight per plot. Plant height was measured from the base of the stem to the highest growing point. Plant height was observed starting two weeks after planting at weekly intervals. The number of leaves was calculated based on fully opened leaves, from young to old. Leaf number was observed at weekly intervals from 2 weeks after planting through harvest. Plant weight per plot was obtained by weighing all bok choy plants in each plot after harvest using an analytical balance.

Observational data were analyzed using analysis of variance (ANOVA) according to a factorial randomized block design. The linear model used is as follows:

$$\mathbf{Yijk = \mu + \beta i + Sj + Kk + (SK)jk + \varepsilon ijk}$$

If the analysis results indicate a real effect, the Duncan Multiple Range Test is used at the 5% level.

RESULTS

Plant Height (cm)

The analysis of variance showed that the cow manure treatment significantly affected pak choy plant height at 2, 3, and 4 weeks after planting (WAP). In contrast, the concentration of liquid organic fertilizer and the interaction between the two treatments did not significantly affect plant height at any observation age. Table 1 presents the average plant height at 2, 3, and 4 weeks after planting, influenced by POC concentrations of cow manure and rabbit urine.

Table 1. Average Plant Height (cm) of Pakcoy Due to the Effect of Different Cow Manure and Liquid Organic Fertilizers at 2, 3, and 4 Weeks After Planting

Treatment	Tall Plant (cm)		
	2 MST	3 MST	4 MST
S0	6.9a	12.44a	16,18a
S1	9.83b	16.13b	21.43b
S2	10.17b	17.15b	22.67b
S3	10.14b	16.31b	21.93b
K1	9.23	15.50	20.66
K2	9.23	15.80	20.49
K3	9.33	15.22	20.51
S0K1	7.17	12.21	15.83
S0K2	6.50	13.25	15.88
S0K3	7.08	11.88	16.83
S1K1	10.00	15.92	21.75
S1K2	9.75	16.21	21.33
S1K3	9.75	16.25	21.21

S2K1	10.08	17.67	23.13
S2K2	10.67	17.54	23.08
S2K3	9.75	16.25	21.79
S3K1	9.67	16.21	21.92
S3K2	10.00	16.21	21.67
S3K3	10.75	16.50	22.21

Information: The numbers that are followed by the same letter in the same column mean no significant difference in the DMRT test at a test level of 5%

Table 1 shows that in the cow manure treatment, the tallest plants were in treatment S2, which was significantly taller than S0 but not significantly taller than S1 or S3. Plant height in treatment S3 was significantly different from S0, but not significantly different from S1. Plant height in treatment S1 was significantly different from S0. The relationship between cow manure and pakcoy plant height is shown in Figure 1.

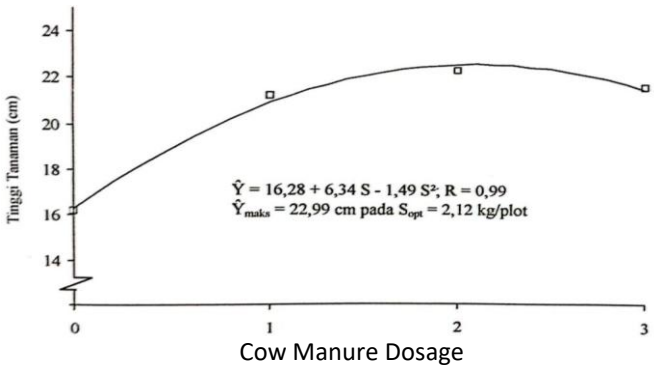

Figure 1. Effect of Cow Manure Dose on the Height of Pakcoy Plants 4 Weeks After Planting

Figure 1 shows that applying 2.12 kg of cow manure per plot resulted in a maximum bok choy plant height of 22.99 cm. Applying more than 2.12 kg of cow manure per plot can suppress plant growth. Table 1 also shows that the liquid organic fertilizer treatment had no significant effect on pakcoy plant height.

Number of leaves (blades)

The analysis of variance (ANOVA) showed that the cow manure treatment had no significant effect on the number of leaves of bok choy plants at 2 weeks after planting (WAP), but had a significant effect at 3 and 4 weeks after planting (WAP). The liquid organic fertilizer concentration treatment, as well as the interaction between the two treatments, had no significant effect on the number of leaves of bok choy plants at all observation ages. Table 3 presents the average number of leaves of bok choy plants at 2, 3, and 4 weeks after planting due to the influence of different cow manure and liquid organic fertilizer concentrations.

Table 2. Average Number of Pakcoy Plant Leaves (strands) Due to the Effect of Different Cow Manure and Liquid Organic Fertilizers at 2, 3, and 4 Weeks After Planting

Treatment	Amount Leaves (cm)		
	2 MST	3 MST	4 MST
S0	4.97	5.69a	7.03a
S1	5.47	6.69b	8.78b
S2	5.58	6.89b	9.53b
S3	5.56	6.50b	9.06b
K1	5.29	6.44	8.42
K2	5.50	6.69	8.69
K	5.40	6.21	8.69
S0K1	5.08	5.33	7.08
S0K2	4.92	6.17	6.83
S0K3	4.92	5.58	7.17
S1K1	5.25	7.17	8.83
S1K2	5.67	6.75	8.83
S1K3	5.50	6.17	8.67
S2K1	5.75	6.75	9.42
S2K2	5.58	6.25	9.67
S2K3	5.42	6.67	9.50
S3K1	5.08	6.50	8.33
S3K2	5.83	6.58	9.42
S3K3	5.75	6.42	9.42

Information: The numbers that are followed by the same letter in the same column mean no significant difference in the DMRT test at a test level of 5%

Table 2 shows that at 3 and 4 weeks after planting, the highest number of leaves was observed in treatment S2, which was significantly different from S0 but not significantly different from S1 or S3. The number of leaves in treatment S3 was significantly different from S0, but not significantly different from S1. The number of leaves in treatment S1 was significantly different from S0. The relationship between cow manure and the number of pak choy leaves is shown in Figure 2.

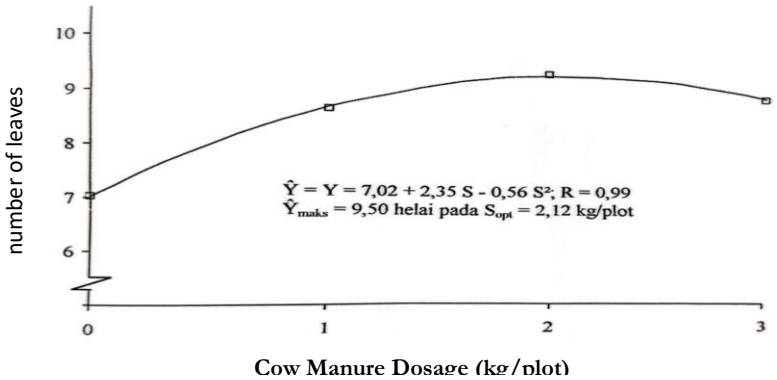

Figure 2. The Effect of Cow Manure Dose on the Number of Leaves of 4-Week-Old Pakcoy Plants.

Figure 2 shows that applying a dose of 1 kg of manure per plot produces a maximum leaf count of 9.50. Applying cow manure above 2.12 kg per plot can suppress plant leaf growth. Table 2 also shows that the treatment of liquid

organic fertilizer concentration had no significant effect on the number of leaves of the pakacoy Plant.

Plant Weight per Plot (g)

The analysis of variance showed that the manure treatment had a significant effect on plant weight per plot, whereas the liquid organic fertilizer concentration treatment and the interaction between the two treatments did not.

Table 3 shows the average plant weight per plot due to the influence of cow manure and different concentrations of liquid organic fertilizer.

Table 3. Average Plant Weight per Plot (g) due to the Effect of Different Cow Manure and Liquid Organic Fertilizers.

Treatment	Plant Weight per Plot (g)
S0	377.11a
S1	1229.00b
S2	1345.89b
S3	1256.00b
K1	1040.25
K2	1037.00
K3	1078.75
S0K1	372.67
S0K2	327.00
S0K3	431.67
S1K1	1261.00
S1K2	1241.33
S1K3	1184.67
S2K1	1338.67
S2K2	1385.00
S2K3	1314.00
S3K1	1188.67
S3K2	1194.67
S3K3	1384.67

Information: The numbers that are followed by the same letter in the same column mean no significant difference in the DMRT test at a test level of 5%

Table 3 shows that the heaviest plant weight was in treatment S2, which was significantly different from S0, but not significantly different from S1 and S3. Plant weight per plot in treatment S3 was significantly different from S0, but not significantly different from S1. Plant weight per plot in treatment S1 was significantly different from S0. The relationship between cow manure and plant weight is shown in Figure 3.

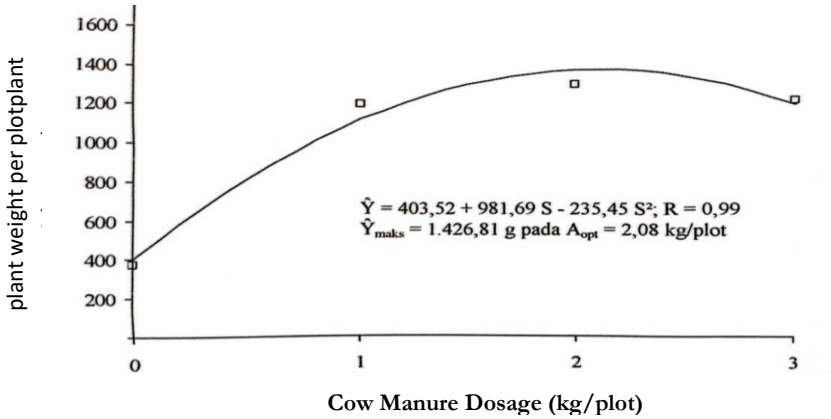

Figure 3. Effect of Cow Manure Dose on Plant Weight per Plot

Figure 3 shows that applying a dose of 2.08 kg of cow manure per plot resulted in a maximum plant weight per plot of 1,426.81 g. Applying cow manure above the dose of 2.08 kg per plot can reduce plant weight per plot. Table 3 also shows that the organic fertilizer concentration treatment did not have a significant effect on plant weight per plot.

DISCUSSION

The analysis of variance showed that the cow manure treatment had a significant effect on plant height, number of leaves, plant weight per sample, plant weight per plot, and net plant weight per plot. The results of this study indicate that applying 2.12 kg of cow manure per plot resulted in the highest plant height. Application of cow manure can increase plant height. This is because applying cow manure can improve soil physical and chemical properties. Cow manure can make the soil moister and crumblier, promoting better root growth in plants. Increased root growth will increase nutrient and water absorption, especially nitrogen, which is very important for plant growth. Rohman and Kurniawan (2018) stated that applying manure can provide the nitrogen needed for the growth and development of bok choy plants. Thus, the height of bok choy plants treated with this treatment is better. This is because nitrogen plays a very important role in the growth of bok choy plants.

The results of this study indicate that the application of cow manure at a dose of 2.12 kg/plot produces the maximum number of plant leaves. The application of cow manure effectively increases growth. This is because the manure has a complete nutrient content to meet plant needs. Cow manure contains macronutrients such as nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), and sulfur (S), so it can meet the nutrient needs of pak choy plants. The application of cow manure at an increasing dose results in an increasing number of leaves. This is because cow manure contains high nitrogen to meet Plant nutritional needs and has a low C/N ratio, so nitrogen is easily absorbed by plants. Plant growth requires an adequate and balanced supply of nitrogen and other nutrients; in addition, the available nutrients must be appropriate for plant absorption(Barokah et al., 2017).

The nitrogen contained in cow manure can be absorbed by plants and used to supply the nitrogen requirements of bok choy plants. The number of plant leaves is closely related to the process of photosynthesis, as leaves are the

plant organs where photosynthesis occurs. A greater number of leaves can increase the optimal absorption of sunlight, which is useful for photosynthesis. Thus, assimilates from photosynthesis can optimally accumulate in growth organs such as roots, stems, and leaves, reflecting the formation of plant biomass. This indicates that the rate of plant photosynthesis is determined by the number of leaves on the Plant: the more leaves, the more optimal sunlight absorption, which increases photosynthesis in bok choy plants. The presence of nutrients in the soil can provide sufficient nutrients for absorption by bok choy plant roots, which are then translocated to the leaves to support photosynthesis and promote plant growth. According to (Yulina & Ambarsari, 2022), high solar radiation increases transpiration, thereby enhancing water and nutrient absorption. This can reduce xylem concentration and affect root absorption of water and nutrients, so that the assimilates produced by photosynthesis are also lost through transpiration. The provision of cow manure will further increase the supply of nutrients to plants, so that the photosynthates produced are also increasingly used in the formation of plant leaves.

The results of this study indicate that applying 2.08 kg of cow manure per plot yielded the highest plant weight. This indicates that applying cow manure at a rate of 2.08 kg/plot can provide better nutrient content than other manures. Adequate nitrogen can increase the number of leaves and the rate of plant photosynthesis, enabling leaves to produce more photosynthate and energy for growth and production (Sari, 2020). Application of manure at a rate above 2.08 kg/plot can reduce plant weight per plot. This is because excessive manure can make the soil too moist, making bok choy roots susceptible to fungal diseases. Disruption of plant roots reduces nutrient and water absorption. Disruption of nutrient and water supply will reduce plant weight per plot.

The analysis of variance test showed that the concentration of liquid organic fertilizer had no significant effect on plant height, leaf number, plant weight per plot. This is because the concentration of liquid organic fertilizer (rabbit urine) is low, so it does not affect the growth and production of bok choy.

The analysis of variance showed that the interaction between cow manure and liquid organic fertilizer concentration had no significant effect on any of the observed parameters. This is because cow manure is a slow-release fertilizer; at the beginning of growth, its main function is to improve soil physical properties, making it looser and allowing plant roots to grow more easily. The improved plant root growth due to the application of cow manure was not supported by an increase in nutrient supply from the application of liquid organic fertilizer from rabbit urine skin. The insignificant effect of the liquid organic fertilizer treatment can render the interaction between the two treatments insignificant, because plant growth is influenced by only one treatment factor.

In this section, the author needs to explain the hardware and software used, dataset sources, initial data analysis, results, and results analysis/discussion. Presenting the results with pictures, graphs and tables is highly recommended. Formulas or evaluation measuring tools also need to be included here. There must be discussion/analysis, and you can't just rewrite the results in sentence form, but you need to provide an explanation of their relationship to the initial hypothesis. In addition, this section needs to discuss and elaborate on important findings.

CONCLUSIONS AND RECOMMENDATIONS

Cow manure up to a dose of 2 kg/plot (equivalent to 20 tons/ha) significantly increased plant height, number of leaves, and plant weight per plot. Application of liquid organic fertilizer made from rabbit urine up to 60 ml/l of water (equivalent to 0.6 l/ha) had no significant effect on plant height, number of leaves, and plant weight per plot. The interaction between cow manure and liquid organic fertilizer made from rabbit urine had no significant effect on plant height, number of leaves, and plant weight per plot.

Suggestion: Good growth and production of pak choy mustard can be obtained by using 2 kg/plot of cow manure (equivalent to 20 tons/ha), and further research is needed using a higher concentration of liquid organic fertilizer from rabbit urine, so that the optimum concentration is obtained to increase the growth and production of pak choy plants.

ACKNOWLEDGMENTS

The authors sincerely thank Universitas Methodist Indonesia for her guidance, support, and encouragement throughout the research process. Her advice, constructive feedback, and assistance in facilitating administrative matters significantly contributed to the successful completion of this study.

REFERENCES

Amini, Z., Dwirayani, D., & Eviyati, R. (2021). Pemanfaatan Pupuk Organik Takakura Terhadap Pertumbuhan Tanaman Pakcoy. *Agrosintesa Jurnal Ilmu Budidaya Pertanian*, *3*(2), 63–70.

Astiti, N. M. A. G. R., Laksmi, A. A. R. S., & Eryani, G. A. P. (2022). Bali Cow Dung Management in Ayunan Village, Abiansemal Sub-District of Badung. *AJARCDE (Asian Journal of Applied Research for Community Development and Empowerment)*, *6*(3), 92–95.

Azeez, M. O., Oladipupo, F. A., Olatoberu, F. T., Farinde, A. J., & Oladepo, W. O. (2025). Liquid organic fertilizers from rabbit wastes under different feeding regimes improve soil properties, growth, yield and nutrient uptake in maize. *Bulgarian Journal of Soil Science, Agrochemistry and Ecology*, *59*(2), 3–16.

Barokah, R., Sumarsono, S., & Darmawati, A. (2017). *Respon pertumbuhan dan produksi tanaman sawi Pakcoy (Brassica chinensis L.) akibat pemberian berbagai jenis pupuk kandang*. Fakultas Peternakan Dan Pertanian Undip.

Bhatla, S. C., & Kathpalia, R. (2023). Essential and functional mineral elements. In *Plant physiology, development and metabolism* (pp. 25–49). Springer.

Bi, H., Xu, J., Li, K., Li, K., Cao, H., & Zhao, C. (2024). Effects of biochar-coated nitrogen fertilizer on the yield and quality of bok choy and on soil nutrients. *Sustainability*, *16*(4), 1659.

Ernanda, M. Y. (2017). *Respon pertumbuhan dan produksi tanaman pakcoy (Brassica rapa L.) terhadap pemberian pupuk organik kandang ayam dan pupuk organik cair (POC) urin sapi*.

Ishfaq, M., Wang, Y., Xu, J., Hassan, M. U., Yuan, H., Liu, L., He, B., Ejaz, I., White, P. J., & Cakmak, I. (2023). Improvement of nutritional quality of food crops with fertilizer: a global meta-analysis. *Agronomy for Sustainable Development*, *43*(6), 74.

Kathpalia, R., & Bhatla, S. C. (2018). Plant mineral nutrition. In *Plant physiology, development and metabolism* (pp. 37–81). Springer.

Kumpanalaisatit, M., Setthapun, W., Sintuya, H., & Jansri, S. N. (2022). Efficiency Improvement of Ground-Mounted Solar Power Generation in Agrivoltaic System by Cultivation of Bok Choy (Brassica rapa subsp. chinensis L.) Under the Panels. *International Journal of Renewable Energy Development*, *11*(1).

Mohamad, N. S., Kassim, F. A., Usaizan, N., Hamidon, A., & Safari, Z. S. (2022). Effects of organic fertilizer on growth performance and postharvest quality of pak choy (Brassica rapa subsp. chinensis L.). *AgroTech-Food Science, Technology and Environment*, *1*(1), 43–50.

Mukhuba, M., Roopnarain, A., Adeleke, R., Moeletsi, M., & Makofane, R. (2018). Comparative assessment of bio-fertiliser quality of cow dung and anaerobic digestion effluent. *Cogent Food & Agriculture*, *4*(1), 1435019.

Nurawalia, L. (2022). *Pertumbuhan Dan Produksi Tanaman Pakcoy (Brassica rapa L.) Hidroponik Dengan Berbagai Sumber Nutrisi Dan Tanaman Refugia (Tagetes*

erecta L.). Universitas Medan Area.

Nurhasanah, S., Komariah, A., Hadi, R. A., & Indriana, K. R. (2021). Respon pertumbuhan dan hasil tanaman pakcoy (Brassica rapa L.) varietas flamingo akibat perlakuan macam media tanam dan konsentrasi pupuk pelengkap cair bayfolan. *Jurnal Inovasi Penelitian*, *2*(3), 949–954.

Ompusunggu, H. E. S., & Daeli, P. M. (2024). Aktivitas antioksidan dari sayur pakcoy (Brassica rapa subsp. chinensis) berbagai jenis tanam menggunakan metode DPPH. *Jurnal Ners*, *8*(1), 728–733.

Pyngrope, B., Singh, Y. K., & Prasad, V. M. (2023). Varietal Evaluation of Pak Choi (Brassica rapa subsp. Chinensis) under Agro-climatic Conditions of Prayagraj, India. *International Journal of Plant & Soil Science*, *35*(18), 592–598.

Rahmatika, W., & Andayani, R. D. (2024). Effectiveness rabbitt's manure liquid organic fertilizer dosage and time of aplication on purple sweet corn. *Agrovigor: Jurnal Agroekoteknologi*, *17*(1), 1–5.

Rahmatika, W., Soenyoto, E., Andayani, R. D., & Susilo, Y. (2022). Peran pupuk organik cair urin kelinci pada tanaman pakcoy (Brassica rapa L). *Buana Sains*, *22*(3), 59–64.

Ratriyanto, A., Widyawato, S. D., Suprayogi, W. P. S., Prastowo, S., & Widyas, N. (2019). Pembuatan Kompos Merupakan Cara Penyimpanan Bahan Organik Sebelum Digunakan Sebagai Pupuk. *Jurnal SEMAR*, *8*(1), 9–13.

Riansyah, K., Amelia, K. I., Dari, A. I., Puspiana, A. R., Negara, B. T., & Zain, M. I. (2022). Gerakan penanaman pakcoy dan sawi sebagai alternatif pemanfaatan pekarangan masyarakat Desa Surabaya Utara. *Jurnal Pengabdian Magister Pendidikan IPA*, *5*(2), 256–260.

Sari, E. K. (2020). Penetapan kadar klorofil dan karotenoid daun sawi (Brassica) menggunakan metode spektrofotometri UV-Vis. *Fullerene Journal of*

Chemistry, *5*(1), 49–52.

Sumiahadi, A., & Putri, T. A. (2025). Growth and Yield of White Bok Choy Plants (Brassica rapa subsp. chinensis) across Various Media Compositions in an Urban Environment. *Agricultural Revolution Journal*, *1*(2), 64–74.

Utara, B. P. S. S. (2021). *Produksi Tanaman Sayuran menurut Kabupaten/Kota dan Jenis Tanaman di Provinsi Sumatera Utara (Kwintal)*.

Verma, B. C., Pramanik, P., & Bhaduri, D. (2019). Organic fertilizers for sustainable soil and environmental management. In *Nutrient dynamics for sustainable crop production* (pp. 289–313). Springer.

Yulina, H., & Ambarsari, W. (2022). Pengaruh Pupuk Sampah Kota Dan Pupuk Kandang Sapi Terhadap Pertumbuhan Vegetatif Dan Hasil Panen Pakcoy (Brassica Rapa) Pada Aluvial Di Kabupaten Indramayu. *Jurnal Agro Wiralodra*, *5*(1), 6–14.

Zhou, Z., Zhang, S., Jiang, N., Xiu, W., Zhao, J., & Yang, D. (2022). Effects of organic fertilizer incorporation practices on crops yield, soil quality, and soil fauna feeding activity in the wheat-maize rotation system. *Frontiers in Environmental Science*, *10*, 1058071.