

The Effect of Concentration of Tofu Liquid Waste POC on the Growth of Pakchoy Plants (*Brassica rapa* L.)

Syaifur Riza^{1*}, Umi Kulsum Nur Qomariah², Mazidatul Faizah³

^{1,2,3}Agroecotechnology, KH. A. Wahab Hasbullah University

*Email: 04syiaifurrz@gmail.com

ABSTRACT

The purpose of the reasearch to determine the effect of Organic fertilizer in liquid form (POC) from liquid waste from tofu on pakcoy plants. The study was conducted in September - December 2025 in an experimental garden located in Pandean Hamlet, Ngoro Village, Ngoro, Jombang. This study employed a quantitative approach with a Completely Randomized Design (CRD). This approach uses five treatments, namely P0 (Control Soil), P1 (Provision of 25% tofu liquid waste POC), P2 (Provision of 35% tofu liquid waste POC), P3 (Provision of 45% tofu liquid waste POC). Some parameters of pakcoy plants are plant height, number of leaves, root volume, growth rate, and plant fresh weight. The results of the study showed that from the results of ANOVA, plant height was known to be $F_{hit} (1.68) < F_{5\%} (2.86)$, number of leaves was known to be $F_{hit} (1.21) < F_{5\%} (2.86)$, root volume $(1.19) < F_{5\%} (2.86)$, fresh weight was known to be $F_{hit} F_{hit} (1.88) < F_{5\%} (2.86)$, growth rate was known to be $F_{hit} (1.60) < F_{5\%} (2.86)$ meaning that liquid organic fertilizer of Moringa leaves had no effect on these 4 parameters.

Keywords: *Liquid organic fertilizer, liquid tofu waste, pakcoy.*

INTRODUCTION

One of the most popular horticultural vegetable varieties in Indonesia, particularly in hilly regions, is pakcoy (*Brassica rapa* L.). Its harvest period is around 40 days after planting. This vegetable is rich in various nutrients such as calories, protein, fat, carbohydrates, fiber, as well as minerals like calcium (Ca), phosphorus (P), and iron (Fe). In addition, it also contains vitamins A, B, C, and E. The magnesium content in pakcoy can help reduce stress and support good sleep patterns. Furthermore, pakcoy has other benefits, such as relieving throat itchiness for cough sufferers, healing headaches, improving kidney function, acting as a blood purifier, and facilitating digestion thanks to its high fiber content (Rukmana and Yudirachman, 2016). Pakcoy plants contain many vitamins and minerals that are very much needed by the human body (Apriyanti and Rahimah, 2016)

Efforts to optimize the growth and productivity of pakcoy plants can be carried out by applying good and effective cultivation methods that support the maximum development of the plants. If the cultivation methods applied are not appropriate, this will cause the plants to lack nutrients and other essential elements, resulting in a decline in growth and harvest yield. According to Putri (2019), one of the important factors in cultivation that supports the survival success of plants is fertilization.

A common problem in fertilization is the low efficiency of nutrient absorption by plants. There are two types of fertilizers: organic and inorganic. The fertilization process is a way to provide nutrients needed by plants so they can grow and develop well. Organic fertilizers derived from plants or animals can improve the physical, chemical, and biological properties of the soil, Putri (2019). Organic fertilizer is fertilizer that

comes from dead plants, animal manure and/or animal parts (Nurwati et al., 2017) and can also come from other organic waste that has undergone a processing treatment. This fertilizer can be in solid or liquid form and can be enriched with minerals and beneficial microbes to increase nutrient content and organic matter in the soil, as well as improve the physical, chemical, and/or biological characteristics of the soil.

Liquid waste from tofu is one of the sources of organic matter that can be processed into liquid organic fertilizer, because it contains important nutrients such as nitrogen, phosphorus, and potassium that support plant physiology. According to Pratiwi et al. (2020), the nutrient content in tofu wastewater can increase nutrient availability in the soil if formulated through an appropriate fermentation process. In addition to reducing environmental pollution, the utilization of tofu wastewater also provides added value to the agricultural sector through improved soil fertility and fertilization efficiency (Rismalati et al., 2024). Nevertheless, the effectiveness of tofu wastewater POC on pakchoy growth still needs to be tested at various concentration levels.

METHOD

This research was conducted from April to June 2025 on the rooftop of Pandean hamlet, Ngoro village, Ngoro sub-district, Jombang district, East Java. The tools used include a shovel, mixer, measuring cup, knife or cutter, ruler, digital scale, stationery, bucket or gallon, and water spray bottle. The materials used were: Nauli F1 pakchoy seeds, 5L of tofu liquid waste, 500ml molasses, 500ml EM4, compost soil containing N (0.40%), P (0.10%), K (0.20), and polybags (15cm x 15cm). This study employed a single-factor Completely Randomized Design (CRD), namely the use of tofu liquid waste POC. The experiment used 4 treatments, namely (P0) Control or compost soil (without POC), (P1) Compost soil + 20% POC, (P2) Compost soil + 35% POC, (P3) Compost soil + 45% POC, each repeated 10 times. Observations were made at 7, 14, 21, 28, 35, and 42 days after planting (DAP), with parameters including plant height, number of leaves, and growth rate. Root volume and fresh weight observations were conducted at 42 DAP. Research data were analyzed using analysis of variance (ANOVA). If there were differences between treatments, further tests were conducted using the Least Significant Difference test at a 5% significance level.

RESULT AND DISCUSSION

Result

The Observation of pakchoy plants on the treatment of POC concentration from liquid tofu waste was carried out by measuring plant height, number of leaves, root volume, fresh weight, growth rate, and fresh weight with treatments conducted at 7, 14, 21, 28, 35, 42 days after planting once a week.



Figure 1 Image of plants per treatment

Source: Syaifur, 2026

Description: P0: (control), P1 (POC of 20% tofu wastewater), P2 (POC of 35% tofu wastewater), P3 (POC

of 45% tofu wastewater)

Plant Height

The outcomes of variance analysis and ANOVA tests show that the treatment of POC concentration in tofu wastewater on pakcoy plants had no significant effect on the height of pakcoy plants at 14, 21, and 35 days after planting (DAP), because the Fcount value was smaller than the Ftable 5% (2.8662) and had a significant effect at 7, 21, and 28 days after planting (Fcount > Ftable 5%). This indicates that the application of POC from tofu wastewater during the vegetative to generative phase of plant growth has the potential to promote plant growth, with treatments affecting plant height increase. The following are the results of the ANOVA table and BNT.

Table 1. Results of Further Testing of Plant Height Averages in Pakcoy Plants Given POC from Tofu Waste Liquid at 7 DAP, 21 DAP, and 28 DAP

Treatment	Plant height (dap)		
	7	21	28
P0 (Control)	5,01 cd	6,46 cd	7,71 cd
P1 (20%)	4,77 bc	6,04 bc	6,97 bc
P3 (35%)	3,77 a	4,96 a	6 a
P4 (45%)	4,23 ab	5,8 ab	6,95 ab
F count 5%	5,05	3,38	3,48
BNT 5%	0,7	1,34	1,76

Description: Based on the 5%, numbers with the same letters suggest no discernible change. LSD test ($p = 0.05$); dap = days after planting; ns = not significant.

Number of leaves

The outcomes of variance analysis and ANOVA tests show that the treatment of POC concentration in tofu wastewater on pakcoy plants did not significantly affect the number of pakcoy leaves at 7, 14, 21, 35, and 42 days after planting because the Fcount value was smaller than the Ftable 5% (2.8662). There was a significant effect on the number of pakcoy leaves at P0 at 28 HST, because the F-count value was above the F-table 5% (>2.8663). The 5% BNT follow-up test showed that treatment P0 (control) produced the highest average number of leaves, 5.9 leaves, indicating a significant difference at 28 HST in all treatments except P1. The following are the results of the ANOVA table and BNT.

Table 2. Results of Further Testing of Average Number of Leaves on Pakcoy Plants Given POC from Tofu Waste at 28 Days After Planting

Treatment	Number of leaves (dap)
	28
P0 (Control)	5,9 bcd
P1 (20%)	5,8 bc
P2 (35%)	4,666667 a
P3 (45%)	4,9 ab
Fcount 5%	2,95
BNT 5%	1,34

Description: Based on the 5%, numbers with the same letters suggest no discernible change. LSD test ($p = 0.05$); dap = days after planting; ns = not significant.

Root volume

The according to table 3 analytical results, the use of POC from tofu wastewater had no effect on the root volume of pakcoy plants, because the Fhit value was less than the F table value. Therefore, the results indicate that the application of POC from tofu wastewater had no significant effect on root volume. Treatment P0 produced the highest root volume of 1 ml compared to all other treatments, but treatment P1 did not differ significantly from treatment P2. The lowest root volume was found in treatment P3. This indicates that soybean waste liquid POC has not had a significant effect on root volume increase.

Table 3. Average root volume with liquid tofu waste POC application

Plant age (dap)	Root Volume				Average
	P0	P1(20%)	P2(35%)	P3(45%)	
42	1	0,9	0,95	0,7	0,8875

Wet weight

The according to table 4 analytical results, the use of POC from tofu wastewater to the root volume of pakcoy plants obtained an $F_{count} < F_{table}$, so the results indicate that the POC treatment from tofu wastewater did not have a significant effect on wet weight.

Table 4 Average wet weight when feeding liquid tofu waste POC.

Treatment	Average wet weight
P0 (control)	5,36
P1 (20%)	4,97
P2 (35%)	4,95
P3 (45%)	3,66
Fcount	1,88
Ftable	2,38
BNT	ns

Description: Based on the 5%, numbers with the same letters suggest no discernible change. LSD test ($p = 0.05$); dap = days after planting; ns = not significant

Growth rate

The according to table 5 analytical results, the use of POC from tofu wastewater had no effect on growth rate, because the calculated $F_{count} < F_{table}$. Therefore, the results indicate that the application of POC from tofu wastewater had no significant effect on growth rate. At the highest treatment level, P0, the average was 10.73, and at the lowest treatment level, P1, the average was 10.63, which was not significantly different.

Table 5. Average growth rate with liquid tofu waste POC application.

Treatment	Average growth rate
P0 (control)	10,73
P1 (20%)	10,63
P2 (35%)	9,86
P3 (45%)	9,04
Fcount	1,6
Ftable	2,86
BNT	ns

Description: Based on the 5%, numbers with the same letters suggest no discernible change. LSD test ($p = 0.05$); dap = days after planting; ns = not significant

Discussion

Plant Height

The application of POC from tofu wastewater had no significant effect on the height of pakcoy plants at 14 DAP, 35 DAP, and 42 DAP, and at 7 DAP, 21 DAP, and 28 DAP showed an increase in plant height during the early vegetative phase and the transition from the vegetative to the generative phase. This is consistent with Nugroho's study findings (2015), which states that plant length and leaf growth are interrelated because a plant that is higher will generate more leaves. Nitrogen is an essential element for growth and is required in large quantities.

The nutrient N plays a significant role in promoting stem and leaf growth in plants. The nutrient N also has a crucial contribution to enhancing the green color of plant leaves. If plants experience a deficiency of N, there will be problems in the formation of green leaf color or chlorophyll, which is essential for carrying out the process of photosynthesis. This is in accordance with Taiz et al., (2015) The main indicator of vegetative growth is closely related to cell division and elongation, especially in apical meristem tissue. The availability of nitrogen (N) nutrients has a significant impact on this process, osmotic balance, and photosynthetic efficiency.

The best research results show that the treatment of tofu liquid waste POC on plant height parameters had a significant effect on P0 (control) compared to other treatments at 42 days of age, but was not significantly different (in Table 4.1). This study is in line with Devi Puji Sutoyo Putri et al. (2025), where coffee seedling height could not be significantly increased by applying POC from tofu waste at all concentrations. This may be because soybean waste POC only contains small amounts of N and P (1.03% and 1.27%), so that the application of POC cannot respond to an increase in plant height. Physiologically, this indicates that compost soil media without the addition of POC from tofu liquid waste has provided more stable and suitable nutritional conditions for pakcoy growth. Conversely, the addition of POC at certain concentrations is thought to cause nutrient imbalance, thereby preventing optimal cell elongation.

Number of leaves

The results showed that the POC treatment of tofu wastewater did not sufficiently affect the growth of pakcoy leaves. However, at 7 days after planting (dap), P1 had a high average number of leaves. It is believed that nitrogen plays an important role in the vegetative growth and photosynthesis processes of plants. Therefore, if nitrogen levels are high, the quantity of a plant's leaves will increase, and plants with sufficient nitrogen will be able to form leaves with high chlorophyll content. Muntashilah et al., (2015). Organic fertilizers with very high concentrations or liquid organic fertilizers with very low concentrations can inhibit and affect plant development during the vegetative phase, as they do not meet the plants' needs. Walunguru et al. (2024) and Putri et al. (2025) also confirmed that the number of pak choi leaves is more influenced by nutritional balance than by high POC doses.

The abundant organic content in POC from tofu wastewater increases the activity of microorganisms in the soil. These microorganisms utilize the nitrogen in the soil for their metabolic processes, resulting in nitrogen fixation and causing plants to experience a deficiency in the nitrogen needed for leaf growth. Hesty Pratiwi et al. (2021) Although the application of tofu wastewater POC had no significant effect, P2 (35%) provided the best response during the growth and development of pakcoy during the vegetative period. At this level, the content provides the best reaction because it provides a balanced amount of major nutrients (N, P, K) that are suitable for the nutritional needs of pak choi during the vegetative phase, thereby supporting leaf growth.

Root volume

The outcomes revealed that the application of tofu effluent POC had no significant effect on root volume. Although the analysis showed no significant differences between treatments, treatment P0 (control) yielded the best results with the highest average root volume of all treatments (Table 3). It is suspected that the effect of organic matter added to the soil through liquid waste has not yet shown a significant impact on the physical properties of the soil. These results are in line with the research by Sutrisno et al. (2015), which reported that soybean curd wastewater can inhibit root growth when applied at high concentrations, as it contains fermentation compounds such as organic acids, alcohols, and free ammonia, which can be phytotoxic to young roots. These substances can damage the root cell layer, inhibit root meristem function, and reduce the root's ability to absorb water and nutrients.

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The results of Silawibawa et al. (2021) state that the root growth of leafy vegetables is greatly influenced by the balance between organic matter and soil aeration, so the accumulation of liquid organic matter in the growing medium can reduce soil porosity and inhibit oxygen diffusion to the root zone. Oxygen deficiency in the root area causes disruption in the root respiration process, thereby reducing the energy required for root cell division and growth. This results in suboptimal root growth, as seen in the POC treatment in this study.

In their research, Pranggana Aranda et al. (2023) found that applying POC from tofu wastewater to pak choi plants had no significant effect on root volume and even tended to reduce it at high concentrations. The researcher explained that the imbalance of nutrients and the presence of compounds that are toxic to plants in POC cause stress to plants, which hinders the work of root meristems. As a result, root branch formation and root size increase are inhibited, thereby reducing the plant's ability to absorb water and nutrients.

Wet weight

The outcomes revealed that the application of tofu effluent POC had no significant effect on wet weight. Treatment P0 (control) yielded the best results with the highest average wet weight, but there was no significant difference between treatments P1 and P2 (Table 4). The results are in line with Rosmiah et al. (2022), which showed that the highest wet weight of green mustard plants was obtained in the control treatment compared to the treatment with POC from tofu liquid waste. The researcher explained that the imbalance of nutrients and the presence of compounds that are toxic to plants in POC cause stress to plants, which hinders water absorption. As a result, root branch formation and root size increase are inhibited, thereby reducing the plant's ability to absorb water and nutrients.

The wet weight results for treatments P1 (20%) and P2 (35%) showed no significant difference, indicating that there was no photosynthetic rate. Sarwono (2018) states that excess N will cause a decline in crop quality and delayed crop maturity (excessive vegetative growth). In addition, problems in absorbing water due to the small number of roots cause the water content in the plant tissue to decrease, resulting in low wet weight. Research by Pranggana Aranda et al. (2023) also states that the application of liquid POC from tofu waste to pakcoy plants did not result in a significant increase in wet weight; in fact, wet weight tended to decrease at high concentrations. The researcher stated that nutritional imbalance and increased osmotic pressure in soil solutions due to high POC concentrations cause plants to experience physiological stress.

Studies conducted by Syamsuwirman et al. (2023) claims that using liquid tofu waste POC has no significant effect on the wet weight of pak choi plants. Based on the researcher's explanation, the wet weight of plants is greatly influenced by the balance between photosynthesis and respiration. In conditions of nutritional imbalance, photosynthesis does not develop properly, while respiration continues, resulting in low net biomass in plants. According to plant growth theory, wet weight is heavily impacted by the balance between the availability of nutrients and water in plant tissues. Adequate and balanced nutrients increase the accumulation of fresh biomass (Alqaramah et al., 2025).

Growth rate

The availability of nutrients in the soil is one of the elements influencing the development and development of these plants (Teresia Buulolo et al., 2022). One nutrient that affects plant growth is nitrogen. Sufficient nitrogen availability can affect plant height. Nitrogen plays an important role in overall plant development, but the requirements of each plant vary. Treatment P1 (25%) showed significantly different average results from P3 (45%). This was because the nutrients derived from the planting medium and from fertilization with 25% concentrated tofu liquid waste were able to meet the availability and absorption of nutrients by the plants and were used for plant growth rate, Ahmad Al Amin, et al. (2017).

Pratiwi et al. (2020) explain that high soil microorganism activity due to POC organic matter causes nitrogen competition between plants and microorganisms. Nitrogen deficiency in plants inhibits chlorophyll formation, thereby reducing the rate of photosynthesis. When photosynthesis temporarily decreases, respiration continues. This results in a low net growth rate for plants. This situation is related to the results of this study, in which the growth rate of plants treated with POC was lower than that of the control group. This indicates that the amount of organic matter and substances produced from fermentation in tofu wastewater can cause physiological stress on plants. This stress causes more energy from photosynthesis to be used to maintain important physiological functions and cellular detoxification processes, thereby reducing the energy that should be allocated for plant growth. This mechanism explains the low growth rate in treatments P1, P2, and P3 compared to P0 (control). Plant growth is closely related to the presence of nitrogen, because nitrogen



has a major impact on the growth and development of plants. Harati et al. (2019) stated that when plants are given sufficient nitrogen, the need for other nutrients such as phosphorus increases to compensate for the

CONCLUSION

Based on the results of research on the effect of the concentration of Liquid Organic Fertilizer (POC) from tofu liquid waste on the growth of pakcoy plants (*Brassica rapa* L.), it can be concluded that:

1. The application of POC at various concentrations (20%, 35%, and 45%) had a significant effect on:
 - a) Plant height at 7 DAP, 21 DAP, and 28 DAP with treatment application of P (control), P1 (20%), and P3 (35%) at 7 DAP, 21 DAP, and 28 DAP.
 - b) Number of leaves at 28 days after planting with treatment P (control), P1 (20%), P3 (35%) 7 days, 21 days, and 28 days following planting.
2. There is no most effective concentration of soybean waste liquid POC in enhancing pakcoy plant growth. Statistically, all POC concentration treatments (20%, 35%, and 45%) did not differ significantly from the control treatment (P0). Even descriptively, the control treatment without POC tended to show the highest average values for most growth parameters.

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