Jurnal Biodjati 10(2): 293–303, November 2025
e-ISSN : 2541-4208
p-ISSN : 2548-1606

JURNAL BIODJATI

http://journal.uinsgd.ac.id/index.php/biodjati

Efficiency of AB MIX with Liquid Organic Fertilizer on Hydroponic Lettuce (*Lactuca sativa* L.) Growth

Dasumiati Dasumiati*[1], Fitri Mutiara Dewi[2], Ardian Khairiah [3], Junaidi[4], Adeel Abdulkarim Fadhl Altuhaish[5]

Received: May 06, 2025
Revise from: June 21, 2025
Accepted: Oct 23, 2025

DOI: 10.15575/biodjati.v10i2.45429

[1,2,3]*Department of Biology, Faculty of Sciences and Technology, State Islamic University Syarif Hidayatullah Jakarta, Ir. H. Djuanda Road No. 95, Ciputat, South Tangerang 15412, Banten, Indonesia.*

[4]*Department of Agribusiness, Faculty of Sciences and Technology, State Islamic University Syarif Hidayatullah Jakarta, Ir. H. Djuanda Road No. 95, Ciputat, South Tangerang 15412, Banten, Indonesia.*

[5]*Department of Biology, Faculty of Science, University of Aden, Aden, Yemen.*

e-mail:
[*1]*dasumiati@uinjkt.ac.id,*
[2]*fitri.dewi19@mhs.uinjkt.ac.id*
[3]*ardian.khairiah@uinjkt.ac.id,*
[4]*junaidi_fst@uinjkt.ac.id,*
[5]*adeeltuh@gmail.com*

**Corresponding author*

Abstract. *The overuse of synthetic AB mix fertilizers in hydroponic systems raises concerns over chemical residues and long-term health risks. Incorporating Liquid Organic Fertilizer (LOF) is a potential strategy to improve nutrient efficiency and enhance crop productivity. This study aimed to evaluate the application of LOF as a sustainable strategy to reduce AB mix dependency while maintaining crop growth and productivity. The experiment was arranged in a Completely Randomized Design (CRD) with five treatments: P1 (100% AB mix/control), P2 (25% LOF + 75% AB mix), P3 (50% LOF + 50% AB mix), P4 (75% LOF + 25% AB mix), and P5 (100% LOF). Plant growth and yield parameters were analyzed using Analysis of Variance (ANOVA) followed by Duncan's Multiple Range Test (DMRT). The combination of LOF and AB mix significantly affected (P<0.05) plant height, root fresh weight, leaf number, and shoot fresh weight, but had no significant effect (P>0.05) on root length. All combinations of LOF and AB mix, including the 100% AB mix treatment, yielded statistically similar results across all measured parameters. However, the treatment with 75% LOF + 25% AB mix tended to produce the highest values, enhanced flavor, and did not reduce shelf life, whereas the 100% LOF treatment resulted in the lowest performance. These findings highlight the potential of LOF to substantially reduce synthetic input in hydroponic lettuce production, supporting more sustainable and health-conscious cultivation practices.*

Keywords: *hydroponic, lettuce, Liquid Organic Fertiliser (LOF), productivity; wick system*

Citation
Dasumiati, D., Dewi, F. M., Khairiah, A., Junaidi & Altuahaish, A. A. F. (2025). Efficiency of AB Mix with Liquid Organic Fertilizer on Hydroponic Lettuce (*Lactuca sativa* L.) Growth. *Jurnal Biodjati*, 10(2), 293-303.

Jurnal Biodjati 10(2): 293–303, November 2025

JURNAL BIODJATI

http://journal.uinsgd.ac.id/index.php/biodjati

INTRODUCTION

Fertilization remains a critical practice for farmers to ensure sufficient nutrient availability for cultivated crops. In vegetable production systems, growers predominantly rely on inorganic fertilizers due to their rapid nutrient release and ease of use. However, such fertilizers may leave harmful chemical residues, especially in leafy vegetables directly consumed by humans (Munthe et al., 2018).

Hydroponics has emerged as a widely adopted cultivation method, particularly suitable for areas with limited land availability. In this system, AB mix is commonly used as the standard nutrient solution (Al Toriq et al., 2025). Despite its effectiveness, the AB mix, composed of synthetic inorganic compounds, raises environmental and health concerns due to potential residual accumulation in plants and surrounding ecosystems (Husnaeni & Setiawati, 2018). To address these concerns, Liquid Organic Fertilizer (LOF), derived from organic materials, has been introduced as a safer and more environmentally sustainable alternative. LOF is free from harmful side effects and supports ecological balance in crop production systems. Integrating LOF into nutrient regimes is expected to reduce the reliance on synthetic fertilizers, thus promoting more efficient and sustainable fertilization practices (Marliah et al., 2012). Moreover, LOF has been reported to enhance the flavor and nutritional quality of leafy vegetables, such as mustard greens, increase resistance to pests and diseases, extend post-harvest shelf life (Hairuddin & Mawardi, 2017), and improve leaf chlorophyll content (Khoiriyah & Nugroho, 2018). Recent studies further support these benefits. Dasumiati et al. (2024) demonstrated that the application of LOF significantly impacted the growth and yield of kale in hydroponic systems, indicating potential for sustainable vegetable production. The liquid organic fertilizer (LOF) used in this study was Nasa LOF. Nasa LOF is produced from organic materials, such as livestock waste, poultry waste, and plant residues. It therefore contains macro- and micronutrients, fats, proteins, organic acids, and plant growth regulators, including auxins, gibberellins, and cytokinins.

One of the easiest hydroponic systems to use is the wick system, which enables continuous delivery of water and nutrients without the need for electricity. This simplicity makes it particularly suitable for widespread use, including in low-resource settings. However, this system is considered passive because the nutrient solution flows into the growth medium from inside the container, assisted by a wick. Therefore, this system will only work optimally for small plants (Fitmawati et al., 2019). For this reason, it is particularly suitable for lettuce plants.

Green lettuce (*Lactuca sativa* L.) is a widely consumed vegetable commodity in Indonesia (Romalasari & Sobari, 2019), resulting in a continued increase in demand for green lettuce, which is linked to population growth and rising public awareness of nutrition (Ramadhanty et al., 2020). However, green lettuce production is declining due to limited land availability (Toriq, 2023). National data indicate a reduction in green lettuce yield from 41.11 tonnes in 2018 to 39.29 tonnes in 2019 (Badan Pusat Statistik, 2019). Moreover, according to the Central Bureau of Statistics of DKI Jakarta Province (2021), domestic production remains insufficient to meet consumption needs, which average 35.30 kg per capita per year. Thus, cultivating green lettuce in a hydroponic wick system will help provide lettuce for households or hobby farmers.

Therefore, this study was conducted to determine the response of growth and production of green lettuce to the application of LOF in combination with AB mix, as well as to obtain the concentration of LOF that can reduce the reliance on AB mix in the hydroponic wick system. The results obtained are expected to serve as a reference for lettuce cultivation, reducing the use of inorganic fertilizers without compromising the quality of production in the hydroponic wick system.

MATERIALS AND METHODS

The research was conducted in the greenhouse of CV Hadid Indonesia Berkarya, located in Kampung Tengkolo, Gaga Village, Pakuhaji Subdistrict, Tangerang Regency, Banten, from January to April 2023. Green lettuce seeds (Var. LE 873 Kepmentan No. 4175/Kpts/SR.120/11/2011) were used; meanwhile, the LOF used in this study was a commercially available product produced by NASA.

Research Design and Sample Collection

This study used a completely randomised design with five treatments, namely P1 (100% AB mix control), P2 (25% LOF + 75% AB mix), P3 (50% LOF + 50% AB mix), P4 (75% LOF + 25% AB mix), and P5 (100% LOF). Each treatment was repeated 4 times. Each replicate consisted of four plants, resulting in a total of 80 experimental units.

Wick system hydroponic installation preparation, seeding, and planting

The hydroponic installation used consisted of 20 nutrient basins, each measuring 38×30×13 cm, and impermeable/ nutrient basin covers with four planting holes, approximately 5 cm in diameter and spaced 10 cm apart, resulting in a total of 80 planting holes. A 2×50 cm flannel cloth was attached to the bottom of each netpot as a wick for nutrients. Plants were planted in a rockwool-based planting medium. Rockwool, measuring 3×3×3 cm, was placed in the seedling tray and watered with distilled water. Planting holes were made in the rockwool using sticks. Next, seeding was done.

Each hole in the rockwool planting media is filled with one lettuce seed, and during seeding, water is applied every morning (7:00-8:00) and afternoon (4:00-5:00). Throughout this process, the planting media must be adequately watered until 12 Days After Sowing (DAS). The seedlings can then be transplanted to the wick system hydroponic installation.

Seedlings are selected by choosing those with three leaves. The selected seedlings, along with the planting media, were transferred into a net pot and then inserted into the hole in the impervious board, which was placed in the wick system hydroponic tub. Each hydroponic tub contained four green lettuce seedlings.

Preparation of LOF and AB Mix Treatment Solutions

The Liquid Organic Fertilizer (LOF) used in this study was a commercial product known as LOF NASA, produced by PT. Natural Nusantara (NASA), Indonesia. This LOF is produced through a controlled anaerobic fermentation process that involves a mixture of organic raw materials, including livestock manure, poultry waste, and decomposed plant residues. During fermentation, beneficial microorganisms such as lactic acid bacteria and decomposers break down complex organic matter into simpler, plant-available compounds.

In the experiment, the LOF was applied in combination with an AB mix nutrient solution to investigate the effects of partial organic substitution on plant growth. The AB mix nutrient solution was prepared by separately diluting stock solutions A and B to avoid precipitation. Nutrient level measurements can be determined based on parts per million (ppm) using the TDS meter. In this study, all treatments were adjusted to the same nutrient concentration each week: 500 ppm, 600 ppm, 700 ppm, and 800 ppm, while the doses of AB mix and LOF used to achieve these concentrations varied according to the treatment, referring to Zamani's research (2022) as follows:

1. 100% AB mix (control): 5 mL of stock solution A and 5 mL of stock solution B were added to 2000 mL of water, resulting in a nutrient concentration of 500 ppm.
2. 25% LOF + 75% AB mix: 2.5 mL LOF, 3.75 mL of stock solution A, and 3.75 mL of stock solution B were added to 2000 mL of water.
3. 50% LOF + 50% AB mix: 2.5 mL LOF, 2.5 mL of stock solution A, and 2.5 mL of stock solution B were added to 2000 mL of water.
4. 75% LOF + 25% AB mix: 7.5 mL LOF, 1.25 mL of stock solution A, and 1.25 mL of stock solution B were added to 2000 mL of water.
5. 100% LOF: 12 mL LOF was added to 2000 mL of water.

Application of LOF and AB Mix Treatment Solutions

The LOF fertilizer treatment solution and AB mix were added to 20 hydroponic containers according to the treatment code at 3:30 p.m., and the TDS values were measured. For the initial transplanting stage of green lettuce, the nutrient concentration was set at 500 ppm (Zahra et al., 2023). The nutrient concentration was subsequently increased in accordance with plant age, as the nutrient requirements of hydroponically grown green lettuce vary on a weekly basis (Senen et al., 2022).

Maintenance and Harvesting of Green Lettuce Plants

Plant maintenance during the cultivation of green lettuce included stirring the nutrient solution twice daily, monitoring the nutrient concentration (ppm) using a TDS meter every two days, adjusting the nutrient concentration when it fell below the required level, manual inspection for pests and diseases, and insecticide application at 12, 21, and 28 Days After Transplanting (DAT). Regular monitoring of the hydroponic container cleanliness was also performed. All hydroponic containers were drained and cleaned of algae every five days until the plants were ready for harvest.

Green lettuce was harvested at 35 DAT, when the plants had reached the appropriate leaf size for harvest. Harvesting was conducted by removing the plants along with the rockwool from the net pots. Post-harvest observations included measurements of plant height, root length, fresh root weight, number of leaves, total fresh plant weight, and chlorophyll content.

Chlorophyll Content Analysis

Chlorophyll analysis was conducted by laboratory staff at the Testing Laboratory of the Department of Agronomy and Horticulture, Faculty of Agriculture, IPB University. The samples consisted of five fresh green lettuce leaves collected at 40 days after transplanting (DAT). Chlorophyll content was determined following the method of Sims & Gamon (2002) using a spectrophotometer at wavelengths of 537 nm, 647 nm, and 663 nm. Total chlorophyll content was calculated using the formula:

$$\text{Total Chlorophyll} = \text{Chlorophyll a} + \text{Chlorophyll b}$$

RESULTS AND DISCUSSION

Growth and Yield of Lettuce under Combined LOF and AB Mix Treatments

Lettuce growth generally follows three distinct phases: a slow growth phase at 7–14 Days After Transplanting (DAT), a linear growth phase from 21–35 DAT, and a senescence phase, which was not observed in this study due to the harvest occurring at 35 DAT (Supiana et al., 2022). All treatments involving combinations of LOF and AB mix exhibited similar growth patterns throughout the 35-day observation period. Plant height increased steadily each week, indicating consistent growth until harvest, although minimal growth was observed at 7 DAT. This early stagnation is associated with the plants' recovery and acclimatization post-transplanting, during which root systems are not yet fully active in nutrient uptake (Aroca et al., 2012).

As the plants matured, particularly between 21–35 DAT, root activity increased, enhancing nutrient absorption and subsequently stimulating the development of meristematic tissues (Senen et al., 2022). Among all treatments, P5 (100% LOF) consistently showed lower plant height and leaf number compared to the other treatments. Notably, the average number of leaves declined slightly at 21 DAT before increasing again by 35 DAT (Figure 1). This temporary reduction was attributed to the yellowing and senescence of basal leaves.

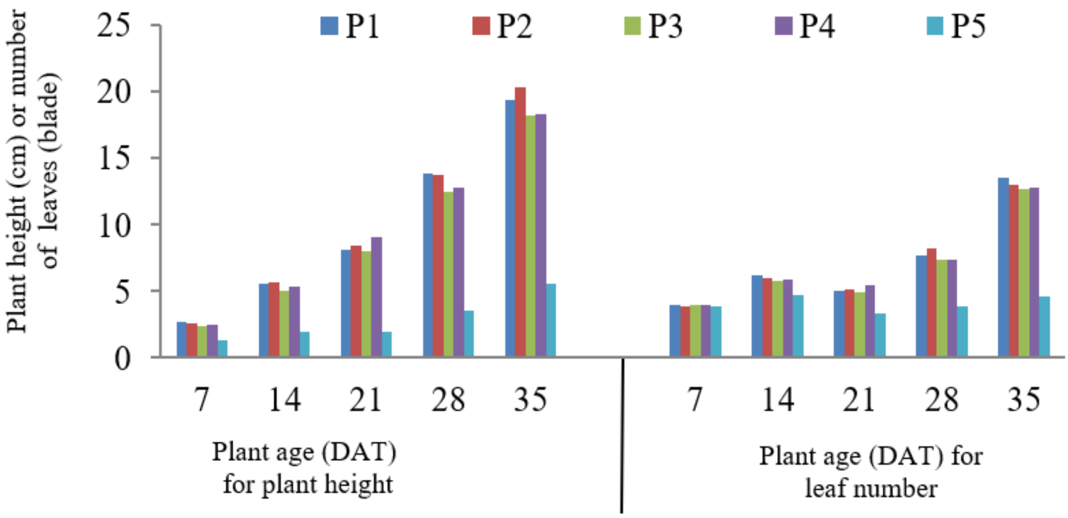

Figure 1. Growth pattern of green lettuce from 7 to 35 Days After Transplanting (DAT) for plant height and leaf number under different treatments of Liquid Organic Fertilizer (LOF) and AB mix. P1 (100% AB mix control); P2 (25% LOF + 75% AB mix); P3 (50% LOF + 50% AB mix); P4 (75% LOF + 25% AB mix); P5 (100% LOF)

Lettuce was harvested by uprooting the entire plant, and the following production parameters were observed: plant height, root length, fresh root weight, number of leaves, and fresh plant weight. The combination of liquid organic fertilizer (LOF) and AB mix treatments significantly affected plant height, fresh root weight, leaf number, and fresh plant weight ($P<0.05$). However, there was no significant effect on root length ($P>0.05$). All treatments combining LOF and AB mix, as well as the 100% AB mix treatment, produced similar responses across all parameters and were significantly different from the 100% LOF treatment (Table 1).

All treatments combining LOF with AB mix showed growth responses similar to those of the 100% AB mix control, demonstrating the efficiency of AB mix use. However, using 100% LOF did not result in better growth than other treatments. This indicates that green lettuce still requires AB mix, albeit in small quantities, for optimal growth. According to Sundari et al. (2016), AB mix is formulated from water-soluble mineral salts that efficiently meet the plant's nutrient needs, as the roots readily absorb them. Nutrients like nitrogen (N), found in both LOF and AB mix, are essential for green lettuce growth, particularly in increasing plant height. As the

Table 1. Average plant height, root length, fresh root weight, number of leaves, and fresh plant weight of green lettuce at 35 Days After Transplanting (DAT) under combined treatments of Liquid Organic Fertilizer (LOF) and AB mix.

Treatments	Plant height (cm)	Root length (cm)	Fresh root weight (g)	Number of Leaves (blade)	Fresh plant weight (g)
P1	19.33a	11.63	17.77a	13.50a	81.09a
P2	20.29a	11.03	18.68a	13.00a	107.59a
P3	18.17a	10.53	17.88a	12.67a	86.67a
P4	18.35a	12.38	15.74a	12.75a	79.25a
P5	6.62b	11.09	4.46b	4.58b	8.67b

Treatments: P1 (100% AB mix control); P2 (25% LOF + 75% AB mix); P3 (50% LOF + 50% AB mix); P4 (75% LOF + 25% AB mix); P5 (100% LOF).

amount of nitrogen absorbed by the plant increases, the meristematic tissue in the stem becomes more active, thereby promoting height growth (Febrianna et al., 2018). The 100% LOF treatment was insufficient to support plant growth due to its slow-release nature (Lestari & Putri, 2022). This finding is consistent with the results reported by Ramli and Makky (2019), who observed that hydroponically grown Ipomoea aquatica under a 100% LOF treatment showed significantly lower plant height and fresh weight than the control (100% AB mix). This suggests that LOF primarily functions as a supplementary nutrient source rather than a complete replacement for the AB mix in fulfilling plant nutritional requirements.

All treatments, with or without AB mix, showed similar root length responses. The roots were constantly submerged in water, and nutrients were always available, so root growth was not influenced by hydrotropism, geotropism, or chemotropism, all of which typically stimulate root elongation. Hydrotropism refers to the growth direction of plant roots towards water sources, allowing them to grow actively in any direction towards water. Geotropism is influenced by gravity, which determines the direction of root growth towards the center of the Earth (Dietrich, 2018).

Chemotropism drives roots to search for and grow towards available nutrient sources (Henke et al., 2014). However, root fresh weight showed a different response to AB mix use, as root enlargement is influenced by the products of photosynthesis, which are translocated by the phloem to all plant tissues, including the roots, to promote size increase. Hasan & Pakaya (2020) suggested that roots absorb the necessary nutrients and water required by the canopy for photosynthesis, and the canopy, in turn, supplies photosynthates to support root growth. Additionally, the presence of growth hormones, such as cytokinin, in LOF has been shown to enhance root growth (Riddech et al., 2025). The calcium (Ca) and phosphorus (P) found in both LOF and AB mix can also accelerate healthy root growth, thereby increasing fresh root weight (Munthe et al., 2018).

The number of leaves and fresh plant weight showed similar responses across all treatments combining LOF with the AB mix and the 100% AB mix, except for the 100% LOF treatment. This similarity is attributed to the sufficient nitrogen (N) content supplied by both the LOF and AB mix, which supports leaf formation. According to Mas'ud (2009), high nitrogen content in hydroponic nutrients stimulates leaf proliferation and enhances green pigmentation. A deficiency in nitrogen causes leaves to turn yellow or pale green and accelerates leaf senescence. Leaf number is also closely related to plant height, as taller plants tend to have more internodes and nodes, which serve as attachment sites for leaves (Novriansyah et al., 2017).

Similarly, fresh plant weight is influenced by water and nutrient absorption through the root system, which is then translocated to various plant organs. When nutrient availability is optimal and not excessive, lettuce plants can reach productive levels of fresh weight (Romza et al., 2024). The combination of LOF and AB mix enriches the hydroponic nutrient solution, stimulating metabolic activity and facilitating effective cell elongation and differentiation. According to Evelyn et al. (2012), fresh plant weight reflects the nutrient composition within plant tissues. One of the key elements is potassium (K), which is required for carbohydrate metabolism, acts as an activator of various enzymes involved in photosynthesis and respiration, and regulates cell osmotic potential, which is critical for stomatal opening and closing (Novriansyah et al., 2017).

Fresh plant weight is also affected by leaf number; higher leaf number leads to greater overall plant weight. Additionally, fresh weight is determined by the extent of branching and the vigor of lettuce plants (Perwitasari et al., 2012). Thus, the availability of essential nutrients through the combined LOF and AB mix treatment enhances both the number and size of plant cells, influencing water content and thereby increasing total fresh plant weight (Damanik, 2019).

Chlorophyll Content of Green Lettuce under Combined LOF and AB Mix Treatments

Chlorophyll is a green pigment found within the chloroplasts of all photosynthetic organisms. It captures solar energy and converts it into carbohydrates, thereby providing energy to support overall plant function (Dharmadewi, 2020). In higher plants, chlorophyll primarily exists in two forms: chlorophyll a and chlorophyll b, both of which play essential roles in photosynthesis. Chlorophyll b functions as a light-harvesting antenna, collecting light energy and transferring it to the photosynthetic reaction center, which is predominantly composed of chlorophyll a. The results of this study indicated that the chlorophyll a, b, and total chlorophyll contents in green lettuce leaves varied significantly across treatments (Table 2).

All treatments combining liquid organic fertilizer (LOF) with AB mix resulted in chlorophyll contents that were comparable to P1 treatment, indicating that LOF application successfully optimized the use of AB mix while maintaining sufficient chlorophyll production. The addition of LOF helped balance nitrogen availability in the AB mix to meet the chlorophyll-formation needs of green lettuce. According to Khan et al. (2019), nitrogen is one of the primary nutrients absorbed by plants for chlorophyll

Table 1. Chlorophyll a, chlorophyll b, and total chlorophyll content of green lettuce leaves under different combinations of Liquid Organic Fertilizer (LOF) and AB mix nutrient treatments.

Treatments	Chlorophyll Content (mg/g)		
	Chlorophyll a	Chlorophyll b	Total chlorophyll
P1	0.65	0.41	1.06
P2	0.89	0.57	1.46
P3	0.65	0.39	1.04
P4	0.79	0.50	1.29
P5	0.17	0.09	0.26

Treatments: P1 (100% AB mix control); P2 (25% LOF + 75% AB mix); P3 (50% LOF + 50% AB mix); P4 (75% LOF + 25% AB mix); P5 (100% LOF).

JURNAL BIODJATI

http://journal.uinsgd.ac.id/index.php/biodjati

synthesis, as indicated by lush canopies and dark green leaves. Panjaitan et al. (2019) also noted that lettuce, being a short-cycle crop, responds positively to nutrient uptake from LOF due to its ease of absorption by the roots.

However, the P5 treatment did not yield chlorophyll content as high as the other treatments, likely due to nitrogen deficiency, as indicated by chlorotic, yellowish-green leaves. The use of LOF alone, without supplementation from the AB mix, failed to meet the nitrogen requirements for optimal chlorophyll biosynthesis in green lettuce. Sangadji (2018) stated that nitrogen-deficient plants exhibit stunted growth, impaired leaf development, and leaf yellowing.

Based on all measured production parameters and chlorophyll content, the use of LOF at various concentrations was able to reduce and optimize the use of AB mix by 25–75% (P2-P4). The highest yield was obtained under P2 treatment. However, since no significant differences were found among the three LOF–AB mix combination treatments, the P4 treatment is considered.

CONCLUSION

The combination of liquid organic fertilizer (LOF) and AB mix produced growth and yield responses in green lettuce similar to those of the 100% AB mix treatment (P1) in a hydroponic wick system. The 100% LOF treatment (P5) without AB mix produced the lowest response in all growth and production parameters. The 75% LOF (7.5 mL in 2000 mL of water) + 25% AB mix (P4) was the most effective in optimizing AB mix use.

AUTHOR CONTRIBUTION

D conceived and designed the study. **F.M.D.**, experimented and collected the data under supervision. **D** and **AK** performed data analysis and interpretation and contributed to the writing of the manuscript. **J.**, assisted in data analysis while **A.A.F.A.** contributed to the language refinement and editing of the manuscript. All authors have read and approved the final version of the manuscript.

ACKNOWLEDGMENTS

The authors would like to express their gratitude to CV. Hadid Indonesia Berkarya and PT. Xpro Nusantara Raya for providing financial support for this research.

CONFLICT OF INTEREST

The authors have no conflicts of interest to declare. the most efficient for reducing AB mix usage by up to 75%.

REFERENCES

Al Toriq, M. R., Puspitawati, R. P., & Oxi, R. Y. (2025). Combination of Hydroponic Natural Nutrient Solution Effect on Kale Plant Growth (*Ipomoea reptans*) Using Wick System. *LenteraBio: Berkala Ilmiah Biologi* , 14(1), 130–137. DOI: 10.26740/lenterabio.v14n1.p130-137

Aroca, R., Porcel, R., & Ruiz-Lozano, J. M. (2012). Regulation of root water uptake under abiotic stress conditions. *Journal of Experimental Botany*, 63(1), 43–57. DOI: 10.1093/jxb/err266 1

Badan Pusat Statistik. (2019). *Produksi Tanaman Sayuran*. In Badan Pusat Statistik.https://www.bps.go.id/indicator/55/61/1/produksi-tanaman-sayuran.html

Badan Pusat Statistik Provinsi DKI Jakarta. (2021). *Statistik Hortikultura Provinsi DKI Jakarta*. In Badan Pusat Statistik.

Dasumiati, Siregar, M. M., Khairiah, A., & Junaidi. (2024). Pertumbuhan Dan Produksi Tanaman Kale (*Brassica oleracea* L. var. acephala) Pada Sistem *Hidroponik Deep Flow Technique*

Dengan Penambahan Pupuk Organik Cair. *Al-Kauniyah: Jurnal Biologi*, *17*(1) 212-219. DOI: 10.15408/kauniyah.v17i1.35563.

Dharmadewi, A. I. M. (2020). Analisis Kandungan Klorofil Pada Beberapa Jenis Sayuran Hijau Sebagai Alternatif Bahan Dasar *Food Suplement*. *Emasains: Jurnal Edukasi Matematika dan Sains*, 9(2), 171–176. DOI: 10.5281/zenodo.4299383

Dietrich, D. (2018). Hydrotropism: How Roots Search for Water. *Journal of Experimental Botany, 69*(11), 2759-2771. DOI: 10.1093/jxb/ery034

Hasan, F., & Pakaya, N. (2020). Perbedaan Jenis Komposisi Media Tanam Terhadap Pertumbuhan dan Produksi Kangkung Darat (*Ipomea reptans* Poir) dalam Polibag. *Jurnal Agercolere, 2*(1), 17-23.

Febrianna, M., Prijono, S., & Kusumarini, N. (2018). Pemanfaatan Pupuk Organik Cair untuk Meningkatkan Serapan Nitrogen serta Pertumbuhan dan Produksi Sawi (*Brassica juncea* L.) pada Tanah Berpasir. *Tanah dan Sumberdaya Lahan, 5*(2), 2549–9793. http://jtsl.ub.ac.id

Fitmawati, Isda, M. N., Isnaini, Sofiyanti, N., & Roza, R. M. (2019). Inovasi Teknologi Hidroponik Melalui Pemanfaatan Barang Bekas dan Nutrisi Buatan Sendiri Sebagai Usaha Peningkatan Pendapatan Petani di Desa Kualu Kecamatan Tambang Kabupaten Kampar. *Unri Conference Series: Community Engagement, 1,* 499–505. DOI: 10.31258/unricsce.1.499-505

Hairuddin, R., & Mawardi, R. (2017). Efektivitas Pupuk Organik Air Cucian Beras Terhadap Pertumbuhan Tanaman Sawi (*Brassica junceai* L.). *Perbal:Jurnal Pertanian Berkelanjutan*, 3(3), 79-84. URL: https://semanticscholar.org/paper/e0876f5a28a1690f613a4dded446bb9f13d5214

Husnaeni, F., & Setiawati, M. R. (2018). Pengaruh Pupuk Hayati dan Anorganik Terhadap Populasi Azotobacter, Kandungan N, dan Hasil Pakcoy pada Sistem *Nutrient Film Technique. Jurnal Biodjati*, 3(1), 90. DOI: 10.15575/biodjati.v3i1.2252

Khan, S., Yu, H., Li, Q., Gao, Y., Sallam, B. N., Wang, H., Liu, P., & Jiang, W. (2019). Exogenous Application of Amino Acids Improves the Growth and Yield of Lettuce by Enhancing Photosynthetic Assimilation and Nutrient Availability. *Agronomy*, 9(5), 266. DOI: 10.3390/agronomy9050266

Khoiriyah. N. & Nugroho, A. (2018). Pengaruh Konsentrasi dan Frekuensi Aplikasi Pupuk Organik Cair Pada Tanaman Pakcoy (*Brassica rapa* L.) Varietas Flamingo. *Jurnal Produksi* Tanaman, 6(8), 1875–1883. URL: https://protan.studentjournal.ub.ac.id/index.php/protan/article/view/852.

Lestari, I. P., & Putri, D. N. (2022). Efikasi Aplikasi Komposisi AB Mix, Eco Enzyme dan Pupuk Hayati Terhadap Pertumbuhan dan Hasil Kangkung pada Sistem Hidroponik Statis. *Prosiding Seminar Nasional Hasil Penelitian Agribisnis VI, 6*(1), 248–254. DOI: 10.25139/prosiding.v6i1.7422.

Marliah, A., Hayati, M., & Muliansyah, I. (2012). Pemanfaatan Pupuk Organik Cair Terhadap Pertumbuhan dan Hasil Beberapa Varietas Tomat (*Lycopersicum esculentum* L.). *Jurnal Agrista, 16*(3), 122–128. http://jurnal.unsyiah.ac.id/agrista/article/view/656

Mas'ud H. (2009). Sistem Hidroponik dengan Nutrisi dan Media Tanam Berbeda Terhadap Pertumbuhan dan Hasil Selada. *Media Litbang Sulteng, 2*(2), 131–136.

Munthe, K., Pane, E., & Panggabean, E. L. (2018). Budidaya Tanaman Sawi (*Brassica juncea* L.) pada Media Tanam yang Berbeda Secara Vertikultur.

Agrotekma: Jurnal Agroteknologi Dan Ilmu Pertanian, 2(2), 138. DOI: 10.31289/agr.v2i2.1632

Novriansyah, W. D., Armaini., & Ruslam, R. (2017). Pengaruh Aplikasi Urine Sapi Terfermentasi Terhadap Pertumbuhan dan Hasil Tanaman Selada (*Lactuca sativa* L.). *Jom Faperta, 4*(1). URL: https://jom.unri.ac.id/index.php/JOMFAPERTA/article/view/16816.

Panjaitan, E., Silaen, S., Damanik, R. D., & Damanik, R. D. (2019). Respon Pertumbuhan dan Produksi Tanaman Selada (*Lactuca sativa* L.) terhadap Pemberian Pupuk Kandang dan Mikroorganisme Lokal (MOL). *Agrotekma: Jurnal Agroteknologi Dan Ilmu Pertanian, 4*(1), 1. https://doi.org/10.31289/agr.v4i1.2712

Putri, N. D., Hastuti, E. D., & Budihastuti, R. (2017). Pengaruh Pemberian Limbah Kopi terhadap Pertumbuhan Tanaman Selada (*Lactuca sativa* L.). *Jurnal Biologi, 6*(4), 41–50.

Ramadhanty, A. R., Wiyono, S. N., Kusno, K., & Trimo, L. (2020). Analisis Kelayakan Usaha Budidaya Selada Krop di CV. Cantigi Desa Cikandang Kecamatan Cikajang Kabupaten Garut. *Forum Agribisnis, 10*(1), 27–35. DOI: 10.29244/fagb.10.1.27-35

Ramli, & Makky, M. N. (2019). Pengujian Nutrisi Organik Cair Plus Agens Hayati pada *Sistem Nutrient Film Technique* (NFT) Hidroponik Tanaman Kangkung (*Ipomoea aquatica*). *Pro-STek, 1*(2), 106–112. DOI: 10.35194/prs.v1i2.829

Riddech, N., Ngo, M. N., Boonlue, S., Dongsansuk, A., Santanoo, S., & Theerakulpisut, P. (2025). Physical and Chemical Properties Evaluation of Liquid Organic Fertilizers (LOFs) and Their Effects on Promoting Rice Growth. *Sustainability, 17*(7), 3087. DOI: 10.3390/su17073087

Romalasari, A., & Sobari, E. (2019). Produksi Selada (*Lactuca sativa* L.) Menggunakan Sistem Hidroponik dengan Perbedaan Sumber Nutrisi. *Agriprima : Journal of Applied Agricultural Sciences, 3*(1), 36–41. DOI: 10.25047/agriprima.v3i1.158

Romza, E., Kalsum, U, & Solihin, M. (2024). Hidroponik Sistem Rakit Apung Tanaman Selada (*Lactuca sativa* L.) Pada Berbagai Konsentrasi Larutan Dan Berbagai Macam Media Tanam. *Jurnal Ilmu Pertanian Agronitas,6*(2), 460–465.

Sangadji, Z. (2018). Pengaruh Konsentrasi dan Waktu Aplikasi Pupuk Organik Cair Nasa Terhadap Pertumbuhan dan Produksi Tanaman Jagung Manis pada Tanah Sawah. *Median: Jurnal Ilmu Ilmu Eksakta, 10*(1), 18–27. 10.33506/md.v10i1.155

Senen, M. A., Leiwakabessy, C., Lamerkabel, J. S., & Uruilal, C. (2022). Studi Kerusakan Tanaman Sawi (*Brassica* sp.) dan Selada (*Lactuca sativa* L) Akibat OPT pada Sayuran Hidroponik di Kota Ambon. Jurnal Pertanian Kepulauan, 6(1), 9–22.

Sundari, Raden, I., & Hariadi, S. U. (2016). Pengaruh POC dan AB Mix Terhadap Pertumbuhan dan Hasil Tanaman Pakchoy (*Brassica chinensis* L.) dengan Sistem Hidroponik. Magrobis Journal, 16(2), 9–19. DOI: 10.4234/jjoffamilysociology.28.250.

Supiana, R., Suheri, H., & Isnaini, M. (2022). Pengaruh Diameter Pipa dan Komposisi Media Tanam Terhadap Pertumbuhan dan Hasil Tanaman Selada Hijau (*Lactuca sativa* L.) pada Sistem Hidroponik Vertikal. Jurnal Ilmiah Mahasiswa Agrokomplek, 1(1), 66–75. DOI: 10.29303/jima.v1i1.1214.

Zahra, N., Muthiadin, C., & Ferial. (2023). Budidaya tanaman selada (*Lactuca sativa* L.) secara hidroponik dengan sistem DFT di BBPP Batangkaluku.

Filogeni: Jurnal Mahasiswa Biologi, 3(1), 18–22. DOI: 10.24252/filogeni.v3i1.29922

Zamani, H. Z. (2022). *Subtitusi Nutrisi AB Mix Menggunakan Pupuk Organik Cair (Nasa dan Urin Kelinci) Terhadap Pertumbuhan Tanaman Sawi (Brassica juncea* L.*) pada Hidroponik Sistem Wick* (Issue 8.5.2017). Universitas Islam Negeri Maulana Malik Ibrahim Malang.