LenteraBio
Berkala Ilmiah Biologi

LenteraBio, 2026; Volume 15, Issue 2: 161-166

p-ISSN: 2252-3979 e-ISSN: 2685-7871
https://journal.unesa.ac.id/index.php/lenterabio/index

Effect of Liquid Organic Fertilizer (LOF) and Inorganic Fertilizer Combination on the Growth of Bok Choy (*Brassica rapa* L.) in Wick Hydroponic System

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Article History:
Received:
26-September-2025
Revised:
6-May-2026
Available online:
31-May-2026
Published regularly:
31-May-2026

Abstract
Liquid Organic Fertilizer (LOF) from vegetable and fruit waste can be used as a nutrient substitute for bok choy growth in a Wick hydroponic system. This study aims to describe the nutritional quality of N, P, and K in LOF and determine the optimal combination of LOF and AB Mix for bok choy growth in wick hydroponic system. This study used a Randomized Block Design with five treatments; P0 (10 ml AB Mix), P1 (2.5 ml AB Mix +25 ml LOF), P2 (5 ml AB Mix + 50 ml LOF), P3 (7.5 ml AB Mix + 75 ml LOF), P4 (100 ml LOF). Data analysis techniques used one-way ANOVA test, followed by Duncan test. The results of this study indicate that the nutrient content in vegetable and fruit waste LOF was N 0.07%; P 0.01%; K 0.19%; C-Organic 0.7%; C/N ratio 10. The optimal treatment for plant height was P2 (19.8±1.46 cm) and P3 (20.5±0.86 cm), the number of leaves was P0 (15±2.0 strands), leaf width was P1 (6.1±0.5 cm), P2 (6.1±0.6 cm), P3 (6.3±0.4 cm), and wet weight was P0 (74.9±33.6 cm). P3 treatment is recommended as an environmentally friendly fertilizer alternative for bok choy cultivation in hydroponic system.

Keywords: Liquid Organic Fertilizer (LOF); bok choy; nutrient content analysis; crop productivity

How to Cite: Amaliyah AT, Ratnasari E, 2026. Effect of Liquid Organic Fertilizer (LOF) and Inorganic Fertilizer Combination on the Growth of Bok Choy (*Brassica rapa* L.) in Wick Hydroponic System. *LenteraBio*; 15(2): 161-166.

DOI: https://doi.org/10.26740/lenterabio.v15n2.p161-166

INTRODUCTION

Bok choy (*Brassica rapa* L.) is one of the plant species in the Brassicaceae family (Priyambodo, *et al*., 2022). Bok choy has health benefits, including containing beta-carotene to prevent cataract disease, vitamin E for skin health, vitamin K to prevent heart disease and stroke, and food fiber that helps the digestive process and lower cholesterol level (Mutryarny and Lidar, 2018). In Indonesia, bok choy has a large demands that must be fulfilled with adequate crop quantity (Priyambodo, *et al*., 2022). Thus, bok choy production has been in increase from year to year. In 2020, bok choy production in East Java was 77,716 tons, in 2021 it increased to 82,613 tons, and in 2022 it increased to 82,994 tons (Badan Pusat Statistik, 2022). With the increasing demand for bok choy, land availability for bok choy cultivation has become one of its main issues. Therefore, hydroponic method can be applied as alternative.

Hydroponic is a method of growing plants that does not involve soil, but instead replaces it with materials such as rockwool, rice husks, cotton, and others. Hydroponic cultivation focuses on utilizing nutrients dissolved in water (Singgih, *et al*., 2019). One of the simplest and most practical hydroponic methods is the Wick system. This method utilizes wicks to deliver nutrients to the roots in the growing medium (Permadi, *et al*., 2020). The nutrient availability in hydroponic media is important because hydroponic cultivation uses water. The nutrients commonly used in hydroponic medium is AB Mix nutrient solutions, generally found in inorganic fertilizers (Paramita and Yuliani, 2022).

Inorganic fertilizers has been used to increase agricultural yields and also is very practical to be applied. However, their continued use may pose negative effects on plant and soil conditions, damaging terrestrial biological life, reduce soil fertility and health, disrupt soil ecosystems, and trigger massive pest attacks. Therefore, agricultural activities start to incorporate fertilizers and pesticides from organic materials. Liquid Organic Fertilizer (LOF) can be used as alternative to reduce the excessive use of inorganic fertilizers. However, LOF also have disadvantages such as low nutrient content and slow availability to plants compared to inorganic fertilizers (Oviyanti, *et al*., 2016).

Organic waste from traditional market can be used to produce LOF, such as fruit and vegetable waste. Fruit waste for example tomato waste and banana waste. Vegetable waste includes bean waste, green mustard waste, and white mustard waste. The produced LOF from organic waste can be used to

provide nutrient in the bok choy cultivation using hydroponic system, as it contains N, P, and K necessary for plant growth. Faruq *et al*. (2021) has shown that LOF made from fruit waste and vegetable waste affected the height, wet and dry weight of mustard greens in hydroponic system.

Based on the results of laboratory tests conducted, N, P, and K nutrients from vegetable and fruit wastes, including chicory, green mustard, beans, tomatoes and bananas, still did not meet national standards based on Decree of Agriculture Ministry No. 261/KPTS/SR.310/M/4/2019. Therefore, the application LOF from vegetable and fruit waste can be combined with AB Mix inorganic fertilizers to fulfill the nutrient requirement and increase the growth and productivity of bok choy plants in Wick hydroponic planting system.

Based on background above, this study was conducted to determine the content of N, P, and K nutrients in LOF and compared them with national standards as well as to determine the optimal combination of LOF and AB Mix on bok choy planted in Wick hydroponic system (Marginingsih, *et al.,* 2018). This study provides information on LOF from organic fruit and vegetable waste and its application to bok choy in hydroponic system combined with AB mix inorganic fertilizer.

MATERIALS AND METHODS

This study consisted of two stages, the first was to produce LO, the second was to apply AB Mix and LOF to bok choy plant. Production of LOF, seeding, and bok choy planting were carried out in Kendalkemlagi village, Karanggeneng sub-district, Lamongan district, East Java. Testing of LOF nutrient content was conducted at UPN Veteran, Surabaya, East Java.

Production of LOF began with the preparation of raw materials, included green mustard, chicory, beans, tomato, and banana wastes. LOF production process followed method from Karyanto *et al*. (2022). Each materials were weighed 300 grams and then cut or chopped, then the waste was put into a container. Into the mixture, 50 mL EM-4, 50 mL molasses, and 3000 mL water were mixed, then the container was closed tightly and the mixture was fermented anaerobically for 25 days (Karyanto, *et al*., 2022). Resulting LOF was tested for N, P, K, and C-Organic contents.

This study used one-factor Randomized Block Design (RBD), which was LOF with AB Mix combination at various concentrations. Five fertilizer treatments were applied to bok choy; AB Mix 10 ml/L (P0), AB Mix 2.5 ml/L + LOF 25 ml/L (P1), AB Mix 5 ml/L + LOF 50 ml/L (P2), AB Mix 7.5 ml/L + LOF 75 ml/L (P3), and LOF 100 ml/L (P4). The concentrations of LOF and AB Mix used were adapted from Rahmayanti *et al*. (2019) and modified with the addition of AB Mix based on the results of nutrient content tests of N, P, and K.

The application of fertilizer mixtures began with the assembly of hydroponic growing media by preparing a hydroponic tray filled with water and nutrients, then closing it using a perforated tray lid. Flannel was attached to the netpot hole as a wick, the netpot was placed in the tray lid hole. Bok choy seeds were sowed using rock wool as a seeding medium. After seedlings aged two weeks old or had grow four leaves, seeds were transplanted to the Wick hydroponic media. Each treatment consisted of five replicates, in which one hydroponic tray contained two units of bok choy plants. Fertilizer treatment of AB Mix and LOF was performed during the period of seedling transplantation. Fertilizer was given to bok choy plants once a week according to treatment groups. Bok choy plants were harvested 45 days after transplantation. Parameters measured including plant height, number of leaves, leaf width, and plant biomass. Bok choy growth parameters were analyzed using SPSS 23 using Kolmogorov Smirnov test, then continued with one-way Anova test, and post-hoc Duncan test.

RESULTS

Resulting LOF after fermentation was observed to have yellowish color and smell like rice winse. Table 1 presents the result of chemical content analysis of the LOF produced in the current study.

Table 1. Content analysis of liquid organic fertilizer (LOF) analysis

Parameter	Content (%)	Quality Standard	Description*
N	0.07	2-6	Less than standard criteria
C-organic	0.7	Minimum 10	Less than standard criteria
P	0.01	2-6	Less than standard criteria
K	0.19	2-6	Less than standard criteria
C/N	10	≤25	Fulfilled standard criteria

Note: *) compared to Quality standards based on the Ministry of Agriculture No. 261/KPTS/SR.310/M/4/2019.

Based on the results of the LOF content analysis (Table 1), it can be seen that the resulted LOF had N, C-organic, P, and K content at less than standard quality criteria. Therefore, the application of LOF was combined with AB Mix to fulfill the nutrients required by bok choy plants.

The effect of Bok Choy plant growth treated with vegetable and fruit waste LOF combined with AB Mix was observed based on four growth parameters; plant height, number of leaves, leaf width, and biomass or fresh weight, as presented in Table 2. Figure 1 presents the final observation of bok choy fresh weight from various treatment groups.

Table 2. Effect of LOF and AB mix combination treatment on bok choy plant growth

Treatment Group	Plant Height (cm)*	Number of Leaves*	Leaf Width (cm)*	Biomass (g)*
P0 (10 ml/L AB Mix)	18.8 ± 1.7^{ab}	15 ± 2.0^{d}	5.3 ± 0.2^{a}	74.9 ± 33.6^{c}
P1 (2,5 ml/L AB Mix + 25 ml/L LOF)	19.3 ± 1.4^{ab}	11 ± 0.4^{ab}	6.1 ± 0.5^{b}	40.8 ± 9.6^{ab}
P2 (5 ml/L AB Mix + 50 ml/L LOF)	19.8 ± 1.5^{b}	12 ± 1.9^{bc}	6.1 ± 0.6^{b}	47.5 ± 12.9^{b}
P3 (7,5 ml/L AB Mix + 75 ml/L LOF)	20.5 ± 0.9^{b}	13 ± 1.4^{c}	6.3 ± 0.4^{b}	57.1 ± 12.0^{bc}
P4 (100 ml/L LOF)	17.8 ± 1.0^{a}	9 ± 0.7^{a}	5.2 ± 0.2^{a}	21.8 ± 5.9^{a}

Note : *) Numbers in columns and rows followed by the same letter are not significantly different according to the Duncan test at the 5% level.

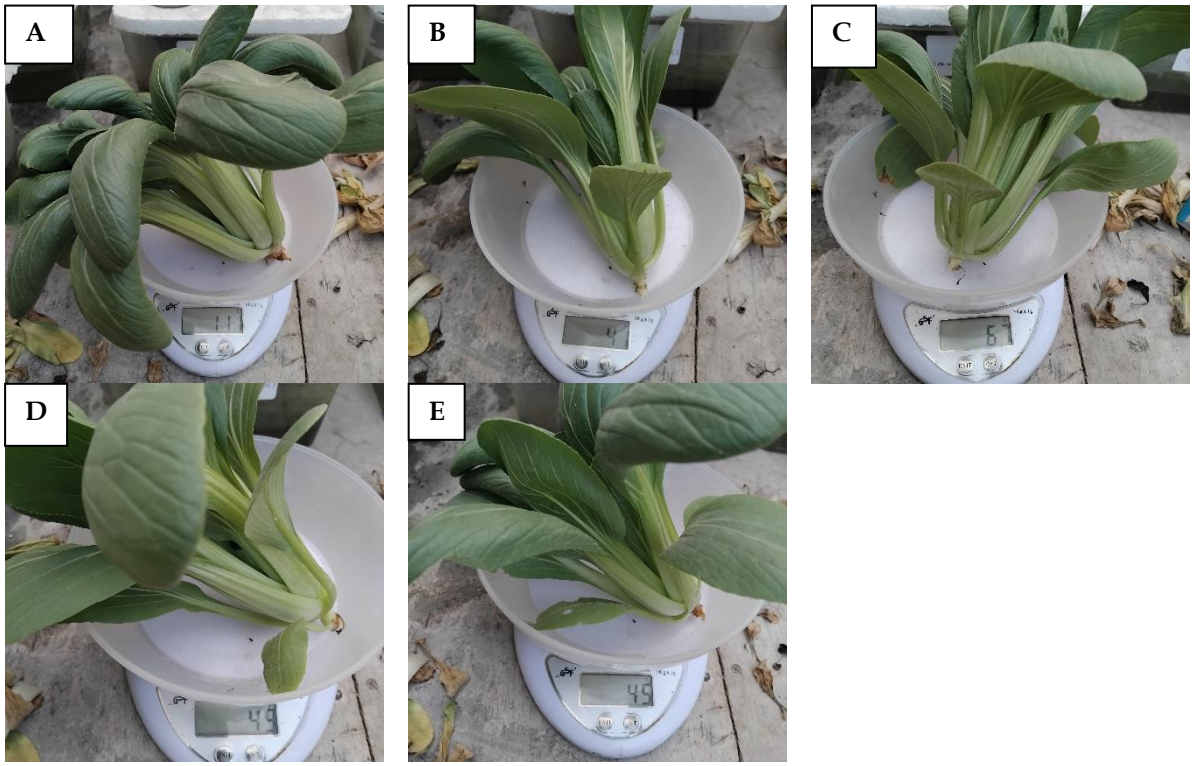

Figure 1. Observation of the bok choy plant growth. A) P0 (10 ml/L AB Mix); B) P1 (2,5 ml/L AB Mix + 25 ml/L LOF); C) P2 (5 ml/L AB Mix + 50 ml/L LOF); D) P3 (7,5 ml/L AB Mix + 75 ml/L LOF); E) P4 (100 ml/L LOF).

Based on the Duncan test (Table 2), the combined treatment of LOF made of organic waste and AB Mix had effect on all growth parameters observed in bok choy plants cultivated in Wick hydroponic system. The highest plant height was obtained in the P2 (19.8 cm) and P3 (20.5 cm) treatments, significantly different from the P4 treatment, but not significantly different from P0 and P1; the lowest plant height was obtained in the P4 treatment (17.8 cm). The highest number of leaves was obtained in treatment P0 (15 strands), significantly different from treatment P1, P2, P3, and P4; the lowest number of leaves was obtained in treatment P4 (9 strands). The highest leaf width was obtained in treatments P1 (6.1 cm), P2 (6.1 cm), and P3 (6.3 cm), significantly different from treatments P0 and P4; the lowest leaf width was obtained in treatment P0 (5.3 cm) and P4 (5.2 cm). The highest wet weight was obtained in treatments P0 (74.9 g), significantly different from treatment P1, P2, and P4, but not significantly different from treatment P3, and the lowest wet weight was obtained in treatment P4 (21.8 g).

DISCUSSION

Liquid organic fertilizer (LOF) produced from fermentation of organic waste produced yellowish brown color and smells like rice wine. According to Sufianto (2015), the indicator of the

successfully fermented LOF was yellowish brown and a smell that is not pungent, as well as the presence of white mold on the surface of the molasses solution. Chemical analysis of LOF resulted in 0.07% total N; 0.7% organic C; 0.01% total P; and 0.19% total K (Table 1). According to Sari *et al*. (2022), low macro-nutrients such as N, P, and K can be caused by inadequate composting process or leachate was harvested too early. The results of content analysis of LOF made from vegetable and fruit waste in the current study did not fulfill most quality standards established by Ministry of Agriculture.

The low nutrients content in the LOF was possibly caused by organic materials not fully converted into nutrients, but they were also used in metabolic process of the microbes. The N content in the LOF was fairly low, due to nitrogen content produced was also released into the air as ammonia gas (NH_3). Similarly, the P content was also low, likely due to the microbial activity of EM-4 bioactivator (Istiqomah *et al*., 2022). The high K content can be caused by potassium dioxide (K_2O) used by microorganisms in the substrate material as a catalyst affecting microbes and their activity during fermentation process. Potassium is bound and stored in cells by bacteria and fungi, which will be available again when the cells are degraded (Istiqomah *et al*., 2022). LOF made from vegetable and fruit waste had a C/N ratio of 10. According to Kurniawati *et al.* (2018), organic matters that has undergone optimal decomposition can be categorized as stable LOF, generally contains C/N ratio in the range of 10-15. LOF with a high C/N ratio can negatively impact plant growth, due to competition for nutrients between microorganisms and plants which ultimately can induce nutrient deficiencies for plants. Conversely, C/N ratio is low caused nitrogen content to increase significantly (Aziza *et al.,* 2022).

Due to the low content of nutrients in LOF, therefore its application to bok choy plants in hydroponic planting was combined with AB Mix fertilizer to support the growth and productivity of bok choy. This is in accordance to Marginingsih *et al.* (2018) that the use of LOF in hydroponics can have a positive impact on plant growth and yield, therefore it can be combined with AB Mix fertilizer to complement each other and meet the nutritional needs of plants.

Application of LOF with AB Mix in the current study on the growth of bok choy showed that the P0, P1, P2, and P3 treatments had a positive effect on the growth of bok choy plants. Only P4 which was given only LOF showed poor plant growth (Table 2). Plant growth requires sufficient macro and micro nutrients. The nutrient content of AB Mix was higher than that of LOF. LOF can be used for nutrient supplementations, however it has yet to be able to substitute AB Mix nutrients. Marginingsih *et al.* (2018) states that the substitution of LOF in AB Mix nutrition should contain sufficient macro and micro nutrients for physiological and metabolic processes to support plant growth. Modern cultivation such as hydroponics requires nutrients with enough macro and micro nutrients needed by plants. Each of these nutrients plays a role in the metabolic process of plants, thus incomplete nutrient availability will inhibit plant growth.

The growth of bok choy plants in hydroponics is not only affected by adequacy of nutrient absorption by plants, but also external factors such as temperature, CO_2, light intensity, and air humidity. In the study of the combination of AB Mix and LOF treatments, the optimal treatment results for pakcoy plant height were treatment P2 (19.8 cm) and P3 (20.5 cm). Bok choy plant height growth occured during vegetative growth phase, characterized mainly by increase in plant length. The nutrient that plays a role in this phase is nitrogen (Rizal, 2017), as it is essential for the formation and vegetative growth of plants, including stems, leaves, and roots (Mappanganro *et al.,* 2018). In addition to nitrogen (N), phosphorus (P) contained in liquid organic fertilizer also affects plant height. Phosphorus plays role in stimulating growth and development of growing points and root tips. Optimal roots growth will enhance the ability of plants to absorb nutrients, thereby support the development of various plant organs, particularly stems, which directly impact on plant height (Wulandari and Ratnasari, 2023).

The number of leaves was affected by the nutrients contained in the fertilizer. Plants with more developed leaves will affect the chlorophyll contents. Chlorophyll in the leaves acts as a light absorber to carry out the photosynthesis process. Higher chlorophyll content in the leaves results in higher rate of photosynthesis (Furoidah, 2018). The optimal treatment for leaf development was P0 (10 ml/L AB Mix) with an average leaf width of 5.3 cm (15 strands). While for the optimal treatment for leaf width was P1 (6.1 cm) with an average number of leaves of 11 strands, P2 (6.1 cm) with an average number of leaves of 12 strands, and P3 (6.3 cm) with an average number of leaves of 13 strands. This can occur because the distribution of photosynthetic products (photosynthate) affects plant growth, such as leaf size. The large number of leaves results in a smaller leaf size because photosynthate is distributed to more leaves. Photosynthate affects the growth of the number of leaves, but reduces leaf size (Nasrulloh, *et al.,* 2016). Vice versa, if the number of leaves is small, the leaves developed larger in size. Insufficient N levels inhibit plant growth and reduce yields because they inhibits the formation of chlorophyll for

photosynthesis. However, excessive N inhibits the process of flowering and fertilization in plants. In addition to N, P also affects the process of leaf formation. Phosphorus increases plant growth through its ability to increase cell formation and tissue growth (Rianditya and Hartatik, 2022). Potassium (K) is also a macronutrient that plants required, as its availability has a significant effect on growth parameters such as the number of leaves, leaf area, total fresh plant weight, and plant uptake weight.

Plant fresh weight is affected by water and nutrient content in plant tissue cells. Plant fresh weight indicates plant metabolic activity (Marginingsih *et al.,* 2018). Fresh weight is related to plant height, number of leaves, and leaf width in the plants. The highest fresh weight came from P0 (74.9 g). This occured because AB Mix solution contained more nutrients, thus the growth focused on of leaves development and plant stem growth, causes increase in the fresh weight of bok choy plants. According to Sintia and Sa'diyah (2024), the higher the vegetative growth, the higher the plant fresh weight. Vegetative growth such as the increase of leaf number on bok choy plant affects plant weight.

The P4 treatment showed low growth compared to other groups. This can be caused by the low content of macro and micro nutrients in the LOF, thus plant growth was less than optimal. Plants absorbing insuffiecient N, P, and K would inhibit enzyme activity, lower growth, and form smaller leaves. LOF made from vegetable and fruit waste in this study had not been able to be used as a substitute for AB Mix nutrients for bok choy in hydroponic wick system, but it could supplement the inorganic fertilizer.

CONCLUSION

Based on the results of the study, it can be concluded that the content of nutrients in vegetable and fruit waste LOF was 0.07% N; P 0.01%; K 0.19%; C-Organic 0.7%; C / N ratio 10, which had not fulfill criteria standards of the Ministry of Agriculture thus its application was combined with AB Mix. LOF and AB Mix combination had a significant effect on the height, leaf width, number of leaves, and wet weight of bok choy plants in hydroponic growing medium. The optimal treatments for plant height were P2 (19.8 ± 1.46 cm) and P3 (20.5 ± 0.86 cm), for leaf number was P0 (15 ± 2.0 strands), for leaf width was P1 (6.1 ± 0.5 cm), P2 (6.1 + 0.6 cm), P3 (6.3 ± 0.4 cm), and for fresh weight was P0 (74.9 ± 33.6 g).

ACKNOWLEDGEMENTS

Thanks to the lecturers and reviewers of the Department of Biology, Faculty of Mathematics and Natural Sciences, Surabaya State University who have provided learning, guidance, and support in the process of completing research and preparing this article.

CONFLICT OF INTEREST

There is no conflict of interest

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