



Effectiveness of Liquid Organic Fertilizer (LOF) from Banana Kepok Peels and Fronds on the Growth and Yield of Pakcoy (*Brassica rapa*)

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Received: July 7th 2025 Revised: August 3rd 2025 Accepted: October 15th 2025

Abstract

Pakcoy (*Brassica rapa*) is one type of vegetables that belongs to the mustard group and is widely consumed by the community. Pakcoy production in 2023 was 686,876 tons. Efforts to increase the amount of pakcoy production can be done with proper fertilization techniques using fertilizers. The use of organic fertilizers is the right solution in overcoming these problems. Organic waste around the community, such as banana kepok peels and fronds can be used as organic fertilizer. The purpose of this research is to obtain information about the effectiveness of Liquid Organic Fertilizer (LOF) of banana kepok peel and fronds on pakcoy growth. This study used an experimental method with a Randomized Group Design (RGD) consisting of 5 LOF treatments and each treatment consisted of 4 replicates, so that the total number of 20 experimental units. The LOF concentrations given are A1 (0%), A2 (10%), A3 (25%), A4 (50%) and A5 (75%). The growth parameters observed were plant height, number of leaves, leaf width and wet weight. The results of data analysis using the ANOVA test showed a significant effect on all treatments. This was followed by a Duncan test to determine which treatments had significantly different averages. It was concluded that the use of LOF with treatment concentration A2 (10%), effectively increased the growth and yield of pakcoy. Thus, it is suitable to be recommended as an alternative fertilizer for pakcoy cultivation.

Keywords: banana leaf; banana peel; LOF; organic waste; pakcoy

INTRODUCTION

Brassica rapa or pakcoy is a variety of vegetable that is part of the mustard family. This vegetable is regularly eaten by the community as an essential part of their diet. Pakcoy is in great demand by the public because it contains vitamin A, which is beneficial for eye health, and it also contains vitamin K, which functions in blood clotting, as well as vitamin E, which acts as an antioxidant (Fitriani *et al.*, 2019; Putri *et al.*, 2022). Based on data from the Badan Pusat Statistik (2024), the production of pakcoy plants in Indonesia in 2023 was 686,876 tons, with West Java province contributing 155,108 tons. It shows that pakcoy plants are still in great demand and are produced to meet the needs of the community. Efforts to increase pakcoy production also need to be supported by various efforts, one of which is by proper fertilizer. So far, farmers still depend on the use of chemical or inorganic fertilizers in plant cultivation. This is because chemical fertilizers are easier to obtain in the market, but the price is relatively more expensive and not environmentally friendly (Kandpal, 2021; Aulady *et al.*, 2024). The continuous use of Liquid Organic Fertilizer (LOF) over a long period of time can also result in nutrient imbalances, soil damage, and loss of microorganisms in the soil (Taher & Murnita, 2021; Chen *et al.*, 2023). As such, this will lead to environmental degradation (pollution) of agricultural land (Kandpal, 2021; Yaser *et al.*, 2023).

Organic fertilizers are regarded as more friendly to the environment and human beings (Dewi & Afrida, 2022) and can be solid or liquid with basic ingredients derived from waste (Munarti, *et al.*, 2025; Qonitah, *et al.*, 2025). Organic fertilizer is generally used in liquid form because their nutrients are more easily absorbed by plants. LOF have the advantage of increasing soil fertility, increasing the productivity of agricultural land in the long run, and can conserve natural resources and the environment (Ji *et al.*, 2017; Mulyanti *et al.*, 2022). In the production of organic fertilizers, mostly plant wastes are used as sources. One of the plant wastes that can be used as LOF material is banana kepok peels and fronds (Lamasrin & Lumingkewas, 2020; Inge *et al.*, 2023). Most bananas are cultivated only for their fruit. The underutilization of banana waste can be processed into organic fertilizer (Putri & Putri, 2023; Sitompul *et al.*, 2023). Banana kepok peel waste can be used as fertilizer because banana peels contain a lot of protein and phosphorus, and contain micronutrients such as Ca, Mg, N, Na and Zn (Riyanti, 2024; Khairunnisa & Hardiansyah, 2025).

The use of banana kepok peel and frond waste as raw material for LOF has shown promising results in various studies. The decomposition of these organic materials produces essential macro and micronutrients such as nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), and magnesium (Mg), which are crucial for plant development (Riyanti, 2024; Khairunnisa & Hardiansyah, 2025). In addition, fermentation with the help of Effective Microorganisms 4 (EM4) accelerates the breakdown of complex organic compounds, thereby increasing nutrient solubility and microbial activity in the soil, and these factors contribute to better nutrient uptake by plants, improved root growth, and enhanced leaf chlorophyll levels all of which are important for the rapid vegetative phase of pakcoy (Mulyanti *et al.*, 2022; Inge *et al.*, 2023). Compared to chemical fertilizers, banana waste based LOF is more affordable and safer for long term use, especially for smallholder farmers (Dewi & Afrida, 2022; Munarti *et al.*, 2025). Moreover, the use of banana waste helps address issues of agricultural and household organic waste management, contributing to a more sustainable farming system and supporting the goals of a circular economy (Sitompul *et al.*, 2023).

Beyond its nutrient content, the long term application of banana based LOF also contributes significantly to improving overall soil health and fertility. Organic fertilizers enhance soil structure, increase microbial biomass, and improve the cation exchange capacity of soils, all of which are essential for sustainable crop productivity (Aulady *et al.*, 2024; Mulatu & Bayata, 2024). Unlike synthetic fertilizers that may cause nutrient leaching and soil compaction over time, organic inputs foster a biologically active rhizosphere that supports beneficial soil organisms such as mycorrhizae and nitrogen fixing bacteria (Taher & Murnita, 2021; Mulyanti *et al.*, 2022; Yaser *et al.*, 2023). For pakcoy, which has a relatively short life cycle, the consistent supply of bioavailable nutrients from organic sources ensures optimal growth and better crop quality in terms of freshness, taste, and nutritional content, and studies also show that organic produce is increasingly preferred by consumers due to concerns over food safety and environmental sustainability (Dewi & Afrida, 2022; Putri *et al.*, 2022). Therefore, integrating banana waste based LOF into pakcoy cultivation is not only a viable strategy for enhancing agricultural productivity, but also a proactive response to the global call for greener and safer food systems.

Banana kepok peel waste can be used as a basic material for making organic fertilizer. The content of nutrients contained in banana fronds such as nitrogen, phosphorus, and potassium serves to stimulate the growth of young plant roots and stems, harden plant stems, and contain chemical content in the form of carbohydrates that can spur the growth of microorganisms in the soil. The local microorganisms (MOL) found in banana fronds include *Bacillus* sp., *Aeromonas* sp., *Azospirillum* sp., *Azotobacter* sp., *Aspergillus niger* and cellulolytic microbes. The microbe can help the growth of vegetable plants (Soniari *et al.*, 2016; Khanyile *et al.*, 2024). Based on these various descriptions, it is necessary to conduct research to test the effectiveness of LOF banana kepok peel and fronds on the growth of pakcoy (*Brassica rapa*). The purpose of this research is to obtain information about the effectiveness of LOF of banana kepok peel and fronds on pakcoy growth.

METHOD

The method used is Randomized Group Design (RGD). RGD was used due to the heterogeneity of environmental conditions in this study (Hanafiah, 2010; Syilfi & Rahmat, 2024). Planning is carried out by grouping experiments into similar groups. Treatments are then randomly assigned to each group. This design was selected to minimize the influence of environmental variability and to ensure that treatment effects could be more accurately compared. Analysis of variance is performed by testing hypotheses against observed variables (Hudori, 2019). The object of this research is the pakcoy plant. The research was conducted from May to July 2024 at Ciomas, Bogor, West Java. The research design consisted of 5 treatments namely A1 (0%) as control, A2 (10% LOF), A3 (25% LOF), A4 (50% LOF) and A5 (75% LOF). Each treatment consisted of 4 replicates, so there were a total of 20 experimental units. The tools and materials used included drums, clear plastic, polybags measuring 25 x 25 cm, knives, cutting boards, gloves, scales, bottles, small shovels, rulers, staplers, label paper, spray bottles, stationery, cell phone cameras, pakcoy seeds, planting media, banana kepok peel, banana kepok fronds, brown sugar, water, EM-4, soil tester, and pH indicator.

The research procedure began with the preparation of LOF banana kepok peels and fronds by collecting waste from the garden and fried banana sellers. The combination of two ingredients, namely banana kepok peel and fronds in making LOF aims to increase the balance and completeness of nutrient content and speed up the composting process (Chan *et al.*, 2024). In making fertilizer, 100% concentration was obtained from weighing 1 kg of banana peel and 1 kg of banana fronds in small pieces, then added 10 L of water, 500 g of brown sugar and 400 mL of EM-4. Fermentation was carried out for 14 days in a closed drum and diluted as much as needed. The next stage is seeding pakcoy seeds for 14 days and transferring them into 25 x 25 cm polybags that have contained planting media. After that, the media is watered first with water to the field capacity so that it is moist. Planting was done by placing the seedlings into the center of the polybag with one seedling per polybag. LOF application starts from the age of 7 Days After Planting (DAP). LOF treatment was given once a week for up to 4 weeks. Maintenance of pakcoy plants is done by watering once a day by getting enough sunlight. If there are weeds around the plants such as wild plants that grow, it must be handled immediately by pulling them out.

Observations were made weekly for 4 weeks (28 DAP) with parameters of plant height, number of leaves, leaf width, and wet weight. Plant height measurements were taken after LOF treatment. Plant height was measured from the base of the stem to the tip of the plant growth point. To ensure data consistency, all measurements were conducted at the same time of day and by the same observer throughout the experiment. Leaf count is counted starting from the young leaves that have opened completely to the oldest leaves. Leaf width was measured using a ruler from the widest part of the leaf (from left to right side or vice versa). Wet weight was weighed at harvest using a weighing scale. In addition, soil temperature, soil acidity (pH) and soil moisture were measured using a soil tester. Fertilizer acidity level was also measured using pH indicator. Statistical analysis was carried out by means of prerequisite tests first, namely the Kolmogorov-Smirnov normality test and Levene homogeneity then followed by ANOVA to see the significant differences, then continued with the Duncan post hoc test. Statistical analysis was conducted using SPSS version 31.

RESULT AND DISCUSSION

From the research activities that have been carried out, the results of all data that have been collected during research in the field are obtained. Data collection in the form of measurements of plant height and number of leaves began when the plants were treated or aged 14 DAP. Then, data collection in the form of leaf width and wet weight of plants is carried out during the harvest period. These data are then analyzed to determine the growth patterns and productivity of the plants under different treatment conditions. The findings are expected to provide insight into the effectiveness of each treatment. Further discussion of the results is presented in the following sections. The data obtained are presented in Table 1.

Table 1. Average values of Duncan Multiple Range Test (DMRT) for plant height, leaf count, leaf width, and wet weight of all pakcoy plants

Treatment (%)	Parameters			
	Plant Height	Leaf Count	Leaf Width	Wet Weight
A1 0	12.05	5.31	6.25	9.10
A2 10	13.26	6.18	7.15	10.77
A3 25	12.86	5.75	6.95	9.70
A4 50	11.85	4.43	5.9	8.30
A5 75	11.71	4.12	5.15	7.80

Based on Table 1, it can be seen that the average growth of pakcoy plants has the highest value in the A2 treatment (10%). While the lowest value is in the A5 treatment (75%). Furthermore, the normality test and homogeneity test were also carried out on the data that had been obtained. The data is normally distributed and homogeneous, so it proceed with the ANOVA test. The following ANOVA test results are presented in the Table 2.

Table 2. ANOVA Test results of plant height data, number of leaves, leaf width, and wet weight in all pakcoy plants

Parameters	DF Treatment	DF Galat	F table	F count	Sig.
Plant Height	7.346*	8.521*	3.06	3.233	0.042
Leaf Count	10.156*	11.844*	3.06	3.216	0.043
Leaf Width	10.252*	8.850*	3.06	4.344	0.016
Wet Weigth	21.958*	10.707*	3.06	7.690	0.001

Notes: (*) significantly different treatments at 5% of the level of significance; (tn) not significantly different.

Table 2 shows the results of the ANOVA test that the treatment given in the form of LOF of banana peel and fronds has an effect on pakcoy plants. This can also be seen from the results of the calculated F value which is greater than the F table ($F_{count} > F_{table}$) and the significance value which is smaller than 0,05 (Sig. < 0.05). Based on the ANOVA test results, it can be concluded that the provision of different LOF treatments of banana peels and fronds has an effect or significantly different on the growth of plant height, number of leaves, leaf width, and wet weight of pakcoy plants. To knowing which treatment is the most influential, DMRT test is conducted.

Table 3. DMRT Test Results of Average Values of Plant Height, Leaf Count, Leaf Width, and Wet Weight in All Pakcoy Plants

Treatment	Parameters			
	Plant Height	Leaf Count	Plant Height	Wet Weight
A1 0%	12.05 ^b	5.31 ^{a,b}	6.25 ^{a,b,c}	9.10 ^{a,b}
A2 10%	13.26 ^a	6.18 ^b	7.15 ^a	10.77 ^{b,c}
A3 25%	12.86 ^{a,b}	5.75 ^b	6.95 ^{a,b}	9.70 ^{b,c}
A4 50%	11.85 ^b	4.43 ^{a,b}	5.9 ^{b,c}	8.30 ^a
A5 75%	11.71 ^b	4.12 ^a	5.15 ^c	7.80 ^a

Note: the numbers followed by the same letter in the same column are not significant different in the DMRT test at the 5% level.

Table 3 shows that in the parameter of plant height, the A2 (10%) treatment is not significantly different from the A3 (25%) treatment, but significantly different from the A1 (0%), A4 (50%), and A5 (75%) treatments. For the leaf count parameter, the A5 (75%) treatment was not significantly different from the A4 (50%) and A1 (0%) treatments, but significantly different from the A3 (25%) and A2 (10%) treatments. Leaf width parameters in the A2 (10%) treatment were not significantly different from the A3 (25%) and A1 (0%) treatments, but significantly different from the A4 (50%) and A5 (75%) treatments. Measurement of wet weight in the A5 (75%) treatment was not significantly different from the A4 (50%)

and A1 (0%) treatments, but significantly different from the A3 (25%) and A2 (10%) treatments.

LOF is a liquid substance used as a fertilizer for plants derived from organic materials. The organic materials used in this study are peel waste and kepok banana fronds. These two organic materials are combined into a LOF that is expected to increase growth in pakcoy plants (Hamidah *et al.*, 2023; Rukmana *et al.*, 2024). This is evidenced by the results of the study which showed an effect on the parameters of plant height, leaf count, leaf width, and wet weight. The ANOVA test analysis that has been carried out, the provision of different LOF concentrations in each treatment has a significant effect on plant height, leaf count, leaf width, and wet weight of pakcoy plants. Followed by the DMRT test which states that the A2 treatment (10%) has the highest effectiveness in the parameters of plant height, leaf count, leaf width, and wet weight. While the A5 treatment (75%) has the lowest effectiveness compared to other treatments. These findings align with the notion that optimal LOF concentrations derived from fruit peel wastes can stimulate vegetative growth better than high concentrations, which may exceed the optimal nutrient or microbial balance (Luthfiyah *et al.*, 2024; Winata *et al.*, 2025).

The A2 treatment (10%) showed the highest average value for all parameters (plant height, number of leaves, leaf width and wet weight) compared to other treatments. This is because the LOF dissolves perfectly. Thus, allowing pakcoy plants to get an optimal supply of nutrients or fulfillment of mineral needs. Like the research conducted by Sari *et al.*, (2020) banana peel LOF with a concentration of 15% gives the best effect on the growth of strawberry plant leaves. Giving the correct dose of fertilizer can increase plant height, number of leaves, and fresh weight of pakcoy plants (Anugrah & Prastamay, 2022; Song *et al.*, 2022). Providing fertilizer with excessive doses or in high amounts will cause poisoning of plants and the results obtained are not optimal (Nuryani *et al.*, 2019; Kadir *et al.*, 2025). Therefore, determining the appropriate concentration of LOF is crucial to achieve optimal growth and yield of pakcoy plants.

The application of LOF banana kepok peels and fronds also has an important role in the photosynthesis process. Banana peels contain macro nutrients such as nitrogen, phosphorus, potassium, calcium, magnesium, iron and manganese. Each of these elements serves to support the growth and development of plants which also has an impact on increasing plant productivity. Meanwhile, banana fronds contain sulfur elements that stabilize nitrogen and help the chlorophyll synthesis process. The combination of these two ingredients makes LOF banana peel and banana leaf is rich in mineral nutrients. The nutrient content possessed by organic fertilizers is considered quite complete and has the potential to reduce the use of inorganic fertilizers by up to 50% (Lamasrin & Lumingkewas, 2020; Aulady *et al.*, 2024). From the observation of the pH parameter, the quality of LOF that has been made has a final pH of 6 (Mustikasari & Asngad, 2023; Abidin *et al.*, 2025). Therefore, the use of banana peel and banana frond based LOF can both supply a broad spectrum of nutrients and support physiological processes like photosynthesis, making it an effective partial substitute for conventional inorganic fertilizers.

Treatment A1 (0%) or as a control has better growth compared to A5 (75%). High doses can damage plants and soil, but a dose of 0% means that plants lack nutrients so that growth is not optimal (Triadiawarman & Rudi, 2019; Wang *et al.*, 2024). This allows for a high nutrient content in the planting media used. Soil fertility is a very important factor in the availability of mineral nutrients to support plant growth (Minardi *et al.*, 2023; Prihantoro *et al.*, 2023). Another factor that influences the A5 (75%) treatment is that the high concentration of fertilizer causes the accumulation of nutrients in the soil and disrupts the vegetative growth of pakcoy plants. According to Nuryani *et al.*, (2019) and Dauda *et al.* (2025) the application of high doses of fertilizer will cause plants to become poisoned and inhibit the process of growth and development in a plant.

Growth and development in a plant is also influenced by abiotic factors such as temperature, pH, humidity, and others. From the observations, it was found that the average ambient temperature ranged from 23 °C – 25 °C. The optimum temperature for pakcoy plants ranges from 15 °C – 30 °C (Harsela *et al.*, 2020; Suciarto & Abbas, 2021). If the temperature during the day in the green house reaches 40 °C, it will cause pakcoy plants to wilt due to the process of evapotranspiration or evaporation of water due to high temperatures. Temperature measurements obtained during the study mean that environmental conditions with optimum temperature can be a success factor in the growth of pakcoy plants. In addition,

soil pH measurements were also taken to determine the level of acidity in the planting media used. The pH levels in all treatments were optimal for pakcoy growth, namely 7. The role and influence of using LOF on environmental and soil conditions is to increase the soil's ability to retain water and reducing the risk of drought in plants. Humidity at the time of the research was also said to be appropriate or optimal for pakcoy plant growth, namely 80%. The optimal soil pH and good for plant survival ranges from 6 - 7. Meanwhile, the optimal humidity for pakcoy plant growth ranges from 80% - 90% (Putri *et al.*, 2022; Reska *et al.*, 2023; Mulatu & Bayata, 2024).

Overall, the results of this study demonstrate that the growth performance and physiological responses of pakcoy are strongly governed by the interaction between nutrient composition, fertilizer dosage, and environmental parameters. The integration of banana peel and frond based LOF provides a balanced and sustainable nutrient source that enhances photosynthetic activity and root function while improving soil physicochemical properties. The proper adjustment of fertilizer concentration ensures efficient nutrient uptake and prevents the occurrence of toxicity or nutrient accumulation that may hinder plant metabolism. In parallel, favorable abiotic factors such as temperature, soil pH, and humidity create an optimal environment for nutrient absorption and enzymatic activities that support vegetative and generative growth. This synergy between organic nutrient management and controlled environmental conditions highlights the potential of LOF as an eco-friendly alternative to inorganic fertilizers. Moreover, it reflects the importance of integrated cultivation systems that not only improve crop productivity but also maintain long term soil fertility and environmental sustainability. Collectively, these findings emphasize that a balanced approach combining organic nutrient application and environmental optimization is essential to achieving sustainable and resilient vegetable production systems.

CONCLUSION

Based on the research results, the application of LOF from waste banana peel and stem significantly affected the growth of bok choy plants, indicated by the parameters of plant height, number of leaves, leaf width, and fresh weight. The analysis results showed that treatment A2 (10%) provided the best results in all growth parameters because the fertilizer solution was optimally absorbed so that it was able to meet the plant's nutritional needs. Conversely, treatment A5 (75%) showed the lowest results because the dose was too high causing excess nutrient accumulation which inhibited the plant's vegetative growth. The macronutrient and micronutrient content of banana peels and stems, such as nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, and manganese, plays a vital role in photosynthesis and supports plant growth and productivity. In addition to fertilizer treatment, successful pakcoy growth is also supported by suitable environmental conditions, namely a temperature of 23–25 °C, humidity of around 80%, and a soil pH of 7, which is within the optimal range for pakcoy growth. Therefore, the use of LOF made from kepok banana peels and stems has the potential to be an effective alternative organic fertilizer to boost pakcoy growth while reducing dependence on inorganic fertilizers. This research has global benefits because it supports sustainable agriculture, organic waste management, and food security. Specifically, farmers can utilize banana peel and stem waste as organic liquid fertilizer, increasing crop yields, reducing chemical fertilizer costs, and maintaining soil fertility.

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