Agro Bali : Agricultural Journal
Vol. 7 No. 3: 676-690, November 2024
e-ISSN 2655-853X
https://doi.org/10.37637/ab.v7i3.1875

Optimization of Liquid Organic Fertilizer from Livestock Manure with Indigofera for Hydroponic Lettuce Growth

Farida Cintiyah♥, Salundik, Karti PDMH, Iyep Komala
Animal Production Science and Technology, Graduate Study Program, IPB University, Bogor, Indonesia
♥Corresponding author email: frdcntyh.fascfarida@apps.ipb.ac.id

Article history: submitted: May 26, 2024; accepted: October 31, 2024; available online: November 25, 2024

Abstract. Indonesia faces the challenge of declining agroecosystem quality due to the long-term use of synthetic chemical fertilizers, indicating the need for a transition to organic fertilizers to support sustainable agricultural practices. Therefore, this study aims to analyze the quality of liquid organic fertilizer made from dairy cow manure, laying hen manure, and Indigofera zollingeriana and to examine the effects of the combination of liquid organic fertilizer on the growth and yield of lettuce (*Lactuca sativa L*.). This research uses a Completely Randomized Design (CRD) experimental method with five treatments of liquid organic fertilizer (LOF) substitution and three replications to evaluate its effects on the growth and yield of hydroponic lettuce, where the data are analyzed using ANOVA and Tukey's post hoc test. The results show that the liquid organic fertilizer produced from the combination of dairy cow manure, laying hen manure, and Indigofera zollingeriana meets the quality standards of Minister of Agriculture Regulation No. 261 of 2019 with a total N content of 3.11%, P2O5 2.12%, and K2O 1.94%, and is effective in enhancing lettuce growth. The combination of liquid organic fertilizer and AB Mix, particularly AB Mix 75% + LOF 25% and AB Mix 50% + LOF 50%, results in optimal lettuce growth. Therefore, using a combination of liquid organic fertilizer and AB Mix can increase the efficiency of lettuce production in hydroponic systems and can be adopted by farmers to improve crop yields and quality.

Keywords: hydroponics; lettuce; liquid organic fertilizer; livestock manure; plant nutrients

INTRODUCTION

Lettuce (*Lactuca sativa L*.) is a green vegetable with high nutritional content and significant demand, although production remains low. Efforts to increase lettuce production are being made using hydroponic systems, a cultivation method that does not use soil media but instead uses rockwool and water (Fussy & Papenbrock, 2022; Gonzalez et al., 2022). Nutrients in hydroponics are provided in the form of a solution containing macro elements such as nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), and sulfur (S), as well as microelements such as manganese (Mn), copper (Cu), zinc (Zn), and iron (Fe) (Kumar et al., 2021; Purba et al., 2021). The nutrient content greatly influences the success of hydroponic cultivation in inorganic fertilizers, but the high cost is a major constraint for farmers (Ilhamdi et al., 2020). As a solution, liquid organic fertilizer (LOF) has become a favored alternative due to increasing public health awareness and many farmers switching from chemicals to liquid organic fertilizers (Amir et al., 2022; Setyowati et al., 2021). Liquid organic fertilizer from livestock manure, such as laying hen and dairy cow manure, can help plants achieve better yields and contain the necessary nutrients at an affordable price (Siswati et al., 2021). According to Rusmayadi et al., (2023) combining liquid organic fertilizer with inorganic fertilizer can increase the production and quality of lettuce. LOF from laying hen manure contains 2.79% N, 0.52% P, and 2.29% K, while dairy cow manure contains 0.25% N, 0.01% P, and 0.56% K (Lussy et al., 2017). To enhance the macro element content such as N in LOF, *Indigofera zollingeriana* (*I. zollingeriana*), a legume that can symbiotically interact with *Rhizobium sp.* bacteria to increase N levels in the nutrient content of liquid organic fertilizer, is used to reduce the use of chemical fertilizers (Damanhuri et al., 2020; Suharlina, 2012). The process of making LOF is carried out anaerobically with the help of microbes such as EM, resulting in dark brown, odorless fertilizer within 14-21 days (Minister of

e-ISSN 2655-853X
https://doi.org/10.37637/ab.v7i3.1875

Agriculture of the Republic of Indonesia, 2019).

Agriculture in Indonesia faces significant challenges that require a shift towards more environmentally friendly and sustainable practices. One of the main issues is the declining quality of agro-ecosystems due to the long-term use of synthetic chemical fertilizers. This has resulted in organic matter content in many rice fields dropping below one percent, far below the level needed to maintain soil fertility (Rahman, 2021). This situation indicates the need for a transition to the use of organic fertilizers to improve soil quality and support sustainable agricultural practices. The dependence on pesticides and herbicides in traditional farming also negatively impacts the environment and human health. In this context, hydroponic farming, such as lettuce cultivation, offers a solution to reduce this dependency due to the more controlled environment, resulting in cleaner and healthier products. Organic fertilizers from livestock manure enriched with Indigofera can support more environmentally friendly organic farming practices. This research is unique in its approach, using livestock manure and Indigofera as the main ingredients for liquid organic fertilizer for hydroponic lettuce. It provides a potential and more economical alternative than expensive inorganic fertilizers.

Previous studies have shown different approaches to the use of fertilizers for hydroponics. For example, Khodijah et al., (2021) study examined various compositions of synthetic liquid, solid synthetic, and organic fertilizers on hydroponic lettuce growth. Still, it did not include using organic fertilizers from Indigofera or livestock manure; instead, it focused on combining synthetic and organic fertilizers from chicken feathers. This study excels in the more diverse fertilizer composition variations, including combinations with commonly used synthetic fertilizers. Phibunwatthanawong & Riddech, (2019) study examined liquid organic fertilizer produced from agricultural residues and industrial waste, such as molasses, distillation waste, and sugarcane leaves, on the growth of Green Cos lettuce. This study showed that liquid organic fertilizer from industrial waste could rival chemical fertilizers but did not use livestock manure as a base material. Meanwhile, Södergren et al., (2022) study assessed the microbiological safety of using anaerobic digestate from food waste as a nutrient source in hydroponic production, focusing mainly on microbiological risk assessment, showing that this digestate is microbiologically safe to use. Overall, the ongoing research stands out with its unique approach using livestock manure and Indigofera as the main ingredients for liquid organic fertilizer for hydroponic lettuce.

Therefore, this study aims to analyze the nutrient quality of liquid organic fertilizer made from dairy cow manure, laying hen manure, and *Indigofera zollingeriana* and to assess the effects of the combination of liquid organic fertilizers on the growth yield of lettuce (*Lactuca sativa L*.). The results of this study are expected to be implemented by farmers and livestock owners on a large scale as an environmentally friendly alternative liquid organic fertilizer that reduces the use of chemical fertilizers. Additionally, this study provides information for those interested in hydroponic lettuce cultivation, hoping to be a beneficial innovation for the community. The scope of the study includes the production of LOF from laying hen manure, dairy cow manure, and *I. zollingeriana* using EM4 activator and molasses. This research offers an environmentally friendly liquid organic fertilizer alternative, using a combination of livestock manure and Indigofera, and is expected to reduce dependence on chemical fertilizers in hydroponic lettuce cultivation.

METHODS

This research was conducted from December 2023 to March 2024 at Arsya Farm Greenhouse, Hambalang. The analysis of the liquid organic fertilizer content was carried out at the ICBB Laboratory – PT.

e-ISSN 2655-853X
https://doi.org/10.37637/ab.v7i3.1875

Biodiversitas Bioteknologi Indonesia. The equipment used included a hydroponic installation, blender, TDS meter, 5 L measuring cylinder, 30 L jerry can, thermometer, pH meter, and maintenance tools. The materials used included dairy cow manure, laying hen manure, Indigofera zollingeriana, lettuce junction seeds, rockwool, AB Mix nutrients, EM4, and molasses. The working procedure began with preparing plant nutrients, namely AB Mix nutrients and liquid organic fertilizer (LOF) from dairy cow manure, laying hen manure, and Indigofera zollingeriana. LOF was made by mixing fresh animal manure, *I. zollingeriana* leaves, water, EM4, and molasses. For the preparation of AB Mix Nutrients, first, prepare two containers, each containing ¾ of 500 mL of water. Then, to mix Nutrient A, pour Nutrient A into the container containing 375 mL of water, stir until dissolved, and add water until it reaches 500 mL. The next step is to mix Nutrient B in the same way: pouring it into the container containing 375 mL of water, stirring until dissolved, and adding water until it reaches 500 mL. After that, take 10 mL from each Mix A and Mix B. The final step is mixing the 10 mL A and 10 mL B solutions into 1 liter of water. Thus, the AB Mix Nutrients are ready for hydroponic plants.

Next, the process of making liquid organic fertilizer (LOF) begins with the preparation of materials consisting of 2.5 kg of dairy cow manure, 2.5 kg of laying hen manure, 5 kg of Indigofera zollingeriana, 1000 mL of molasses, 500 mL of Effective Microorganisms Activator (EMA), and sufficient water. After all the materials are gathered, the next step is mixing and homogenizing them evenly. During the fermentation process, the temperature of the LOF needs to be checked weekly to ensure the fermentation process runs well. The homogeneous mixture is then poured into a jerry can. The jerry can is tightly closed and equipped with a hose inserted into the jerry can and a bottle filled with water to create anaerobic fermentation conditions. This fermentation process lasts for 21 days. After 21 days, the LOF is filtered to separate the liquid from the insoluble solid material. The filtered LOF is then analyzed to ensure its quality and nutrient content. This analysis is crucial to ensure that the LOF contains the appropriate and beneficial nutrients for use as liquid organic fertilizer. The LOF is used by diluting 25 mL of LOF in 1 liter of water. Next, an analysis of the macro and micro nutrient content of LOF was conducted using spectrophotometry and the Kjeldahl method to measure the levels of N, P, K, Fe, Mn, and Zn. The hydroponic installation was constructed using a floating raft system with 20 holes on each styrofoam board, totaling 30 styrofoam boards. The installation had a tarp and pump for water and nutrient circulation. Lettuce seeds were sown in rockwool media, each rockwool containing one seed. According to the treatment dosage, hydroponic nutrients were provided on days 7, 14, 21, and 28 after transplanting (DAT). Transplanting was done after the seedlings were ten days old and had uniform and healthy growth characteristics. The maintenance involved checking the nutrient ppm levels weekly, and harvesting was done at 28 DAT. The observed variables included plant height, number of leaves, leaf width, leaf color, root length, fresh biomass, edible biomass, and yield analysis. Plant height, number of leaves, and leaf width were measured on days 7, 14, 21, and 28 DAT, while leaf color was observed on day 28 DAT using the Munsell color chart. Root length, fresh biomass, and edible biomass were measured at harvest on day 28 DAT. Yield analysis was conducted based on Minister of Agriculture Regulation No. 261 of 2019, calculating the total fertilizer cost and lettuce yield. Data were analyzed using a Completely Randomized Design (CRD) with five treatments and three replications:

A100C0 = AB Mix 100% + 0% Liquid Organic Fertilizer
A75C25 = AB Mix 75% + 25% Liquid Organic Fertilizer
A50C50 = AB Mix 50% + 50% Liquid

e-ISSN 2655-853X
https://doi.org/10.37637/ab.v7i3.1875

Organic Fertilizer
A25C75 = AB Mix 25% + 75% Liquid Organic Fertilizer
A0C100 = AB Mix 0% + 100% Liquid Organic Fertilizer

Each replication consisted of 40 plants. Data were tabulated using Microsoft Excel 2016 and analyzed with ANOVA using Minitab Statistical Software Version 21.1.0, with a Tukey test at a significance level of 0.05. The linear model for CRD is:

$$Yij = \mu + Ai + \varepsilon ij \quad (1)$$

Explanation:

Yij : Observation result on the j-th replication of the i-th LOF level substitution

μ : General mean value

Ai : LOF addition treatment at the i-th level (0%; 25%; 50%, 75%, 100%)

εij : Experimental error from the i-th level of LOF (0%; 25%; 50%, 75%, 100%)

i : Level (concentration) of LOF addition (0%; 25%; 50%, 75%, 100%)

j : Replication (1, 2, 3)

The data obtained were analyzed using analysis of variance (ANOVA) at a 95% confidence level to determine the effect of the treatments. If the treatment had a significant effect, a Tukey test was performed (Robert & Torrie, 1995).

RESULTS AND DISCUSSION

Analysis of Macro and Micro Nutrient Content in Liquid Organic Fertilizer

The results of the analysis of macro and micro nutrient content in liquid organic fertilizer (LOF) from dairy cow manure, laying hen manure, and *I. zollingeriana* can be seen in **Table 1**.

Table 1. Results of macro and micro nutrient content analysis in liquid organic fertilizer

Parameter	Method	Unit	Liquid Organic Fertilizer (LOF)	Standard of the Ministry of Agriculture	Character of LOF
Total N	Kjeldahl	%	3.11		High
Total P2O5	HClO4 HNO3 - Spektrofotometri	%	2.12	2-6%	Sufficient
Total K2O	HClO4 HNO3 - AAS	%	1.94		Slightly Low
Total Iron (Fe)	HClO4 HNO3 - AAS	ppm	357.50	90-900 ppm	Sufficient
Manganese (Mn)	HClO4 HNO3 - AAS	ppm	36.25	25-500 ppm	Sufficient
Zinc (Zn)	HClO4 HNO3 - AAS	ppm	8.00	25-500 ppm	Low

Note: Results of Laboratory Analysis ICBB-PT. Biodiversitas Bioteknologi Indonesia (2024)

Based on the laboratory analysis results in **Table 1**, the total nitrogen (N) content in the liquid organic fertilizer (LOF) is 3.11%, which meets the quality standards required for LOF as stipulated in the Ministry of Agriculture Regulation No. 261 of 2019 concerning the quality requirements for LOF with a minimum N standard of 2%. The high nitrogen content in the LOF combining dairy cow manure, laying hen manure, and *Indigofera zollingeriana* is due to the macronutrients such as N, P, K, Mg, and Ca found in the leaves of *I. zollingeriana*. The nutrient content of *I. zollingeriana* forage (leaves and branches) includes 4.68% N (Abdullah, 2010). In addition to the high nitrogen content in *I. zollingeriana*, the addition of dairy cow manure and laying hen manure also increases the nitrogen content in the LOF because they contain macronutrients such as N, P, and K. According to Zhu et al., (2020), dairy cow manure contains 0.7–1.3% N while laying hen manure contains 1.0% N. The combination of these three components

e-ISSN 2655-853X
https://doi.org/10.37637/ab.v7i3.1875

(dairy cow manure, laying hen manure, and *I. zollingeriana*) demonstrates that the extract of Indigofera leaves, cow manure, and chicken manure contains high nitrogen, as evidenced by the analysis results showing 3.11% N in the LOF.

The high phosphorus content in the LOF combining dairy cow manure, laying hen manure, and *I. zollingeriana* at 2.12% also meets the standards required for LOF in the Ministry of Agriculture Regulation No. 261 of 2019, with a minimum P standard of 2%. This is because the extract of *I. zollingeriana* leaves contains high P minerals at 0.46% (Abdullah, 2010). The high phosphorus content in the LOF is also influenced by the addition of dairy cow manure and laying hen manure. This is supported by Sulistyono et al., (2023) research, which found that the fermentation of cow manure using EM4 resulted in a LOF with 0.09% P. Additionally, Okolie et al., (2023) found that the high P content in LOF can be influenced by the balance of nutrients in the fertilizer, allowing the bacteria present in cow and chicken manure to convert nutrients into macronutrients without turning them into methane gas.

The potassium (K) content in the LOF combining dairy cow manure, laying hen manure, and *I. zollingeriana* is 1.94%. This K content meets the quality standards required in the Ministry of Agriculture Regulation No. 261 of 2019, with a minimum % macronutrient standard of 2%. The high K content is due to K being a catalyst for microbes or microorganisms to accelerate the fermentation process. Furthermore, adding bioactivators in the production of LOF also influences the high K content. This is consistent with Apriani & Asngad, (2023) who stated that K in potassium dioxide compounds used by microorganisms in the substrate acts as a catalyst, affecting bacterial presence and activity during fermentation.

The analysis results in **Table 1** show the micronutrient contents of Fe, Mn, and Zn in the LOF from dairy cow manure, laying hen manure, and *I. zollingeriana* are 357.50 mg/L, 36.25 mg/L, and 8.00 mg/L, respectively. The micronutrient content meets the minimum standards required in the Ministry of Agriculture Regulation No. 261 of 2019, which specifies Fe as a total micronutrient of 90-900 ppm and Mn as a total of 25-500 ppm. However, the Zn micronutrient does not meet the minimum 25-500 ppm standard. Although micronutrients are needed in small amounts, they are essential for plants to perform normal metabolic processes (Abdoli, 2020; Ernawati et al., 2021).

Plant Height

Based on the analysis of variance results in **Table 2**, there is a significant effect ($P<0.05$) on the height of lettuce plants on days 7, 14, 21, and 28 days after planting (DAP). The average height of lettuce plants shows significant differences on days 7, 14, 21, and 28 DAP.

Table 2. Average height of lettuce plants (cm) at various observation ages

Treatment	Observation Age			
	7	14	21	28
$A_{100}C_0$	5.65±0.86a	9.13±1.71a	13.37±2.44a	16.48±2.60b
$A_{75}C_{25}$	5.08±1.06b	7.43±1.48b	12.31±2.45b	17.41±2.62a
$A_{50}C_{50}$	3.96±1.28c	5.65±1.31c	10.67±1.69c	16.96±1.72ab
$A_{25}C_{75}$	3.50±0.68d	5.58±1.12c	11.02±1.69c	10.97±1.91c
A_0C_{100}	2.14±0.53e	2.85±0.67d	7.28±1.18d	8.05±1.34d

Note: Different letters in the same column indicate significant differences in Tukey's test at α=0.05.

Observations on plant height on days 7, 14, and 21 DAP show that the A_0C_{100} treatment had the lowest heights compared to treatments with AB Mix and LOF substitution. The highest averages can be seen in the $A_{100}C_0$ treatment as the control

e-ISSN 2655-853X
https://doi.org/10.37637/ab.v7i3.1875

and $A_{75}C_{25}$ as the AB Mix substitution, which differs significantly from $A_{50}C_{50}$ and $A_{25}C_{75}$. This is because the lettuce plants have not fully absorbed the absorption of macro and micronutrients in the treatments given liquid organic fertilizer doses. According to Trisnawati & Suparti, (2023), the difference in the composition of AB Mix and liquid organic fertilizer substitution results in differences in plant height because the nutrients contained in the liquid organic fertilizer cannot replace the nutrients in the AB Mix. Observations on days 7, 14, and 21 show significantly different growth. On day 28, there is a significant difference in the height of plants given AB Mix and LOF substitutions compared to those without AB Mix.

Observations of plant height on the 28th day after planting (DAP) showed that the treatment $A_{75}C_{25}$ had the highest average, followed by $A_{50}C_{50}$, which was not significantly different from $A_{100}C_{0}$ as the control treatment. This is due to the increase in liquid organic fertilizer (LOF) doses, which leads to increased lettuce plant height. According to Miranti et al., (2023), the height of the plants in the $A_{75}C_{25}$ treatment was due to the provision of AB Mix nutrients, which are complete and can function as a supplement, while LOF has relatively low nutrient content. Therefore, treatments given AB Mix nutrient doses with higher or equal concentrations to LOF can optimally support lettuce plant growth. The results of the $A_{0}C_{100}$ treatment without AB Mix showed less than optimal plant height growth compared to other treatments. Liquid organic fertilizer from three combinations (dairy cow manure, laying chicken manure, and *I. zollingeriana*) contains macro and microelements such as N, P, K, Mn, Fe, and Zn, but these nutrients have not met the lettuce plant's needs in the vegetative phase, particularly plant height. The low Zn content in LOF does not affect the increase in plant height (Indriyani et al., 2021).

Number of Leaves

Based on the results of the variance analysis in **Table 3**, it can be seen that there is a significant effect ($P<0.05$) of the combination substitution of AB Mix and Liquid Organic Fertilizer (LOF) on the number of lettuce leaves on days 7, 14, 21, and 28 after planting. The average number of leaves shows that the $A_{100}C_{0}$ treatment was the highest on days 7 and 21, the $A_{25}C_{75}$ treatment was the highest on day 14, and the $A_{75}C_{25}$ treatment was the highest on day 28. Meanwhile, the number of leaves given the $A_{0}C_{100}$ nutrient treatment was significantly different from the other treatments on days 7, 14, 21, and 28 DAS.

Table 3. Average number of leaves of plants (leaves) at various observation ages

Treatment	**Observation Age**			
	7	**14**	**21**	**28**
$A_{100}C_{0}$	3.93±0.59a	5.14±0.94b	6.87±1.19a	10.45±1.82a
$A_{75}C_{25}$	3.78±0.55ab	5.00±0.78b	6.61±0.98a	10.87±1.69a
$A_{50}C_{50}$	3.42±0.68c	4.34±1.05c	6.71±1.09a	10.38±1.43a
$A_{25}C_{75}$	3.57±0.57bc	5.55±0.85a	6.18±0.91b	9.08±1.09b
$A_{0}C_{100}$	2.69±0.57d	4.16±0.52c	5.13±0.79c	7.75±1.13c

Note: Different letters in the same column indicate significant differences in the Tukey test α=0.05

The number of leaves in the nutrient treatment without AB Mix was relatively low due to a suspected deficiency of the micronutrient Zn. Although required in small amounts, a deficiency in micronutrients can cause the plant to become less fertile. A Zn deficiency can affect vegetative growth, particularly the number of leaves (Hacisalihoglu, 2020; Phuphong et al., 2020). The combination of the AB Mix and LOF application influences the number of leaves in lettuce growth. Treatments with higher

 e-ISSN 2655-853X
https://doi.org/10.37637/ab.v7i3.1875

concentrations of AB Mix compared to LOF, such as $A_{100}C_0$, $A_{75}C_{25}$, and $A_{50}C_{50}$, showed high average leaf counts. Meanwhile, treatments with higher concentrations of LOF, such as $A_{25}C_{75}$ and A_0C_{100}, had relatively fewer leaves. Although A25C75 was relatively low, it had the highest average on day 14 and significantly differed from $A_{100}C_0$ and $A_{75}C_{25}$. This occurred because, on day 14, many leaves in each treatment experienced wilting and yellowing and were unfit, but the $A_{25}C_{75}$ treatment did not experience any wilting or damage on day 14. Regarding maintenance, wilted and unfit leaves were immediately removed, resulting in a higher average in the $A_{25}C_{75}$ treatment compared to the others on day 14. According to Sudiartini et al., (2021), leaf spot symptoms in lettuce plants have been reported to be caused by several fungi in hydroponic plants, characterized by wilting, yellow leaves, and brown spots.

Applying LOF without AB Mix resulted in a relatively low number of leaves. The number of leaves on lettuce plants on day 28 DAS with the $A_{50}C_{50}$ or higher treatment can provide sufficient nutrients. According to Ichsan et al., (2021) explains that the number of leaves is closely related to the plant's productivity in producing photosynthates needed by the plant during the vegetative phase.

Leaf Width

Based on the analysis of variance in **Table 4**, it can be seen that there is a significant effect ($P<0.05$) of the substitution combination of AB Mix and POC on the leaf width of lettuce at 7, 14, 21, and 28 days after transplanting (DAT). The average leaf width of lettuce plants in treatment A100C0 was significantly different from treatments A75C25, A50C50, and A25C75, and had the highest average from 7, 14, and 21 DAT.

Table 4. Average leaf width of lettuce plants (cm) at various observation ages

Treatment	Leaf width at observation age (cm) ± SD			
	7	14	21	28
$A_{100}C_0$	3.19±0.53a	6.09±1.18a	7.67±1.95a	8.88±1.68b
$A_{75}C_{25}$	2.88±0.64b	4.83±1.17b	6.93±1.60b	8.97±1.72b
$A_{50}C_{50}$	2.35±0.63c	3.57±1.00c	6.74±1.54bc	9.93±2.05a
$A_{25}C_{75}$	2.22±0.40c	3.77±0.82c	6.32±1.28c	6.99±1.49c
A_0C_{100}	1.35±0.34d	1.87±0.45d	4.21±1.02d	5.67±1.22d

Note: Different letters in the same column indicate significant differences based on Tukey's test α=0.05.

The leaf width of lettuce plants given the $A_{50}C_{50}$ nutrient treatment showed the highest average significantly different from all other treatments on the 28th DAT, reaching 9.9 cm. This is because at the observation age of 28 DAT, the application of LOF and AB Mix ($A_{50}C_{50}$) was able to capture sunlight more optimally in the photosynthesis process. This is consistent with the opinion of Zheng et al., (2021), which states that increased sunlight reception can enhance the photosynthesis process and produce higher photosynthates. The presence of Fe elements from the nutrient combination tends to increase leaf width but does not affect stem diameter. The more leaves present, the wider the leaf becomes. With a larger number of leaves and a wider area, sunlight energy can be captured more maximally for the photosynthesis process, resulting in higher assimilate production (Shen et al., 2021).

The leaf width in the A_0C_{100} treatment without AB Mix was relatively small and significantly different from the other treatments, which is suspected to be due to the insufficient nutrient content available in LOF, particularly nitrogen (N) and phosphorus (P) elements. Therefore, it is necessary to add AB Mix in larger or equal concentrations when combined with LOF. Although the leaf width in the A_0C_{100} treatment was relatively small, the growth of lettuce still increased weekly due to the results of the analysis of liquid organic

e-ISSN 2655-853X
https://doi.org/10.37637/ab.v7i3.1875

fertilizer from dairy cow manure, laying chicken manure, and *I. zollingeriana*, which produced N and P nutrient values that met the standards of Minister of Agriculture Regulation No.261 of 2019. Liquid organic fertilizer will be richer in nutrient types and quantities if the fertilizer composition comes from various organic sources. Although liquid organic fertilizer is richer in nutrients,

Based on the variance analysis results in **Table 5**, it can be seen that there is a significant effect (P<0.05) of the substitution combination of AB Mix and LOF on fresh biomass, edible biomass, root length, and leaf color of lettuce plants on days 7, 14, 21, and

the leaf width of lettuce plants in the A_0C_{100} treatment did not grow faster than the other treatments. This is suspected because the absorption of nutrients from the first to the fourth week was not yet maximal.

Fresh Biomass, Edible Biomass, Root Length, and Leaf Color

28 at harvest. Treatments with different concentrations showed that liquid organic fertilizer produced fresh plant biomass. The highest fresh biomass response was shown in the $A_{75}C_{25}$ treatment, with an average of 117.30 g.

Table 5. Average fresh biomass, edible biomass, root length, and leaf color of lettuce plants at harvest

Treatment	Fresh Plant Weight (g) ± SD	Edible Weight (g) ± SD	Root Length (cm) ± SD	Leaf Color
$A_{100}C_0$	107.56±9.23b	91.34±10.18a	18.02±1.62c	10.0GY 5/12
$A_{75}C_{25}$	117.30±9.67a	88.24±6.45b	35.40±0.92a	10.0GY 6/12
$A_{50}C_{50}$	116.08±9.52a	80.74±5.59c	28.22±1.44b	10.0GY 7/12
$A_{25}C_{75}$	65.45±5.41c	45.28±3.88d	15.47±1.26d	10.0GY 7/12
A_0C_{100}	38.43±4.90d	29.08±3.79e	11.30±0.91e	10.0GY 7/12

Note: Different letters in the same column indicate significant differences based on Tukey's test α=0.05

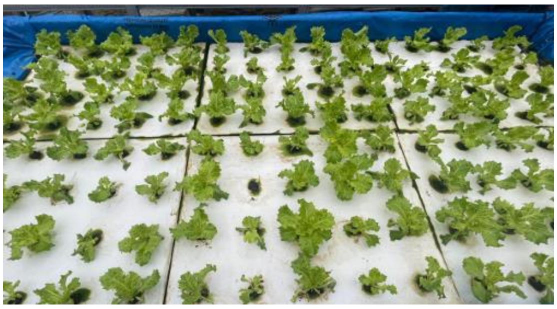
$A_{100}C_0$ Treatment

A_75C_{25} Treatment

$A_{50}C_{50}$ Treatment

$A_{25}C_{75}$ Treatment

e-ISSN 2655-853X
https://doi.org/10.37637/ab.v7i3.1875



A_0C_{100} Treatment

Figure 1. Lettuce plants in each treatment

Based on **Table 5**, the $A_{75}C_{25}$ treatment was not significantly different from $A_{50}C_{50}$, with the highest averages of 117.30 g and 116.08 g, respectively. Meanwhile, the A100C0 treatment was the third highest and significantly different from the A_0C_{100} treatment. This is presumably because fresh plant biomass is influenced by plant height, number of leaves, and rockwool media. The taller the lettuce plant and the more leaves it has, the higher the fresh biomass. Fresh plant biomass is the accumulation of photosynthate in the form of plant biomass consisting of proteins, carbohydrates, lipids, and water content in the leaves (Yavari et al., 2021). The larger a plant's biomass, the more nutrients the lettuce plant absorbs (Sudiarto et al., 2019). This shows that the treatment given LOF without AB Mix resulted in suboptimal growth of the lettuce plants. However, applying liquid organic fertilizer can increase the plants' absorption of macronutrients, gradually improving the growth of the lettuce plants.

Biomass is generally used as an indicator of plant growth. Edible biomass is a growth parameter that plays a role in determining the economic quality of the lettuce crop. Based on **Table 5**, the $A_{100}C_0$ treatment significantly differed from $A_{75}C_{25}$, A50C50, A25C75, and A0C100, with the highest average of 91.34 g. This is presumably because edible biomass is influenced by leaf quality, plant height, and root length. The more leaves that are damaged, the lower the weight of the lettuce vegetables. The high value of edible biomass in the A100C0 treatment is likely due to the high nutrient content that can be absorbed and used for plant metabolism, resulting in fewer damaged leaves. Based on **Table 5**, the combination of liquid organic fertilizer significantly affected the edible biomass in each treatment. The application of LOF to lettuce plants requires complex management due to the presence of many pests and pathogenic fungi. Lettuce plants infected with these pests and fungi lose weight because damaged leaves must be cut off and cannot be sold to premium markets due to the lower quality of the product obtained (Sudiartini et al., 2021).

According to the variance analysis in **Table 5**, the combination of liquid organic fertilizer with hydroponic nutrition significantly affected the root length of lettuce plants over 28 days at harvest. It can be seen that the longest average root length was shown by the $A_{75}C_{25}$ treatment at 35.40 cm. The shortest root length was found in the A0C100 treatment, with an average of 11.30 cm, indicating that the higher the LOF and AB Mix concentration, the shorter the plant roots. The $A_{25}C_{75}$ and A_0C_{100} treatments produced short roots that developed slowly, likely due to less optimal nutrient absorption and excess P nutrients. The amount of dissolved oxygen in the water also affects plant growth (Ayi et al., 2019). According to Fussy & Papenbrock, (2022), sufficient oxygen in water helps plant roots absorb oxygen. Hydroponic cultivation with a floating system using styrofoam results in a wider root system, and water in the styrofoam does not absorb heat. The nutrients stored in the nutrient solution from the combination of AB Mix and LOF treatments significantly support root development (Miranti et al., 2023).

Leaf color is one aspect of plant diversity. Leaf color was measured using the Munsell color chart. Visual observation of leaf color showed differences based on the Munsell color chart (**Table 5**). The value indicates the lightness or darkness of the leaf color; the lower the value, the darker the color. The chroma indicates the purity gradient of the leaf color spectrum (Khodijah et al., 2022).

e-ISSN 2655-853X
https://doi.org/10.37637/ab.v7i3.1875

Nutrient treatments combined with the application of AB Mix and LOF resulted in leaf colors with codes 10 GY 6/12, 10 GY 7/12, and 10 GY 7/12, while nutrient treatments without the combination of AB Mix and LOF resulted in leaf colors with codes 10 GY 5/12 and 10 GY 7/12. The difference in leaf color at harvest is due to the higher chlorophyll content in leaves treated with AB Mix than in plants not treated with AB Mix. The leaf chlorophyll content is greatly influenced by the N in the nutrient solution provided (Tsouvaltzis et al., 2020). Based on the table of LOF content used, LOF nutrients have a higher N content but are still lower than AB Mix nutrients, so in application, the $A_{100}C_0$ treatment leaves tend to be greener. The low chlorophyll content also affects the photosynthesis process in plants, which tends to be slower in plant growth (Khodijah et al., 2022).

Analysis of Liquid Organic Fertilizer (LOF) and AB Mix Production

The use of Liquid Organic Fertilizer (LOF) and AB Mix as detailed in **Table 6** involves an average requirement of 10 kg of cow manure, chicken manure, and *I. zollingeriana* for LOF production. In contrast, an average of 4.5 kg of AB Mix is used in production.

Table 6. Cost efficiency of using LOF and AB Mix

Treatment	Description	Total Usage	Price Conversion	Total Cost (Rp)	Total Expenditure (Rp)
$A_{100}C_0$	AB Mix	4.500 mL	35 /mL	157.500	196.500
	POC	0 mL	1.25/mL	0	
	Lettuce Seeds	120 pcs	325 /pcs	39.000	
$A_{75}C_{25}$	AB Mix	4.000 mL	35 /mL	140.000	181.819
	POC	2.250 mL	1.25/mL	2.819	
	Lettuce Seeds	120 pcs	325 /pcs	39.000	
$A_{50}C_{50}$	AB Mix	2.500 mL	35 /mL	87.500	135.271
	POC	7.000 mL	1.25 /mL	8.771	
	Lettuce Seeds	120 pcs	325 / pcs	39.000	
$A_{25}C_{75}$	AB Mix	1.600 mL	35 /mL	56.000	113.795
	POC	15.000 mL	1,25 /mL	18.765	
	Lettuce Seeds	120 pcs	325 /pcs	39.000	
A_0C_{100}	AB Mix	0 mL	35 /mL	0	64.060
	POC	20.000 mL	1,25 /mL	25.060	
	Lettuce Seeds	120 pcs	35 /pcs	39.000	

Notes: Primary data was processed in March 2024; the conversion rate for AB Mix fertilizer per mL is Rp35; the conversion rate for liquid organic fertilizer (POC) per mL is Rp1.25; the conversion rate for lettuce seeds per piece is Rp325.

Efficient fertilizer cost expenditure will yield high income in lettuce production. According to Hanafie, (2010), efficiency is a measure that indicates economic resources in the production process to produce output. The total cost of using AB Mix and liquid organic fertilizer (LOF) and their combinations can be seen in **Table 6**. The table shows that the most significant cost component in fertilizer usage is AB Mix. The $A_{100}C_0$ treatment has the highest total cost of Rp196.500, while the lowest total cost is in the A_0C_{100} treatment, which is Rp64.060. The lowest total cost in the A_0C_{100} treatment is due to the 100% use of liquid organic fertilizer, where the raw materials for the liquid organic fertilizer are taken directly from livestock waste. The cost efficiency of using liquid organic fertilizer can be determined by comparing the production income obtained from selling lettuce plants. The detailed production income of lettuce is shown in **Table 7**.

e-ISSN 2655-853X
https://doi.org/10.37637/ab.v7i3.1875

Table 7. Lettuce production income from using LOF and AB Mix

Treatment	Units	Selling Price/Unit	Total Sales	Total Cost	Total Income
$A_{100}C_0$	60	Rp 8,000	Rp 480,000	196,500	Rp 283,500
$A_{75}C_{25}$	60	Rp 8,000	Rp 480,000	181,819	Rp 298,181
$A_{50}C_{50}$	55	Rp 8,000	Rp 440,000	135,271	Rp 304,729
$A_{25}C_{75}$	46	Rp 8,000	Rp 320,000	113,795	Rp 254,205
A_0C_{100}	44	Rp 8,000	Rp 320,000	64,060	Rp 287,940

Notes: Primary data processed in March 2024

The analysis results in **Table 7** show that the total sales from each treatment vary due to different sizes. The total income obtained varies from each treatment. The total income is derived from the total sales minus the fertilizer usage cost. The highest total income is in the $A_{50}C_{50}$ treatment, while the lowest is in the $A_{25}C_{75}$ treatment. Based on Tables 6 and 7, the most efficient use of LOF and AB Mix in lettuce production is the A_0C_{100} treatment. However, from observations using 100% LOF, lettuce growth has not provided optimal results and still requires several weeks to be harvested according to standards. LOF without AB Mix results in low lettuce growth and production. As observations and harvesting results show very low yields, liquid organic fertilizer cannot be used as the primary fertilizer in hydroponic activities. The use of liquid organic fertilizer must be accompanied by the use of AB Mix to achieve optimal results with a composition of AB Mix 50% or more (Astuti et al., 2021). Lettuce production achieves optimal results in the $A_{50}C_{50}$ and $A_{75}C_{25}$ treatments with a substitution composition of AB Mix 50% + LOF 50% and AB Mix 75% + LOF 25%. The $A_{25}C_{75}$ and A_0C_{100} treatments can be sold when harvest standards are met at the observation age of 49 DAP (Days After Planting). This is because the size of lettuce leaves can affect the selling and market prices.

CONCLUSION

Research findings indicate that the produced liquid organic fertilizer (LOF) contains macro and micro nutrients that meet established quality standards, with nitrogen (N) content at 3.11%, phosphorus (P) at 2.12%, and potassium (K) at 1.94%. The combination of LOF with AB Mix in various proportions has a significant impact on plant height growth, number of leaves, leaf width, fresh biomass, edible biomass, root length, and leaf color of lettuce. The best treatments were found in the combinations of AB Mix 75% + LOF 25% ($A_{75}C_{25}$) and AB Mix 50% + LOF 50% ($A_{50}C_{50}$), which provided optimal growth and production results for lettuce. LOF without AB Mix resulted in less optimal growth, thus it is recommended to use a combination of LOF and AB Mix to achieve maximum results in hydroponic lettuce cultivation.

ACKNOWLEDGEMENTS

This research would not have been successful without the support and assistance of various parties. We would like to thank Green House Arsya Farm, Hambalang, for providing facilities and logistical support during this study. We also extend our gratitude to the ICBB Laboratory team – PT. Biodiversitas Bioteknologi Indonesia for their cooperation and laboratory facilities provided for the analysis of the liquid organic fertilizer content.

REFERENCES

Abdoli, M. (2020). Effects of Micronutrient Fertilization on the Overall Quality of Crops. In *Plant Micronutrients: Deficiency and Toxicity Management*. Springer Nature Switzerland AG. https://doi.org/10.1007/978-3-030-49856-6_2

Abdullah, L. (2010). *Pengembangan Produk Hay, Tepung dan Pelet Daun Indigofera*

 e-ISSN 2655-853X
https://doi.org/10.37637/ab.v7i3.1875

cordifolia Sebagai Alternatif Sumber Protein Murah Pakan Kambing Perah. Bogor Agricultural University. https://repository.ipb.ac.id/handle/123456789/45190?show=full

Amir, N., Marlina, N., Palmasari, B., Aluyah, C., Aminah, I. S., Rompas, J. P., & Rohman, N. (2022). Respon Pertumbuhan dan Hasil Jagung Manis (Zea mays Saccharata Sturt L.) terhadap Pupuk Organik Cair Asal Limbah Buahan dan NPK di Lahan Kering. *Agro Bali : Agricultural Journal*, *5*(3), 498–503. https://doi.org/10.37637/ab.v5i3.1027

Apriani, D. P., & Asngad, A. (2023). International Conference on Biology Education , Natural Science , and Technology Quality of Moringa oleifera Leaf and Kiambang (Salvinia molesta) Solid Organic Fertilizer with Banana Peel Bioactivator. *International Conference on Biology Education, Natural Science, and Technology*, *1*(1), 122–132. https://proceedings.ums.ac.id/index.php/incobest/article/download/3425/3230/3955

Astuti, Y., Setyaningsih, M., & Lestari, S. (2021). Alternatif Pengganti Ab Mix Pada Perangkat Hidroponik. *Journal ABDI*, *7*(1), 6–11. https://journal.unesa.ac.id/index.php/abdi/article/view/4424

Ayi, Q., Zeng, B., Yang, K., Lin, F., Zhang, X., van Bodegom, P. M., & Cornelissen, J. H. C. (2019). Similar growth performance but contrasting biomass allocation of root-flooded terrestrial plant alternanthera philoxeroides (Mart.) Griseb. in response to nutrient versus dissolved oxygen stress. *Frontiers in Plant Science*, *10*(1), 1–10. https://doi.org/10.3389/fpls.2019.00111

Damanhuri, D., Erdiansyah, I., Eliyatiningsih, E., Sari, V. K., Pratama, A. W., & Wiharto, K. S. (2020). Utilization of Rhizobium spp as substitution agent of nitrogen chemical fertilizer on soybean cultivation. *IOP Conference Series: Earth and Environmental Science*, *411*(1), 1–5. https://doi.org/10.1088/1755-1315/411/1/012065

Ernawati, A., Abdullah, L., & Permana, I. G. (2021). Kandungan dan Serapan Mineral Pucuk Indigofera zollingeriana dari Tanaman dengan Kerapatan Tanam Berbeda. *Jurnal Ilmu Nutrisi Dan Teknologi Pakan*, *19*(2), 49–58. https://doi.org/10.29244/jintp.19.2.49-58

Fussy, A., & Papenbrock, J. (2022). An Overview of Soil and Soilless Cultivation Techniques—Chances, Challenges and the Neglected Question of Sustainability. *Plants*, *11*(1), 1–32. https://doi.org/ 10.3390/plants11091153

Gonzalez, R. S. V., Garcia-Garcia, A. L., Ventura-Zapata, E., Barceinas-Sanchez, J. D. O., & Sosa-Savedra, J. C. (2022). A Review on Hydroponics and the Technologies Associated for Medium- and Small-Scale Operations. *Agriculture (Switzerland)*, *12*(5), 1–21. https://doi.org/10.3390/agriculture12050646

Hacisalihoglu, G. (2020). Zinc (Zn): The last nutrient in the alphabet and shedding light on zn efficiency for the future of crop production under suboptimal zn. *Plants*, *9*(11), 1–9. https://doi.org/10.3390/plants9111471

Hanafie, R. (2010). *Pengantar Ekonomi Pertanian*. ANDI. https://books.google.co.id/books?id=RQ_mXpuCl9oC&printsec=frontcover#v=onepage&q&f=false

Ichsan, C. N., Bakhtiar, Sabaruddin, & Efendi. (2021). Morpho-agronomic traits and balance of sink and source of rice planted on upland rainfed. *IOP Conference Series: Earth and Environmental Science*, *667*(1), 1–9. https://doi.org/10.1088/1755-1315/667/1/012108

Ilhamdi, M. L., Khairuddin, K., & Zubair, M. (2020). Pelatihan Penggunaan Pupuk

e-ISSN 2655-853X
https://doi.org/10.37637/ab.v7i3.1875

Organik Cair (POC) Sebagai Alternatif Pengganti Larutan Nutrisi AB Mix pada Pertanian Sistem Hidroponik di BON Farm Narmada. *Jurnal Pengabdian Masyarakat Sains Indonesia*, *2*(1), 1–5. https://doi.org/10.29303/jpmsi.v2i1.20

Indriyani, L., Sutarno, & Sumarsono. (2021). (The effect of micro nutrition dose of zinc (Zn) on two types of manual fertilizer on growth and production of green bean (Vigna radiata L.)). *J. Agro Complex*, *5*(1), 66–73. http://ejournal2.undip.ac.id/index.php/joac

Khodijah, N. S., Arisandi, R. A., Saputra, H. M., & Santi, R. (2022). Kangkung Akuaponik dengan Perlakuan Berbagai Jenis Pupuk Foliar dan Padat Tebar Lele Pada Sistim Budikdamber Lele Kangkung. *Kultivasi*, *21*(1), 105–112. https://doi.org/10.24198/kultivasi.v21i1.37436

Khodijah, N. S., Santi, R., Kusmiadi, R., & Asriani, E. (2021). The growth rate of hydroponic lettuce at various nutrient compositions from liquid synthetic, solid synthetic, and liquid organic fertilizers. *Anjoro: International Journal of Agriculture and Business*, *2*(2), 41–49. https://doi.org/10.31605/anjoro.v2i2.993

Kumar, S., Kumar, S., & Mohapatra, T. (2021). Interaction Between Macro- and Micro-Nutrients in Plants. *Frontiers in Plant Science*, *12*(1), 1–9. https://doi.org/10.3389/fpls.2021.665583

Lussy, N. D., Walunguru, L., & Hambamarak, K. H. (2017). Karakteristik Kimia Pupuk Organik Cair Dari Tiga Jenis Kotoran Hewan Dan Kombinasinya. *Partner*, *22*(1), 452. https://doi.org/10.35726/jp.v22i1.239

Menteri Pertanian RI. (2019). *Keputusan Menteri Pertanian Republik Indonesia: Persyaratan Teknis Minimal Pupuk Organik, Pupuk Hayati, dan Pembenah Tanah* (pp. 1–18). Menteri Pertanian RI. https://psp.pertanian.go.id/

Miranti, P. A., Budi, S., & Nurjani, N. (2023). Pengaruh Kombinasi Ab Mix Dan Poc Terhadap Pertumbuhan Dan Hasil Selada Secara Hidroponik Wick System. *Jurnal Sains Pertanian Equator*, *12*(3), 337. https://doi.org/10.26418/jspe.v12i3.62124

Okolie, J. A., Jimoh, T., Akande, O., Okoye, P. U., Ogbaga, C. C., Adeleke, A. A., Ikubanni, P. P., Güleç, F., & Amenaghawon, A. N. (2023). Pathways for the Valorization of Animal and Human Waste to Biofuels, Sustainable Materials, and Value-Added Chemicals. *Environments - MDPI*, *10*(3). https://doi.org/10.3390/environments10030046

Phibunwatthanawong, T., & Riddech, N. (2019). Liquid organic fertilizer production for growing vegetables under hydroponic condition. *International Journal of Recycling of Organic Waste in Agriculture*, *8*(4), 369–380. https://doi.org/10.1007/s40093-019-0257-7

Phuphong, P., Cakmak, I., Yazici, A., Rerkasem, B., & Prom-u-Thai, C. (2020). Shoot and root growth of rice seedlings as affected by soil and foliar zinc applications. *Journal of Plant Nutrition*, *43*(9), 1259–1267. https://doi.org/10.1080/01904167.2020.1730900

Purba, J. H., Parmila, P. I., & Dadi, W. (2021). Effect of Soilless Media (Hydroponic) on Growth and Yield of Two Varieties of Lettuce. *Journal Of Agricultural Science And Agriculture Engineering*, *4*(2), 154–165. https://agriculturalscience.unmerbaya.ac.id/index.php/agriscience/article/view/58/44

Rahman, M. R. (2021). *Pertanian hidroponik dinilai jadi solusi keterbatasan lahan*. Antara. https://www.antaranews.com/berita/249

e-ISSN 2655-853X
https://doi.org/10.37637/ab.v7i3.1875

4253/pertanian-hidroponik-dinilai-jadi-solusi-keterbatasan-lahan

Robert, S., & Torrie, J. (1995). *Prinsip dan prosedur statistika: Suatu pendekatan biometrik* (2nd ed.). Gramedia pustaka utama.

Rusmayadi, G., Tan, H. T., Puspitoningrum, E., Pramono, S. A., & Dewa, D. M. R. T. (2023). Nutrient film in hydroponic system providing organic fertilizer of the Tithonia diversifolia and AB Mix for lettuce. *Nativa*, *11*(4), 470–475. https://doi.org/10.31413/nat.v11i4.16456

Setyowati, N., Hardianto, N., Widodo, W., & Muktamar, Z. (2021). Leek (Allium fistulosum, L.) Growth and Yield as Affected by Cow Manure and Guava Waste Liquid Organic Fertilizer. *Agro Bali : Agricultural Journal*, *4*(3), 305–313. https://doi.org/10.37637/ab.v4i3.732

Shen, L., Lou, R., Park, Y., Guo, Y., Stallknecht, E. J., Xiao, Y., Rieder, D., Yang, R., Runkle, E. S., & Yin, X. (2021). Increasing greenhouse production by spectral-shifting and unidirectional light-extracting photonics. *Nature Food*, *2*(6), 434–441. https://doi.org/10.1038/s43016-021-00307-8

Siswati, L., Rini Nizar, & Anto Ariyanto. (2021). Manfaatkan Kotoran Sapi Menjadi Kompos Untuk Tanaman Masa Pandemi Di Kelurahan Umbansari Kota Pekanbaru. *Dinamisia : Jurnal Pengabdian Kepada Masyarakat*, *5*(2), 531–537. https://doi.org/10.31849/dinamisia.v5i2.6343

Södergren, J., Larsson, C. U., Wadsö, L., Bergstrand, K. J., Asp, H., Hultberg, M., & Schelin, J. (2022). Food waste to new food: Risk assessment and microbial community analysis of anaerobic digestate as a nutrient source in hydroponic production of vegetables. *Journal of Cleaner Production*, *333*(1), 1–9. https://doi.org/10.1016/j.jclepro.2021.130239

Sudiartini, N. P. R., Wirya, G. N. A. S., & Sudarma, I. M. (2021). Identifikasi Jamur Penyebab Penyakit Utama pada Tanaman Kangkung Hidroponik. *Jurnal Agroekoteknologi Tropika*, *10*(3), 308–323. https://ojs.unud.ac.id/index.php/JAT308

Sudiarto, S. I. A., Renggaman, A., & Choi, H. L. (2019). Floating aquatic plants for total nitrogen and phosphorus removal from treated swine wastewater and their biomass characteristics. *Journal of Environmental Management*, *231*(1), 763–769. https://doi.org/10.1016/j.jenvman.2018.10.070

Suharlina. (2012). Manfaat Indigofera Sp. dalam Bidang Pertanian dan Industri. *Pastura*, *2*(1), 30–33. https://ojs.unud.ac.id/index.php/pastura/article/download/9013/6790

Sulistyono, A., Putri, K. A., & S., D. P. (2023). Effect of Liquid Organic Fertilizer Type and Concentration on the Growth and Production of Purple Eggplant (Solanum melongena L.). *Jurnal Teknik Pertanian Lampung (Journal of Agricultural Engineering)*, *12*(4), 997–1009. https://doi.org/10.23960/jtep-l.v12i4.997-1009

Trisnawati, D. P., & Suparti. (2023). Mustard (Brassica Juncea L.) Growth Hydroponically Using AB-Mix and Liquid Organic Fertilizer Tea Pulp. *International Conference on Biology Education, Natural Science, and Technology*, *1*(1), 394–401. https://proceedings.ums.ac.id/index.php/incobest/article/view/3445%0Ahttps://proceedings.ums.ac.id/index.php/incobest/article/download/3445/3250

Tsouvaltzis, P., Kasampali, D. S., Aktsoglou, D. C., Barbayiannis, N., & Siomos, A. S. (2020). Effect of reduced nitrogen and supplemented amino acids nutrient

 e-ISSN 2655-853X
https://doi.org/10.37637/ab.v7i3.1875

solution on the nutritional quality of baby green and red lettuce grown in a floating system. *Agronomy*, *10*(7), 1–15. https://doi.org/10.3390/agronomy10070922

Yavari, N., Tripathi, R., Wu, B. Sen, MacPherson, S., Singh, J., & Lefsrud, M. (2021). The effect of light quality on plant physiology, photosynthetic, and stress response in Arabidopsis thaliana leaves. *PLoS ONE*, *16*(3 March), 1–19. https://doi.org/10.1371/journal.pone.0247380

Zheng, J., Zhang, T. J., Li, B. H., Liang, W. J., Zhang, Q. L., Cai, M. L., & Peng, C. L. (2021). Strong Response of Stem Photosynthesis to Defoliation in Mikania micrantha Highlights the Contribution of Phenotypic Plasticity to Plant Invasiveness. *Frontiers in Plant Science*, *12*(1), 1–15. https://doi.org/10.3389/fpls.2021.638796

Zhu, Z., Li, L., Dong, H., & Wang, Y. (2020). Ammonia and greenhouse gas emissions of different types of livestock and poultry manure during storage. *Transactions of the ASABE*, *63*(6), 1723–1733. https://doi.org/10.13031/TRANS.14079