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Sustainable Nutrient Management for NFT Hydroponic Lettuce: Integrating Kipahit (*Tithonia diversifolia*) Liquid Organic Fertilizer with AB-Mix

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ABSTRACT

Purpose of the study: This study aims to determine the optimal combination of kipahit liquid organic fertilizer concentration and AB Mix to enhance the growth and production of green lettuce using the nutrient film technique in hydroponics.

Methodology: This study used a completely randomized design with 5 treatments, namely P1 = liquid organic fertilizer kipahit 0% + AB Mix 100% (control), P2 = liquid organic fertilizer kipahit 25%+AB Mix 75%, P3 = liquid organic fertilizer kipahit 50%+AB Mix 50%, P4= liquid organic fertilizer kipahit 75%+AB Mix 25%, P5=POC kipahit 100% + AB Mix 0%. Data analysis used the test of variance (ANOVA) and the DMRT follow-up test at the 5% level.

Main Findings: The provision of AB Mix and liquid organic fertilizer Kipahit nutrition had a significant effect on all parameters. P2 is a combination treatment of AB Mix and liquid organic fertilizer Kipahit, which can reduce the use of AB Mix nutrients on the parameters of plant height, leaf length, leaf width, number of leaves, and plant wet weight, but cannot increase plant growth and production of green lettuce compared to the use of 100% AB Mix. No combination of kipahit liquid organic fertilizer concentration and Ab Mix could increase the growth and production of green lettuce compared to using 100% AB Mix.

Novelty/Originality of this study: This study provides new insights into the potential of kipahit liquid organic fertilizer as a partial substitute for AB Mix in NFT hydroponics for lettuce production.

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1. INTRODUCTION

Lettuce (*Lactuca sativa* L.) is a leafy vegetable widely consumed by the public due to its high nutritional value, relatively short growing period, and increasing market demand. As a horticultural commodity, lettuce has good economic prospects and can be cultivated in various environments, both rural and urban [1], [2]. As consumer awareness of fresh, healthy, and safe vegetable products increases, the need for sustainable cultivation systems is increasing [3], [4]. One rapidly developing modern cultivation technology is the hydroponic system.

Hydroponics is a method of growing plants without soil, but instead using water as a medium, nutrients, and oxygen [5], [6]. Hydroponic cultivation is more efficient because it is more cost-effective and produces high-quality vegetables [7], [8]. The hydroponic technique widely used to produce leafy vegetables, such as lettuce, is the Nutrient Film Technique (NFT) [9], [10]. The NFT system has the advantage of a continuous flow of nutrients, ensuring adequate nutrient supply [11], [12]. The shallow, circulating layer of nutrient solution prevents stagnant water, ensuring adequate water, nutrients, and oxygen flow to the plants [13], [14].

The Nutrient Film Technique (NFT) is an efficient hydroponic system, where the nutrient solution is distributed in a thin, continuous stream, ensuring optimal nutrient uptake by the plant roots [15], [16]. The advantages of this system include efficient water use, relatively easy maintenance, and the ability to promote faster plant growth [17], [18]. However, the success of hydroponics depends heavily on the quality of the nutrient solution used. AB Mix nutrient is a commonly used inorganic nutrient solution because it contains a complete range of macro and micronutrients to support plant growth [19], [20]. While effective, AB Mix has limitations, including its relatively high cost and reliance on synthetic chemicals that are less environmentally friendly.

The nutrient used in hydroponic cultivation is AB Mix chemical fertilizer. The AB Mix fertilizer required for hydroponic cultivation is increasingly expensive [21], [22]. The price of fertilizer is around IDR 80,000-100,000 for a 1,000-liter package of A and B fertilizers. Furthermore, the continued use of chemical fertilizers can have negative impacts on human health [23]-[25]. This can be addressed by utilizing organic materials to reduce the use of chemical fertilizers. One organic material that can be used as a hydroponic nutrient is liquid organic fertilizer from the kipahit plant.

Kipahit (*Tithonia diversifolia*) can be used as a liquid organic fertilizer. This plant contains nutrients needed by plants [26], [27]. The nutrient content of kipahit consists of N, P, K, Ca, and Mg [28], [29]. The nutrient content in kipahit is quite high, namely 3.5–4.0% N; 0.35–0.38% phosphorus (P); 3.5–4.1% K; 0.59% calcium (Ca) and 0.27% magnesium (Mg). Kipahit has been successfully used as a natural nutrient in NFT hydroponic cultivation of lettuce plants using a dose of 1 L of liquid organic fertilizer kipahit / 5 L of water. Kurniawan et al. reported that kipahit-based liquid organic fertilizer provides essential macro nutrients and effectively supports plant growth, emphasizing that appropriate dosage is critical to avoid nutrient imbalance and wilting symptoms [29]. Doses that do not meet plant needs will result in wilting symptoms.

Recent studies have explored the use of organic nutrient solutions as alternatives to synthetic fertilizers in hydroponic lettuce cultivation. Endoh et al., demonstrated that commercial liquid organic fertilizers such as "Power Fish" could promote lettuce growth under controlled hydroponic conditions, although careful management of pH and microbial activity was required [30]. Similarly, Ezziddine et al., used nutrient solutions derived from aerobically digested aquacultural sludge and found no significant difference in lettuce yield compared to conventional inorganic solutions, despite slightly lower fresh weight [31]. Alkaabi et al., further reported that organic nutrients in vertical NFT systems reduced leaf nitrate content and enhanced antioxidant compounds [32], while Chowdhury et al., observed that organic fertilizers performed less effectively in NFT systems than in substrate-based systems [33]. These findings indicate that organic nutrients can partially replace mineral fertilizers, but their application in NFT hydroponics remains technically challenging and often produces lower yields. Moreover, most previous research has relied on commercial products or materials such as fish emulsion, aquaculture sludge, or animal manure, with limited attention to locally available plant-based sources. To date, no study has systematically evaluated *Tithonia diversifolia* (kipahit) as a liquid organic nutrient for lettuce in NFT hydroponics, particularly in tropical environments. This creates a critical research gap in optimizing dosage and nutrient formulation to achieve comparable growth and production to AB Mix while reducing dependence on synthetic fertilizers. The present study addresses this gap by testing different concentrations of kipahit liquid organic fertilizer combined with AB Mix to determine the most effective nutrient composition for sustainable NFT hydroponic lettuce cultivation.

The purpose of this study was to determine the effect of liquid organic fertilizer kipahit and AB Mix on the growth and production of green lettuce using the NFT hydroponic system. Then to obtain the best concentration of P liquid organic fertilizer kipahit and AB Mix to increase the growth and production of green lettuce using NFT hydroponics. With the benefits of this study, namely Obtaining the best concentration of liquid organic fertilizer kipahit and AB Mix on the growth and production of green lettuce using the NFT hydroponic system. Then provide knowledge to farmers to utilize kipahit as liquid organic fertilizer that can reduce the use of AB Mix nutrients in the NFT hydroponic system.

2. RESEARCH METHOD

The tools used in this study were a series of NFT models, spoons, chopsticks, scissors, knives, stirrers, trays, measuring cups, water jerry cans, water barrels, net pots, data sheets, plastic cups, digital scales, rulers, stationery, cameras, pH litmus paper, and a Total Dissolve Solid (TDS) meter. The materials used in this study were clean water, Grand Rapids lettuce seeds, fungicide, rockwool media, kipahit plants, brown sugar, coconut water, EM4, and AB Mix nutrient solution. This study employed an experimental research method, employing a Completely Randomized Design (CRD) consisting of five treatments: P1 = 0% kipahit organic fertilizer + 100% AB Mix (control), P2 = 25% kipahit organic fertilizer + 75% AB Mix, P3 = 50% kipahit organic fertilizer + 50% AB Mix, P4 = 75% kipahit organic fertilizer + 25% AB Mix, and P5 = 100% kipahit organic fertilizer + 0% AB

Mix. Each treatment was replicated four times, with five netpots per replication, each containing one lettuce plant.

The kipahit liquid organic fertilizer was made by mixing 25 kg of chopped kipahit, 25 L of water, 25 L of coconut water, 1 kg of liquid brown sugar, and 1 L of EM4 in a 150 L barrel, then fermented for 14 days. Fermentation is considered successful if the pH reaches 4–8, is brownish yellow, has a tapai aroma, no larvae, and white spots appear, after which the solution is filtered three times before use. The hydroponic installation uses an NFT system assembled from 21-inch pipes with a slope of 2–10% and a distance between holes of 10 cm, equipped with a nutrient tank according to the treatment. The nutrient solution used is AB Mix, consisting of stock A (Ca Nitrate, K Nitrate, BMX) and stock B (MKP, $(NH_4)_2SO_4$, K_2SO_4, $MgSO_4$) with a ratio of 5 ml/L of water, stirred until homogeneous, then adjusted to a ppm value of 730–1122 and a pH of 5–6. Lettuce seeds are sown in 3×3 cm rockwool for 14 days, followed by 7 days of rejuvenation, then 21-day-old seedlings with three leaves are transferred to the production installation in net pots. Maintenance included checking the pump, hose, and nutrient levels, replanting the plants, and measuring growth. Harvesting was carried out 43 days after planting (DAP), with the criteria being 20–25 cm long, 15 cm wide, 100–400 g in weight, a fresh appearance, and freedom from pests and diseases. The plants were removed along with their growing medium.

The observation parameters in this study were as follows: 1) Plant height (cm): measured from the growing medium to the tip of the tallest leaf at 22–42 days after planting (7-day intervals); 2) Leaf width (cm): measured at the widest leaf, 22–42 days after planting (7-day intervals); 3) Leaf length (cm): measured from the petiole to the tip of the longest leaf, 22–42 days after planting (7-day intervals); 4) Number of leaves (leaflets): counted on fully opened leaves, 22–42 days after planting (7-day intervals); 5) Root length (cm): measured from the base to the tip of the root at harvest; 6) Plant wet weight (g): weighed all parts of the plant using a digital scale at harvest.

The data are presented in tables and graphs. The data obtained were analyzed quantitatively and subjected to a 5% test of variance (ANOVA). If there was a significant effect ($P<0.05$), a Duncan's Multiple Range Test (DMRT) was performed at the 5% level to determine which treatments were significantly different. Data processing and analysis were performed using Microsoft Excel and SPSS 20 software.

3. RESULTS AND DISCUSSION

3.1 General Conditions of the Research

Lettuce growth is influenced by environmental factors such as total dissolved solids (TDS) and the pH of the nutrient solution. TDS and pH measurements for each treatment varied. TDS, the amount of dissolved solids in nutrients, is a crucial factor in hydroponic cultivation. The TDS values measured in this study ranged from 730 to 1120 ppm. The optimum TDS value for lettuce growth is around 560 to 840 ppm (Marisa et al., 2021). TDS values exceeding the optimum limit can reduce water absorption by plants, disrupting photosynthesis [34], [35]. Unstable TDS values or values below the optimum limit can cause yellowing and wilting of leaves, stunted growth, and stunted growth [36], [37].

Ph is a crucial factor in lettuce growth. The pH values measured in this study ranged from 5 to 6. The optimum pH for lettuce growth is around 5.5 to 6.5 [38], [39]. P4 and P5 have a more acidic pH due to the higher concentration of kipahit liquid organic fertilizer applied compared to P1, P2, and P3. A pH below 5.5 or above 6.5 will disrupt nutrient solubility, causing nutrients to precipitate and become unavailable to plant roots. The pH value is influenced by biological factors such as photosynthesis, respiration of organisms, microorganisms, growing media, temperature, and nutrient solution [40], [41].

Environmental factors influence plant susceptibility and resistance to pathogen proliferation and activity. This in turn influences the emergence of disease. The disease symptoms encountered in this study were root rot, characterized by brownish roots and wilting of plants in P4 and P5 at 40 days after planting. This disease is caused by an overly acidic nutrient pH due to the administration of high concentrations of liquid organic fertilizer. This is consistent with research by Pancawati & Yulianto [42], who found that if the pH of hydroponic nutrients ranges from 3-5, it will result in fungal growth and root rot. This can cause damage to plant cells or tissues.

Damage to plant cells or tissues can trigger the proliferation of pathogens. Pathogens will come into contact with plant cells or tissues, leading to infection [43], [44]. The pathogen that frequently attacks the roots of plants in NFT hydroponic systems is the fungus Pythium spp. Plants infected with Pythium spp. experience symptoms of root rot. This is consistent with Sudiartini et al. [45], who found that Pythium spp. fungi are commonly found in plants using NFT hydroponic cultivation systems. Plants infected with Pythium spp. are characterized by symptoms of root rot. Pythium spp. fungi The fungi that cause root rot in hydroponic plants can be transmitted from their sources, including water, plant debris, airborne dust, tools used, previously infected plant seeds, and several media containers. The fungus will infect plants if contaminated inocula enter the growth system, thus colonizing the root system and causing the roots to turn brown and rot [46]. Control is carried out by sterilizing the nutrient tank and installation by cleaning the nutrient tank and pipes regularly and ensuring sufficient oxygen availability for the plants.

3.2 Lettuce Plant Growth

The observed growth parameters were plant height, number of leaves, leaf width, leaf length, and root length. The provision of AB Mix and liquid organic fertilizer kipahit nutrients significantly affected all plant growth parameters. P1 was the treatment that produced the highest parameters in plant height, leaf length, leaf width, and number of leaves. P5 was the treatment that produced the highest parameter in root length. P4 was the treatment that produced the lowest parameters in plant height, leaf length, leaf width, and number of leaves. P2 was the best combination among other combination treatments for the parameters of plant height, leaf length, leaf width, and number of leaves (Table 1).

Table 1. Average growth parameters of green lettuce in response to the administration of liquid organic fertilizer kipahit and AB Mix at 43 HST

Treatment	Plant height (cm)	Leaf length (cm)	Leaf width (cm)	Number of leaves (cm)	Root length (cm)
P1 (0% liquid organic fertilizer bittersweet + 100% AB Mix)	23.52 ± 0.27^{a}	16.58 ± 0.27^{a}	13.35 ± 0.12^{a}	10.25 ± 0.50^{a}	9.05 ± 0.64^{bc}
P2 (25% liquid organic fertilizer bittersweet + 75% AB Mix)	20.40 ± 0.57^{b}	14.50 ± 0.25^{b}	11.45 ± 0.26^{b}	7.75 ± 0.50^{b}	8.50 ± 0.76^{c}
P3 (50% liquid organic fertilizer kipahit + 50% AB Mix)	18.58 ± 0.29^{c}	14.73 ± 0.50^{c}	9.50 ± 0.18^{c}	6.50 ± 0.57^{c}	6.63 ± 1.05^{d}
P4 (75% liquid organic fertilizer kipahit + 25% AB Mix)	15.40 ± 0.49^{e}	11.73 ± 0.78^{e}	7.35 ± 0.20^{e}	5.00 ± 0.00^{e}	9.93 ± 1.38^{bc}
P5 (100% liquid organic fertilizer bittersweet + 0% AB Mix)	15.88 ± 0.92^{d}	13.58 ± 0.71^{d}	8.95 ± 0.67^{d}	5.78 ± 0.50^{d}	10.45 ± 1.36^{a}

Description: The average value followed by a different letter indicates that the treatment is significantly different at the 5% Duncan Test level.

P1 provided the highest growth in plant height, leaf length, leaf width, and leaf number compared to the combination treatment and the liquid organic fertilizer treatment (Table 1). AB Mix nutrients contain a complete range of macro and micronutrients in appropriate amounts for plant growth. Nutrient adequacy affects the rate of vegetative plant growth [47], [48]. AB Mix nutrients consist of stock solution A and stock solution B. Stock solution A contains Ca, K, N, and P, while stock solution B contains Mg, S, and Fe [49]. AB Mix nutrients are more stable and dissolve quickly in water because they are in a purer form. Higher AB Mix nutrient levels can increase plant growth in appropriate amounts. This is consistent with research by Meriaty et al. [50]. The higher the AB Mix nutrient concentration, the higher the nutrient content, thereby enhancing plant growth. The highest AB Mix nutrient concentration of 1200 ppm yielded the best results for plant height, leaf area, root weight, and lettuce weight in hydroponic cultivation.

P2 was the best combination of AB Mix and Kipahit Organic Fertilizer for lettuce growth, specifically for plant height, leaf length, leaf width, and leaf number (Table 1). P2 was the best combination treatment, reducing AB Mix nutrient usage in hydroponic cultivation. This is because P2 has a higher AB Mix concentration than other combination treatments. The use of liquid organic fertilizer Kipahit in hydroponic cultivation must be accompanied by AB Mix nutrient application to achieve good growth, as AB Mix contains all the necessary nutrients for plants.

The growth of green lettuce plants treated with AB Mix and liquid organic fertilizer Kipahit increased with increasing plant age in all treatments. This is because increasing plant age increases the growth of vegetative organs. As plants age, their development is directed towards the formation of vegetative organs to expand growth and meet their nutritional needs. Green lettuce plants showed relatively similar growth at 22 days after planting (DAP) because no treatment was applied to each plant. Lettuce growth at 29 days after planting increased across all treatments, but P1 showed higher yields than the other treatments (Figure 4). Plant growth differed between 36 and 43 days after planting, experiencing faster growth (Figure 4). This is because at 36 and 43 days after planting, nutrient concentrations are optimal, providing the necessary nutrients for lettuce growth in the appropriate amounts. Providing too much nutrient can be toxic to the plant. Providing too little nutrient can inhibit root development, thus disrupting nutrient uptake.

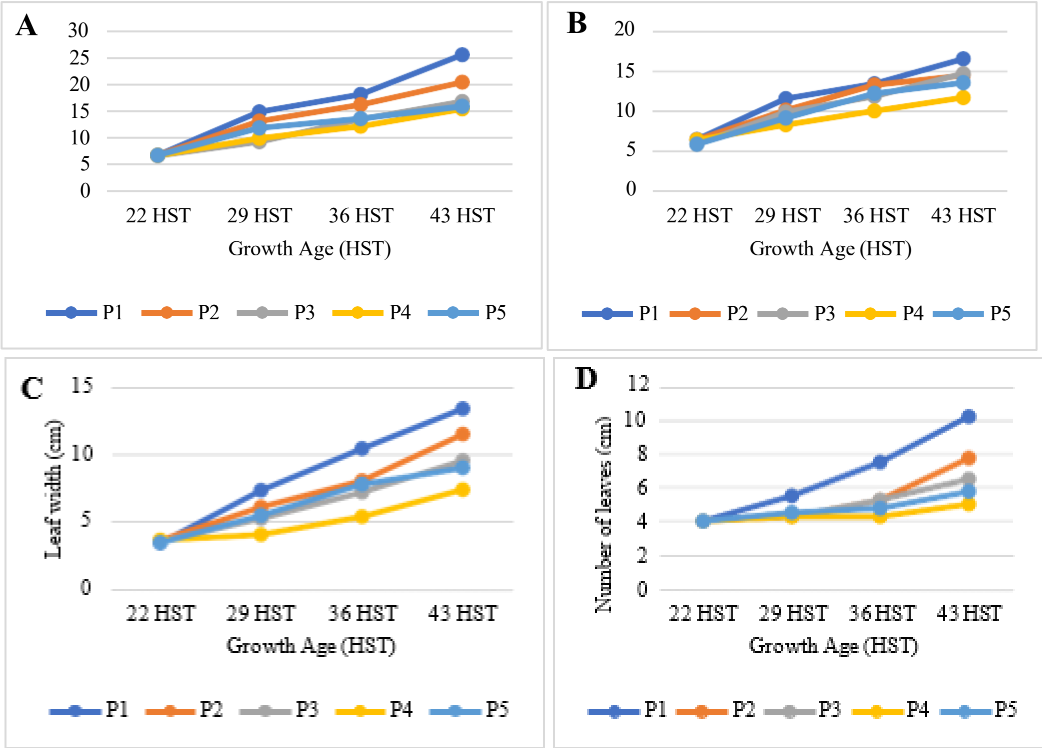

Figure 1. Growth pattern of green lettuce at 22 - 43 HST with liquid organic fertilizer kipahit and Ab Mix treatments A. Plant height; B. Leaf length; C. Leaf width; D. Number of leaves

The growth pattern in all treatments experienced a logarithmic phase at 36–43 days after planting (DAP). This is because green lettuce growth is slow in the early stages, followed by a rapid increase in the late stages. logarithmic phase indicates a slow growth rate at the beginning, but a steady increase towards the end.

P1 had the highest plant height growth rate among the other treatments. P4 had the lowest plant height growth rate among the other treatments (Figure 4). The provision of 100% AB Mix nutrients provided the complete nutritional requirements of the plants. Plants require optimal levels of N, P, and K to accelerate growth processes such as cell division and cell elongation, which in turn increase plant height.

Leaves are the site of photosynthesis. Proper photosynthesis produces abundant photosynthetic products, which are then used for the formation of organs and tissues within the plant. The growth of leaf length, leaf width, and leaf number in P1 was the highest compared to the other treatments. Meanwhile, the growth of leaf length, leaf width, and leaf number in P4 was the lowest compared to the other treatments. This is because P1 has complete nutrients for plant growth and development. AB Mix nutrition provides complete nutrients for plant growth, especially leaf growth. Leaf growth will be optimal if the nutrients contained in a fertilizer are sufficient to stimulate plant metabolism in leaf growth. Leaf growth in P4 and P5 yielded less favorable results compared to the other treatments. This is suspected to be due to deficiencies in N and micronutrients, namely Zn, Mo, Fe, Mn, Co, and B.

N and micronutrients play a role in chlorophyll formation. The greater the amount of chlorophyll, the more photosynthetic activity will produce photosynthates, which play a role in the development of leaf meristematic tissue. Micronutrients are needed in small amounts, but if plants are deficient in them, leaf growth will be suboptimal. Micronutrient deficiencies can affect vegetative growth. Adequate nutrient supply for plant growth determines plant biomass, as the amount of nutrients supplied and absorbed by plants significantly impacts the rate of vegetative growth.

The number of leaves and leaf area significantly influence chlorophyll formation. Leaf length and width determine leaf area. The larger the leaf area, the greater the amount of sunlight received, as light is more readily absorbed by the leaves. Sunlight is the energy source used in photosynthesis. A greater number of leaves provides more space for photosynthesis and increases yields, which can be translocated throughout the plant.

Roots are the plant organs responsible for absorbing and acquiring nutrients as food, which are then translocated throughout the plant. Root length in P5 was the longest compared to other treatments. The P5 nutrient content is not sufficient to meet the needs of plant growth and development, resulting in nutrient deficiencies. Nutrient deficiencies cause plant roots to lengthen. This is due to the greater distribution of assimilates, which leads to faster and longer root growth, enabling them to supply nutrients for plant growth. The concentration of kipahit liquid organic fertilizer in P5 was the highest among other treatments. Kipahit liquid organic fertilizer contains P elements that function in the growth of seeds, roots, flowers, and fruit. In plant root growth, P elements help improve root structure in nutrient absorption. Kipahit liquid organic fertilizer is effective in accelerating and increasing root growth.

3.3 Lettuce Plant Production

Lettuce production parameters include plant fresh weight. The provision of AB Mix and Kipahit POC nutrients significantly affected the plant fresh weight ($P>0.05$).

Table 2. Effect of liquid organic fertilizer administration on average wet weight of plants

Treatment	Wet weight (g)
P1 (0% liquid organic fertilizer bittersweet + 100% AB Mix)	101,00 ± 2.16[a]
P2 (25% liquid organic fertilizer bittersweet + 75% AB Mix)	74,25 ± 5.67[b]
P3 (50% liquid organic fertilizer kipahit + 50% AB Mix)	52,25 ± 3.50[c]
P4 (75% liquid organic fertilizer kipahit + 25% AB Mix)	33,00 ± 1.82[e]
P5 (100% liquid organic fertilizer bittersweet + 0% AB Mix)	42,00 ± 1.82[d]

Description: The average value followed by different letters indicates that the treatment is significantly different at the 5% Duncan Test level.

P1 was the treatment that produced the highest fresh weight, while P4 produced the lowest fresh weight (Table 2). The increase in lettuce fresh weight across treatments is closely related to the availability of N, P, and K, which are key macronutrients for plant growth and production. Fresh weight is affected by the number of leaves, leaf area, water content, stem diameter, and plant height, as these factors contribute to total plant biomass. Water is the dominant component of fresh weight, comprising approximately 80–90% of plant tissue. Adequate and balanced nutrient supply promotes optimal growth and high production, whereas nitrogen deficiency leads to stunted and slow growth. Based on Table 2, P1 yielded the best wet weight results because the AB Mix nutrient solution contained essential macro- and micronutrients that support vegetative growth. In contrast, P4 and P5 produced lower fresh weights due to the higher proportion of liquid organic fertilizer compared to AB Mix, which provides less immediately available nutrients for plant uptake [29], [33]. Although organic fertilizers improve soil organic matter and microbial activity, their nutrient release is generally slower than that of inorganic nutrient solutions, which can limit rapid biomass accumulation in hydroponic systems [33].

Several studies have shown that the composition and concentration of AB-Mix nutrient solutions significantly affect the growth and fresh weight of lettuce in hydroponic systems; optimal concentrations increase plant height and weight, while concentrations that are too high or too low reduce yields [51]. In addition, several studies have reported that liquid organic fertilizers formulated from various materials (e.g., molasses, factory waste, fermented organic fertilizers) can be used in hydroponic systems and sometimes provide biomass yields comparable to inorganic fertilizers but with slower nutrient release, requiring adjustments in composition [31]. Another study combining AB-Mix with liquid organic fertilizers showed the potential to reduce AB-Mix use while maintaining growth if the ratio and concentration are chosen appropriately, but effectiveness is highly dependent on the chemical composition of the liquid organic fertilizer and the stability of the solution parameters (pH, TDS/EC) [52]. Additionally, root disease by Pythium often occurs in NFT/recirculating systems when nutrient conditions (including very acidic pH or low dissolved oxygen) favor the pathogen causing brown roots, wilting, and decreased biomass, making pH/TDS management and system sanitation crucial [53].

The novelty of the present study resides in evaluating specific ratios between AB-Mix and a locally derived liquid organic fertilizers "Kipahit" (liquid organic fertilizer) within an NFT system for green lettuce, and in providing a detailed account of how such ratios affect solution parameters (TDS 730–1120 ppm, pH 5–6) and the incidence of root disease. The finding that the combination of 25% liquid organic fertilizers (Kipahit) + 75% AB-Mix (treatment P2) is capable of reducing AB-Mix usage without compromising key vegetative parameters (plant height, leaf dimensions, leaf count) provides practical evidence of a partial substitution approach something not previously well documented for this particular liquid organic fertilizer /Kipahit formulation in NFT hydroponics, especially with full traceability of TDS/pH data and observed *Pythium* incidence at high liquid organic fertilizer concentrations.

Implications of this study suggest a practical pathway toward reducing reliance on inorganic fertilizer (AB-Mix) by partially substituting it with a locally available liquid organic fertilizer, potentially lowering input costs and promoting greater sustainability in hydroponic cultivation provided that precise formulation and nutrient solution monitoring are applied. However, this research also cautions that excessive liquid organic fertilizer concentrations may depress pH and elevate the risk of root pathogens (e.g. *Pythium*), mandating tight control of pH/TDS, regular monitoring of nutrient cycles, and microbial assessments of liquid organic fertilizer. Limitations of the study include: (1) lack of fully quantitative chemical profiling of the liquid organic fertilizer (e.g. nitrogen, phosphorus, potassium, micronutrients) and microbial composition; (2) experiments limited to one lettuce variety and a single cultivation period, which constrains generalizability to other varieties or seasonal conditions; and (3) relatively short observation duration longer-term studies assessing total biomass yield, postharvest quality, and microbial pathogen accumulation are needed before recommending large-scale adoption.

4. CONCLUSION
Based on the results of the research conducted, it can be concluded that the administration of liquid organic fertilizer kipahit and AB Mix significantly affected the growth and production of green lettuce using the NFT hydroponic system. No combination of liquid organic fertilizer kipahit and AB Mix concentrations has been found that can increase the growth and production of green lettuce when compared to the use of 100% AB Mix. Further research is needed regarding a more optimal dose for the growth and production of green lettuce plants. Improvements in the liquid organic fertilizer kipahit filtration process are needed to avoid leaving dregs and research is needed using other plants and hydroponic systems to determine the effectiveness of liquid organic fertilizer kipahit use.

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REFERENCES
[1] R. Islam *et al.*, "Evaluation of lettuce growth, yield, and economic viability grown vertically on unutilized building wall in Dhaka City," *Front. Sustain. Cities*, vol. 3, no. March, pp. 1–10, 2021, doi: 10.3389/frsc.2021.582431.
[2] M. M. Khan, M. T. Akram, R. Janke, R. W. K. Qadri, A. M. Al-Sadi, and A. A. Farooque, "Urban horticulture for food secure cities through and beyond covid-19," *Sustain.*, vol. 12, no. 22, pp. 1–21, 2020, doi: 10.3390/su12229592.
[3] S. M. E. Rahman, M. A. Mele, Y. T. Lee, and M. Z. Islam, "Consumer preference, quality, and safety of organic and conventional fresh fruits, vegetables, and cereals," *Foods*, vol. 10, no. 1, pp. 1–17, 2021, doi: 10.3390/foods10010105.
[4] L. C. Huang, "Consumer attitude, concerns, and brand acceptance for the vegetables cultivated with sustainable plant factory production systems," *Sustain.*, vol. 11, no. 18, 2019, doi: 10.3390/su11184862.
[5] R. S. Velazquez-Gonzalez, A. L. Garcia-Garcia, E. Ventura-Zapata, J. D. O. Barceinas-Sanchez, and J. C. Sosa-Savedra, "A review on hydroponics and the technologies associated for medium-and small-scale operations," *Agric.*, vol. 12, no. 5, pp. 1–21, 2022, doi: 10.3390/agriculture12050646.
[6] H. R. Atherton and P. Li, "Hydroponic cultivation of medicinal plants—plant organs and hydroponic systems: techniques and trends," *Horticulturae*, vol. 9, no. 3, pp. 1–26, 2023, doi: 10.3390/horticulturae9030349.
[7] S. Shilpa, P. Sharma, and Bansuli, "Hydroponics in vegetable crops: a review BT - hdroponics: the future of sustainable farming," N. Kumar, Ed., New York, NY: Springer US, 2024, pp. 15–41. doi: 10.1007/978-1-0716-3993-1_2.
[8] M. E. A. Elsallam, S. H. EL-Moslamy, A. A. El-Al, and H. F. Zahran, "Scaling-up production of cost-effective and eco-friendly bio-fertilizer and its application on Barley green fodder via IoT hydroponic system," *J. Genet. Eng. Biotechnol.*, vol. 19, no. 1, pp. 1–12, 2021, doi: 10.1186/s43141-021-00196-1.
[9] O. D. Palmitessa, A. Signore, and P. Santamaria, "Advancements and future perspectives in nutrient film technique hydroponic system: a comprehensive review and bibliometric analysis," *Front. Plant Sci.*, vol. 15, no. December, pp. 1–21, 2024, doi: 10.3389/fpls.2024.1504792.
[10] S. A. Gillani, R. Abbasi, P. Martinez, and R. Ahmad, "Comparison of energy-use efficiency for lettuce plantation under nutrient film technique and deep-water culture hydroponic systems," *Procedia Comput. Sci.*, vol. 217, pp. 11–19, 2023, doi: 10.1016/j.procs.2022.12.197.
[11] M. R. Rozilan, A. S. Mohd Rodzi, A. Faiz Zubair, A. R. Hemdi, R. Deraman, and N. D. Md Sin, "Design and fabrication of nutrient film technique (NFT) hydroponic system," in M. H. A. Hassan, M. H. Zohari, K. Kadirgama, N. A. N. Mohamed, and A. Aziz, Eds., Technological Advancement in Instrumentation & Human Engineering. ICMER 2021. Lecture Notes in Electrical Engineering, vol 882. Springer, Singapore, 2023, pp. 123–144.
[12] G. Carrasco *et al.*, "Enhancing leafy greens' production: nutrient film technique systems and automation in container-based vertical farming," *Agronomy*, vol. 14, no. 9, pp. 1–19, 2024, doi: 10.3390/agronomy14091932.
[13] A. Mielcarek, K. Kłobukowska, J. Rodziewicz, W. Janczukowicz, and K. Ł. Bryszewski, "Water nutrient management in soilless plant cultivation versus sustainability," *Sustain.*, vol. 16, no. 1, 2024, doi: 10.3390/su16010152.
[14] M. Manna, B. Rengasamy, and A. K. Sinha, "Nutrient and water availability influence rice physiology, root architecture and ionomic balance via auxin signalling," *Plant. Cell Environ.*, vol. 48, no. 4, pp. 2691–2705, Apr. 2025, doi: 10.1111/pce.15171.
[15] E. Fathidarehnijeh, M. Nadeem, M. Cheema, R. Thomas, M. Krishnapillai, and L. Galagedara, "Current perspective on nutrient solution management strategies to improve the nutrient and water use efficiency in hydroponic systems," *Can. J. Plant Sci.*, vol. 104, no. 2, pp. 88–102, 2024, doi: 10.1139/cjps-2023-0034.
[16] O. A. Nitu, E. Ş. Ivan, A. S. Tronac, and A. Arshad, "Optimizing lettuce growth in nutrient film technique hydroponics: evaluating the impact of elevated oxygen concentrations in the root zone under LED illumination," *Agronomy*, vol. 14, no. 9, 2024, doi: 10.3390/agronomy14091896.
[17] E. Bwambale, F. K. Abagale, and G. K. Anornu, "Smart irrigation monitoring and control strategies for improving water use efficiency in precision agriculture: A review," *Agric. Water Manag.*, vol. 260, p. 107324, 2022, doi: 10.1016/j.agwat.2021.107324.
[18] M. Mallareddy *et al.*, "Maximizing water use efficiency in rice farming: A comprehensive review of innovative

irrigation management technologies," *Water (Switzerland)*, vol. 15, no. 10, 2023, doi: 10.3390/w15101802.
[19] N. D. S. Sanusi, F. C. Ros, S. Z. N. Demon, I. Ismail, and I. Hamadneh, "Recent use of AB mix nutrients for urban farming in Malaysia: a mini review," *J. Adv. Res. Des.*, vol. 122, no. 1, pp. 150–162, 2024, doi: 10.37934/ard.122.1.150162.
[20] M. Hayati, D. M. Indriani, and M. Rahmawati, "The effect of AB mix and organic fertilizer concentration on growth and yield of two mustard varieties in a floating hydroponic system," *IOP Conf. Ser. Earth Environ. Sci.*, vol. 1183, no. 1, 2023, doi: 10.1088/1755-1315/1183/1/012034.
[21] B. Hermanto, D. Habibie, A. F. Lubis, and R. A. Syahputra, "Analysis of Pakcoy Mustard (*Brassica rapa*) growth using hydroponic system with AB mix nutrition," *J. Phys. Conf. Ser.*, vol. 1819, no. 1, 2021, doi: 10.1088/1742-6596/1819/1/012059.
[22] K. Kano *et al.*, "Effects of organic fertilizer on bok choy growth and quality in hydroponic cultures," *Agronomy*, vol. 11, no. 3, 2021, doi: 10.3390/agronomy11030491.
[23] N. Dhankhar and J. Kumar, "Impact of increasing pesticides and fertilizers on human health: A review," *Mater. Today Proc.*, 2023, doi: 10.1016/j.matpr.2023.03.766.
[24] M. E. Hossain, S. Shahrukh, and S. A. Hossain, "Chemical fertilizers and pesticides: Impacts on soil degradation, groundwater, and human health in Bangladesh BT-Environmental Degradation: Challenges and Strategies for Mitigation," V. P. Singh, S. Yadav, K. K. Yadav, and R. N. Yadava, Eds., Cham: Springer International Publishing, 2022, pp. 63–92. doi: 10.1007/978-3-030-95542-7_4.
[25] H. N. Pahalvi, L. Rafiya, S. Rashid, B. Nisar, and A. N. Kamili, "Chemical fertilizers and their impact on soil health BT-Microbiota and Biofertilizers, Vol 2: Ecofriendly Tools for Reclamation of Degraded Soil Environs," G. H. Dar, R. A. Bhat, M. A. Mehmood, and K. R. Hakeem, Eds., Cham: Springer International Publishing, 2021, pp. 1–20. doi: 10.1007/978-3-030-61010-4_1.
[26] D. Alfarado, S. Shiyan, and F. Ferlinahayati, "Study of Potential α-Glucosidase Inhibitor from Tithonia diversifolia: In Vitro, Pharmacokinetics, Toxicology, and Molecular Docking," *Indones. J. Chem.*, vol. 25, no. 2, pp. 575–589, 2025, doi: 10.22146/ijc.103111.
[27] U. Karo-Karo *et al.*, "The reduction of armyworms on mustard greens using the extract of Papaya Leaf And Kipahit Leaf," *IOP Conf. Ser. Earth Environ. Sci.*, vol. 1083, no. 1, 2022, doi: 10.1088/1755-1315/1083/1/012052.
[28] A. Rahayu, N. Rochman, and W. Nahraeni, "Production and Quality of Katuk (Sauropus androgynous (L.) Merr) Plants on Various Composition of Urea Fertilizer and Mexican Sunflower Compost," *J. Hortik. Indones.*, vol. 12, no. 1, pp. 31–41, 2021, doi: 10.29244/jhi.12.1.31-41.
[29] D. Kurniawan, A. Nadhira, O. S. Sijabat, N. U. Angkat, and R. Rosmaladewi, "Pembuatan POC (Pupuk Organik Cair) dengan menggunakan tanaman kipahit [Making LOF (Liquid Organic Fertilizer) using Kipahit plants]," *J. Abdimas Maduma*, vol. 2, no. 1, pp. 42–46, 2023, doi: 10.52622/jam.v2i1.152.
[30] T. Endoh, M. Takagaki, P. Suwitchayanon, C. Chanseetis, and N. Lu, "Hydroponic lettuce cultivation with organic liquid fertilizer: Examining bacterial inhibition and phosphate solubilization," *Crops*, vol. 4, no. 4, pp. 502–513, 2024, doi: 10.3390/crops4040036.
[31] M. Ezziddine, H. Liltved, and R. Seljåsen, "Hydroponic lettuce cultivation using organic nutrient solution from aerobic digested aquacultural sludge," *Agronomy*, vol. 11, no. 8, p. 1484, Jul. 2021, doi: 10.3390/agronomy11081484.
[32] A. Alkaabi *et al.*, "Vertical hydroponic lettuce: Impact of organic nutrients on antioxidant phytochemicals," *Ann. Agric. Sci.*, vol. 70, no. 1, p. 100386, Jun. 2025, doi: 10.1016/j.aoas.2025.100386.
[33] M. Chowdhury, U. C. Samarakoon, and J. E. Altland, "Evaluation of hydroponic systems for organic lettuce production in controlled environment," *Front. Plant Sci.*, vol. 15, Aug. 2024, doi: 10.3389/fpls.2024.1401089.
[34] A. M. Ahmed and S. L. Kareem, "Evaluating the role of hydraulic retention time (HRT) in pollutant removal efficiency using Arundo donax in vertical subsurface flow constructed wetlands," *Bioremediat. J.*, pp. 1–15, Dec. 2024, doi: 10.1080/10889868.2024.2439829.
[35] Y. L. Pang, Y. Y. Quek, S. Lim, and S. H. Shuit, "Review on Phytoremediation Potential of Floating Aquatic Plants for Heavy Metals: A Promising Approach," *Sustain.*, vol. 15, no. 2, 2023, doi: 10.3390/su15021290.
[36] K. Z. Ansyafa *et al.*, "Intelligent Hydroponic Control System with IoT and Fuzzy Logic on Kale Plants," *J. Appl. Sci. Technol. Humanit.*, vol. 2, no. 2, pp. 199–222, 2025, doi: 10.62535/5w3gk317.
[37] V. Ghimirey, J. Chaurasia, and S. Marahatta, "Plant nutrition disorders: Insights from clinic analyses and their impact on plant health," *Agric. Ext. Dev. Ctries.*, no. May, pp. 09–17, 2024, doi: 10.26480/aedc.01.2024.09.17.
[38] X. Jia, A. Speck, X. Feng, and C. W. Lee, "Impact of Water pH and Cultivar on Lettuce Growth, Water Use Efficiency, and Nutrient Use Efficiency in Deep Water Culture Systems," *Water (Switzerland)*, vol. 17, no. 17, pp. 1–19, 2025, doi: 10.3390/w17172637.
[39] S. S. Yaakup, N. A. Halim, and P. Ding, "Effect of nutrient solution pH on the growth and quality of lactuca sativa grown in a static hydroponic system," *Pertanika J. Trop. Agric. Sci.*, vol. 47, no. 4, pp. 1175–1189, 2024, doi: 10.47836/pjtas.47.4.08.
[40] A. Balliu, Y. Zheng, G. Sallaku, J. A. Fernández, N. S. Gruda, and Y. Tuzel, "Environmental and cultivation factors affect the morphology, architecture and performance of root systems in soilless grown plants," *Horticulturae*, vol. 7, no. 8, 2021, doi: 10.3390/horticulturae7080243.
[41] A. S. Zurano, C. G. Serrano, F. G. Acién-Fernández, J. M. Fernández-Sevilla, and E. Molina-Grima, "Modelling of photosynthesis, respiration, and nutrient yield coefficients in Scenedemus almeriensis culture as a function of nitrogen and phosphorus," *Appl. Microbiol. Biotechnol.*, vol. 105, no. 19, pp. 7487–7503, 2021, doi: 10.1007/s00253-021-11484-8.
[42] D. Pancawati and A. Yulianto, "Implementasi fuzzy logic controller untuk mengatur Ph Nutrisi pada sistem hidroponik nutrient film technique (NFT) [Implementation of fuzzy logic controller to regulate nutrient pH in nutrient film technique (NFT) hydroponic system]," *J. Nas. Tek. Elektro*, vol. 5, no. 2, p. 278, 2016, doi:

10.25077/jnte.v5n2.284.2016.

[43] R. Lorrai and S. Ferrari, “Host cell wall damage during pathogen infection: Mechanisms of perception and role in plant-pathogen interactions,” *Plants*, vol. 10, no. 2, pp. 1–21, 2021, doi: 10.3390/plants10020399.

[44] S. Zhang, C. Li, J. Si, Z. Han, and D. Chen, “Action mechanisms of effectors in Plant-Pathogen interaction,” *Int. J. Mol. Sci.*, vol. 23, no. 12, 2022, doi: 10.3390/ijms23126758.

[45] N. P. R. Sudiartini, G. Wirya, and I. M. Sudarma, “Identifikasi jamur penyebab penyakit utama pada tanaman selada (Lactuca sativa L.) hidroponik [Identification of the main disease-causing fungi in hydroponic lettuce (Lactuca sativa L.) plants],” *J. Agroekoteknologi Trop. ISSN*, vol. 2301, p. 6515, 2021.

[46] M. Li *et al.*, “Monitoring by real-time PCR of three water-borne zoosporic Pythium species in potted flower and tomato greenhouses under hydroponic culture systems,” *Eur. J. Plant Pathol.*, 2014.

[47] N. Mahmoud, M. A. H. Abdou, S. Salaheldin, W. S. Soliman, and A. M. Abbas, “The Impact of Irrigation Intervals and NPK/Yeast on the Vegetative Growth Characteristics and Essential Oil Content of Lemongrass,” *Horticulturae*, vol. 9, no. 3, 2023, doi: 10.3390/horticulturae9030365.

[48] S. Farjana, I. S. Park, and J. M. Choi, “Impact of controlled nitrogen application in water solution on seedling growth, tissue and soil nutrient concentrations in vegetative propagation of strawberry,” *Hortic. Environ. Biotechnol.*, vol. 64, no. 1, pp. 41–50, 2023, doi: 10.1007/s13580-022-00460-4.

[49] B. Ariananda, T. Nopsagiarti, and M. Mashadi, “Pengaruh pemberian berbagai konsentrasi larutan nutrisi AB mix terhadap pertumbuhan dan produksi selada (Lactuca sativa L.) hidroponik sistem floating [The effect of providing various concentrations of AB mix nutrient solution on the growth and production,” *Green Swarnadwipa J. Pengemb. ilmu Pertan.*, vol. 9, no. 2, pp. 185–195, 2020.

[50] Meriaty, A. Sihaloha, and K. D. Pratiwi, “Pertumbuhan dan hasil tanaman selada (Lactuca sativa L.) akibat jenis media tanam hidroponik dan konsentrasi nutrisi ab mix [Growth and yield of lettuce (Lactuca sativa L.) due to the type of hydroponic growing media and concentration of ab mix nutrients],” *Agroprimatech*, vol. 4, no. 2, pp. 75–84, 2021, doi: 10.34012/agroprimatech.v4i2.1698.

[51] G. V. A. Balansag, E. M. Anud Jr, G. P. A. Balansag, K. M. Anud, and G. N. A. Balansag, “The effect of ab mix nutrient solution on the height, number of leaves and fresh weight of lettuce (Lactuca sativa L.) in hydrophonics cultivation system,” *Int. J. Appl. Sci. Res.*, vol. 06, no. 02, pp. 93–100, 2022, doi: 10.56293/ijasr.2022.5510.

[52] A. En Yulia, M. Murniati, I. R. Dini, and L. Manja, “The effect of combination of AB-mix nutrition with liquid organic fertilizer of tofu liquid waste on hydroponical growth and production of lettage (Lactuca sativa L.),” *Int. J. Sci. Res. Arch.*, vol. 4, no. 1, pp. 165–170, 2021, doi: 10.30574/ijsra.2021.4.1.0190.

[53] J. J. Amrhein, F. Rotondo, C. Kubota, S. A. Miller, and A. L. Testen, “Diagnostic guide for pythium root rot in hydroponic leafy green and herb production,” *Plant Heal. Prog.*, vol. 26, no. 1, pp. 87–95, Jan. 2025, doi: 10.1094/PHP-07-24-0070-DG.