

Research Article



Response of Pakchoy (*Brassica rapa* L.) to the Combination of Liquid Organic Fertilizer from Kepok Banana Peel and NPK in Organosol Soil

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Abstract

Pakchoy (*Brassica rapa* L.) is a high-value horticultural crop rich in essential nutrients that support human health. However, its cultivation in Organosol soils is often constrained by low pH, poor drainage, and limited nutrient availability. Excessive use of chemical fertilizers can further degrade soil quality and reduce long-term productivity. This study aimed to determine the effect of combining banana peel-based liquid organic fertilizer (LOF) with NPK fertilizer on the growth and yield of Pakchoy grown in Organosol soil. The experiment was conducted at Politeknik Pertanian Negeri Payakumbuh from February to June 2025 using a Randomized Complete Block Design (RCBD) with four treatments: 100% NPK, 75 mL LOF + 50% NPK, 100 mL LOF + 50% NPK, and 125 mL LOF + 50% NPK. Data were analyzed using ANOVA followed by Duncan's Multiple Range Test (DMRT) at a 5% significance level. The results showed that the 100 mL LOF + 50% NPK treatment produced the highest number of leaves and a shoot weight statistically comparable to the 125 mL LOF + 50% NPK treatment, while leaf length did not differ significantly among treatments. This treatment reduced the NPK fertilizer dose by 50% while maintaining strong vegetative performance. The utilization of Kepok banana peel waste as a raw material for liquid organic fertilizer has potential to support horticultural crops in the Brassicaceae family.

Keywords: brassicae, fertilizer efficiency, liquid organic fertilizer, sustainable agriculture, vegetative growth



1. Introduction

Pakchoy (*Brassica rapa* L.), a member of the Brassicaceae family, is characterized by its broad, glossy green leaves, thick, succulent stems, and high levels of vitamins A, C, E, and K, which play crucial roles in maintaining human health (Harahap et al., 2024). Owing to its rich nutritional composition, Pakchoy has become one of the most popular leafy vegetables among consumers.

However, cultivating Pakchoy in Organosol soils can pose challenges due to acidic conditions, poor drainage, and low fertility. Organosol soils are characterized by low pH, poor aeration, and compact structure, which limit microbial activity and nutrient absorption (Chen & Huang, 2024). Excessive use of chemical fertilizers further exacerbates these conditions by degrading soil structure and reducing long-term fertility. Iticha et al. (2024) reported that excessive chemical fertilization accelerates soil acidification and decreases nutrient use efficiency.

One environmentally friendly solution is the use of liquid organic fertilizer (LOF). LOF can improve soil physical, chemical, and biological properties, enhance microbial activity, and accelerate plant nutrient uptake (Nisa et al., 2024). Kepok banana peel represents a potential natural material for LOF production because it contains macronutrients such as nitrogen,

phosphorus, and potassium that are readily decomposable and easily absorbed by plants.

Previous studies have demonstrated that banana peel-based LOF can enhance vegetative growth of horticultural crops, particularly plant height and leaf number, owing to its readily assimilable nutrient composition (Nisa et al., 2024; Syaifuddin et al., 2022). Munar et al. (2018) reported that the application of 75 mL of Kepok banana peel LOF per polybag resulted in the best growth in plant height and leaf area of Pakchoy, making this dosage a reference for subsequent studies. Therefore, banana peel waste holds great potential as a raw material for LOF to promote the growth of leafy vegetables such as Pakchoy.

These findings highlight the need to investigate the effectiveness of Kepok banana peel LOF on Pakchoy plants. The objective of this study was to determine the effect of applying Kepok banana peel LOF in combination with NPK fertilizer on the growth and yield of Pakchoy plants. Considering the cultivation challenges of Pakchoy and the numerous benefits of using banana peel-based LOF, this research specifically examined the "Response of Pakchoy (*Brassica rapa* L.) to the Combination of Kepok Banana Peel Liquid Organic Fertilizer and 50% NPK Fertilizer on Organosol Soil.

2. Materials and Methods

The study was conducted from February to June 2025 at the experimental field of the Payakumbuh State Agricultural Polytechnic, Harau District, Lima Puluh Kota Regency, West Sumatra Province, Indonesia.

The tools used in this experiment included a measuring tape, a hoe, a watering can, a bucket, a ruler, writing instruments, and a digital balance. The materials consisted of pakcoy (*Brassica rapa* L.) F1 Nauli seeds, NPK 16:16:16 fertilizer, and liquid organic fertilizer (LOF) made from Kepok banana (*Musa paradisiaca*) peels. Additional ingredients for LOF production included EM4 (Effective Microorganisms), molasses, and clean water.

The experiment employed a Randomized Complete Block Design (RCBD) consisting of four fertilizer treatments as follows:

Po: 100% NPK fertilizer (3 g/plant)

P1: 75 mL banana peel LOF + 50% NPK fertilizer (1.5 g/plant)

P2: 100 mL banana peel LOF + 50% NPK fertilizer (1.5 g/plant)

P3: 125 mL banana peel LOF + 50% NPK fertilizer (1.5 g/plant)

Each treatment was replicated six times, resulting in a total of 24 experimental units. Each experimental unit contained 20 plants, of which 10 plants were randomly

selected as samples. Blocking was based on the sunlight intensity gradient from east to west across the experimental area, and the treatments were randomly assigned to the plots within each block.

The preparation of the liquid organic fertilizer began with cutting 25 kg of Kepok banana peels into small pieces. 0.5 kg of molasses were dissolved in 30 liters of water and mixed with 0.5 L of EM4 to activate the microbial culture. The solution was then combined with the chopped banana peels and stirred until homogeneous. The mixture was placed in an airtight container, covered tightly, and stored in a shaded area to avoid direct sunlight.

The fermentation process lasted for 14 days. The container was opened every two days to release accumulated gas, and the mixture was stirred to homogenize it after gas release. The LOF was considered mature when it emitted a strong yet pleasant aroma reminiscent of fermented cassava (tape). If a foul odor developed, the fermentation process was deemed unsuccessful.

All fertilizer applications were carried out in the morning, with NPK applied to the soil at planting. The undiluted LOF (75, 100, and 125 mL) was applied by soil drenching directly onto the plants at the respective treatment levels. The fertilizer was applied three times during the growing period, at 7, 14, and 21 days after transplanting (DAT).

The observed parameters included: number of leaves (leaves/plant), leaf length (cm), leaf width (cm), root length (cm), shoot weight (g), and root weight (g).

All collected data were subjected to Analysis of Variance (ANOVA) to determine treatment effects.

3. Results and Discussion

Number of Leaves (Leaves per Plant)

The analysis of variance (ANOVA) showed that fertilizer treatments had a significant effect on Pakchoy leaf number. The obtained significance value (0.011)

When significant differences were detected, mean separations were performed using Duncan's Multiple Range Test (DMRT) at the 5% significance level. Statistical analyses were carried out using SPSS software version 20.

was < 0.05 , indicating that fertilizer treatments significantly influenced this parameter. The results of the DMRT 5% test are presented in Table 1, showing the average number of Pakchoy leaves at four weeks after transplanting (WAT).

Table 1. Average number of leaves (Leaves per Plant), maximum leaf width (cm), and longest leaf length (cm) of Pakchoy at 4 WAT

Treatment	Mean Number of Leaves (Leaves per Plant)	Mean Leaf Width (cm)	Mean Leaf Length (cm)
100% NPK	14.3 a	7.0 a	16.7 a
75 mL LOF from banana peel + 50% NPK	13.7 a	6.7 a	15.5 a
100 mL LOF from banana peel + 50% NPK	16.2 b	6.3 a	17.0 a
125 mL LOF from banana peel + 50% NPK	14.0 a	6.6 a	16.0 a
CV (%)	8.22	9.80	5.84

Note: Means followed by different letters are significantly different at the 5% level.

The treatment of 100 mL LOF from banana peel + 50% NPK produced the highest average number of leaves, reaching 16.2 leaves per plant. This treatment was significantly different from 100% NPK, 75 mL LOF + 50% NPK, and 125 mL LOF + 50% NPK. Thus, the application of 100 mL LOF in combination with 50% NPK was the most optimal dosage for enhancing leaf formation in Pakchoy grown on Organosol soil.

Organosol soils generally exhibit low fertility due to the slow decomposition of organic matter, which limits the availability of Nitrogen (N). Such conditions are typical in acidic or peat-like soils with a high C/N ratio (Manalu et al., 2024a, 2024b). Nitrogen plays an essential role in leaf formation by stimulating cell division, accelerating the growth of young tissues, and supporting chlorophyll and protein synthesis (Sembiring & Sabrina, 2022).

The application of banana peel LOF increased nitrogen availability in Organosol soils because it contains *Bacillus* bacteria, which release bound nitrogen (Sriwahyuni et al., 2023). These microorganisms help provide a sufficient nitrogen supply for new leaf formation (Rahmadani et al., 2025). Increased nitrogen availability directly contributes to a higher number of leaves, as nitrogen is also crucial for the synthesis of proteins and enzymes that promote vegetative growth (Laia, 2023).

Appropriate fertilizer levels can also improve the chemical properties of Organosol soils, which are typically acidic and poorly drained. According to Rachman & Teapon (2016), Organosol soils can be

utilized for agricultural purposes if acidity and drainage conditions are improved. The addition of banana peel LOF may enhance soil structure, increase aeration, and improve nutrient availability for plant roots.

The application of 50% NPK fertilizer, combined with banana peel LOF, adequately supplied nitrogen for Pakchoy growth while improving soil fertility. Nitrogen plays a dominant role in leaf tissue formation (Nazara et al., 2025). The integration of organic and inorganic fertilizers improves fertilizer efficiency, reduces soil chemical residues, and maintains vegetative growth comparable to that with a full (100%) NPK application. The high potassium, phosphorus, and nitrogen content in banana peels makes them an effective biofertilizer for supporting the growth of horticultural crops (Khanyile et al., 2024).

Therefore, the combination of 100 mL banana peel LOF with 50% NPK is recommended as an efficient fertilization strategy to enhance vegetative growth and leaf development of Pakchoy on Organosol soils. This combination also enhances fertilizer efficiency while preserving soil fertility and long-term environmental sustainability.

Leaf Width (cm)

The analysis of variance (ANOVA) showed that the fertilizer treatments had no significant effect on Pakchoy's maximum leaf width ($p = 0.946 > 0.05$). The results of the DMRT 5% test are presented in Table 1.

The results indicated that all treatment levels produced leaf widths that were statistically similar, ranging from 6.3 to 7.0 cm. The non-significant difference may be attributed to the limited nutrient

availability in Organosol soils. Organosol soils are acidic, have high C/N ratios, and exhibit slow decomposition of organic matter, resulting in limited availability of macronutrients such as N, P, and K (Manalu et al., 2024a, 2024b). These conditions restrict nutrient uptake by roots and inhibit leaf expansion.

Despite the lack of statistical significance, applying banana peel LOF may still provide agronomic benefits by supporting soil structure and microbial activity. The presence of microorganisms in organic materials enhances nutrient mineralization and nutrient availability to plants (Dohare et al., 2025). Although leaf width did not differ significantly among treatments, the mean values showed no consistent increasing trend with LOF dose. According to Rahmi et al. (2023), organic liquid fertilizers derived from natural materials can improve soil chemical and biological properties by stimulating microbial activity responsible for nutrient mineralization. This process increases the availability of nutrients for plant roots, thereby expanding leaf lamina areas. Nitrogen plays a key role in cell enlargement and chlorophyll synthesis, both of which are essential for photosynthesis (Sembiring & Sabrina, 2022).

In addition to nitrogen, potassium, and phosphorus, the LOF in banana peel contributes to enzymatic activity and energy transfer in plant cells. Khanyile et al. (2024) reported that banana peels contain high levels of potassium and bioactive compounds that enhance soil nutrient availability. The combination of LOF and NPK thus provides a balanced supply of organic and inorganic nutrients, supporting optimal leaf tissue development. Potassium regulates osmotic pressure and carbohydrate formation, while phosphorus promotes cell division and the formation of new tissue (Chairunnisak et al., 2025).

The banana peel LOF treatment combined with 50% NPK was as effective as the 100% NPK treatment for leaf width. These findings suggest that liquid organic fertilizer derived from banana peels can serve as a complementary input to chemical fertilizers in a balanced fertilization system for Organosol soils.

Leaf Length (cm)

The analysis of variance (ANOVA) indicated that the fertilizer treatments had no significant effect on the longest Pakchoy leaf length ($p = 0.115 > 0.05$). The results of the 5% DMRT test are presented in Table 1.

The observations revealed that all treatment levels produced leaf lengths that were relatively similar, ranging from 15.5 to 17.0 cm. Fertilizer application according to plant requirements still played a role in supporting Pakchoy growth. Handayani and Elfarsina (2021) reported that the use of banana peel LOF containing nitrogen can promote leaf growth equivalent to that achieved by 100% NPK fertilization.

The low variation among treatments is likely due to the characteristics of Organosol soils, which possess low natural fertility. These soils are typically acidic, dense in texture, and have a high C/N ratio, resulting in slow decomposition of organic matter and limited availability of nitrogen (N) and phosphorus (P) (Rahmi

et al., 2023). Such nutrient limitations reduce root absorption efficiency, meaning that increased fertilizer dosages do not always result in significantly longer leaves.

Nevertheless, the broadly similar leaf lengths among treatments indicate that combining LOF with 50% NPK maintained leaf length comparable to the 100% NPK treatment. The enhanced microbial activity resulting from LOF application contributes to the mineralization of organic matter, releasing nutrients that are more readily absorbed by plants (Rahmi et al., 2023). This process enhances the availability of nitrogen and phosphorus, which are crucial for cell division and leaf tissue elongation.

Potassium in banana peel LOF supports the translocation of photosynthetic products, while nitrogen plays a role in amino acid and protein formation, which are essential components of plant tissues. The balance between these nutrients supports the plant's physiological functions, particularly chlorophyll formation and mesophyll development. Additionally, banana peel LOF improves soil structure, enhances microbial activity, and increases nutrient uptake efficiency (Syaifuddin et al., 2022).

Nitrogen in NPK fertilizer supports the synthesis of chlorophyll and proteins, which directly influence photosynthetic efficiency (Sukiman et al., 2023). Adequate NPK fertilization enhances vegetative growth, including leaf length development. Phosphorus contributes to energy formation in the form of ATP required for cell division and tissue formation, while potassium maintains osmotic balance within plant cells (Sembiring & Sabrina, 2022).

Banana peel LOF contains potassium, phosphorus, and bioactive compounds that help improve soil structure and nutrient absorption (Khanyile et al., 2024). These components strengthen the function of NPK fertilizer in supporting longer leaf growth. The combination of organic and inorganic fertilizers thus produced leaf lengths comparable to those achieved with 100% NPK, demonstrating its effectiveness as a sustainable fertilization approach.

Shoot Weight (g)

The analysis of variance (ANOVA) revealed that the fertilizer treatments had a significant effect on Pakchoy shoot weight ($p < 0.001$). The results of the DMRT 5% test are presented in Table 2.

The 100 and 125 mL LOF + 50% NPK treatments produced the highest shoot weights, averaging 116.51 and 118.95 g, respectively, and were not significantly different from each other. Both treatments produced significantly higher shoot weights than the 75 mL LOF + 50% NPK treatment (84.93 g), which in turn was significantly higher than the 100% NPK treatment (64.50 g).

Shoot weight is closely related to photosynthetic activity and leaf development. The higher shoot weights observed under the 100 and 125 mL LOF + 50% NPK treatments indicate greater above-ground biomass accumulation. The combination of banana peel LOF

and NPK fertilizer may have improved nutrient availability in the rhizosphere, thereby supporting photosynthetic activity and biomass formation.

Table 2. Average shoot weight (g), root weight (g) and root length (cm) of Pakchoy at 4 WAT

Treatment	Mean Shoot Weight (g)	Mean Root Weight (g)	Mean Root Length (cm)
100% NPK	64.50 a	4.00 b	10.7 a
75 mL LOF from banana peel + 50% NPK	84.93 b	3.67 ab	11.7 a
100 mL LOF from banana peel + 50% NPK	116.51 c	3.17 a	12.3 a
125 mL LOF from banana peel + 50% NPK	118.95 c	3.33 a	11.0 a
CV (%)	5.02	8.63	14.93

Note: Means followed by different letters are significantly different at the 5% level.

Liquid organic fertilizer enhances soil structure and microbial activity, while NPK fertilizer provides essential nutrients such as nitrogen, phosphorus, and potassium in readily available forms (Rahmi et al., 2023). Nitrogen plays a central role in the formation of chlorophyll and proteins necessary for new tissue formation in the shoots (Sembiring & Sabrina, 2022). Phosphorus supports energy transfer through ATP synthesis, and potassium regulates osmotic pressure and carbohydrate synthesis, both of which contribute to vegetative growth.

The increase in shoot weight reflects greater accumulation of photosynthetic products and more efficient nutrient utilization. According to Afryanto et al., (2024), leaves, as the primary organs of photosynthesis, contain the highest water content, particularly in vegetable crops.

NPK fertilizer also contributes to thicker leaf formation through chlorophyll and protein synthesis. The potassium and phosphorus in banana peel LOF further promote soil microbial populations, improving nutrient cycling and soil fertility (Khanyile et al., 2024). The combined use of organic and inorganic fertilizers balances soil chemistry and provides essential nutrients for optimal canopy biomass formation.

The higher shoot weight was accompanied by the highest number of leaves under the 100 mL LOF + 50% NPK treatment, whereas leaf length and leaf width did not differ significantly among treatments. The 100 and 125 mL LOF + 50% NPK treatments produced the highest shoot weights. Among these, the 100 mL LOF + 50% NPK treatment can be considered more input-efficient because it used a lower LOF dose while producing a statistically comparable shoot weight.

Root Weight (g)

The analysis of variance (ANOVA) indicated that the fertilizer treatments had a significant effect on Pakchoy root weight ($p = 0.010 < 0.05$). The results of the DMRT 5% test are presented in Table 2.

The 100% NPK treatment produced the highest average root weight of 4.00 g and was not significantly different from the 75 mL LOF + 50% NPK treatment (3.67 g). The 100% NPK treatment was significantly different from the 100 and 125 mL LOF + 50% NPK

treatments, whereas the 75 mL LOF + 50% NPK treatment, marked with the intermediate letter group "ab" did not differ significantly from either group.

An increase in root weight reflects a positive interaction between macro- and micronutrients in the root zone. The application of liquid organic fertilizer may improve soil structure and organic matter content, while NPK fertilizer provides readily available N, P, and K nutrients for plant uptake (Rahmi et al., 2023). Phosphorus plays a crucial role in the formation of meristematic root tissues and accelerates cell division, potassium maintains turgor pressure within cells, and nitrogen supports protein synthesis necessary for root tissue development (Sembiring & Sabrina, 2022).

Banana peel LOF contains potassium, phosphorus, and bioactive compounds that accelerate the decomposition of organic matter and enhance soil aeration. According to Khanyile et al. (2024), banana peel-based biofertilizer increases nutrient availability by promoting the activity of phosphate-solubilizing microorganisms and by releasing natural growth-promoting hormones such as auxins and cytokinins, which stimulate lateral root formation. Increased microbial activity also improves the efficiency of water and nutrient absorption.

The application of banana peel LOF may help ameliorate acidic soil conditions and provide nutrients in more bioavailable forms for root uptake. Liu et al. (2024) reported that balanced NPK fertilizer application can enhance fine root biomass, root length density, and root surface area in soil layers. Therefore, the combination of LOF and NPK fertilizers may improve soil conditions in Organosol and increase nutrient uptake efficiency.

Root Length (cm)

The analysis of variance (ANOVA) showed that the fertilizer treatments had no significant effect on Pakchoy root length ($p = 0.489 > 0.05$). The results of the DMRT 5% test are presented in Table 2.

The average root length ranged from 10.7 to 12.3 cm, with no statistically significant differences among treatments. The lack of a significant response was likely due to limited nutrient availability in Organosol soils. These soils have low pH, low cation exchange capacity,

and slow organic matter decomposition (Manalu et al., 2024a, 2024b), all of which reduce nutrient uptake efficiency.

Roots function as the primary organs for absorbing nutrients and water, which are then distributed throughout the plant. Root growth is influenced by the availability of carbohydrates produced through photosynthesis in the shoots (Saprianti et al., 2025). The dense texture of Organosol soils may limit root elongation even when nutrients are sufficient. Moreover, the natural growth-promoting hormones contained in banana peel LOF tend to stimulate above-ground vegetative growth more strongly than root elongation.

The application of NPK fertilizer on Organosol soils enhances the availability of essential nutrients for plant growth. Nitrogen supports vegetative development, phosphorus promotes the formation of a robust root system, and potassium improves water absorption efficiency (Hariyanti et al., 2022). The use of LOF further increases soil microbial activity, which facilitates the mineralization of organic matter and the

4. Conclusions

The combination of liquid organic fertilizer (LOF) from Kepok banana peel and NPK fertilizer significantly affected the number of leaves, root weight, and shoot weight of Pakchoy (*Brassica rapa* L.) cultivated on Organosol soil. Overall, 100 mL of banana peel LOF combined with 50% NPK was the most input-efficient treatment because it produced the highest number of leaves and a shoot weight statistically comparable to the 125 mL LOF + 50% NPK treatment while using a

release of macronutrients such as N, P, and K (Rahmi et al., 2023).

Physiologically, phosphorus contributes to the development of meristematic root tissues, while potassium regulates osmotic pressure and enzymatic activity within root cells (Sembiring & Sabrina, 2022). These nutrients support the formation of primary and secondary roots and improve the efficiency of water and nutrient uptake. The bioactive compounds and macronutrients in banana peel LOF also enhance soil aeration and structure around the root zone (Khanyile et al., 2024).

Root length did not differ significantly among treatments, although the 100 mL LOF + 50% NPK treatment had the numerically longest roots. The combined use of banana peel LOF and NPK fertilizer may support Pakchoy growth by improving nutrient availability and root-zone conditions in Organosol soils. Further optimization of fertilizer dosage and application frequency may enhance nutrient absorption efficiency in subsequent growth stages.

lower LOF dose. The utilization of Kepok banana peel LOF can reduce the NPK fertilizer dose by 50% while maintaining strong vegetative performance.

5. Conflict of Interests

The authors have declared that no competing interest exists.

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