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Yield and Quality Improvement of Curly Kale (*Brassica oleracea var. Sabellica L.*) by Utilizing Agricultural Waste

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ABSTRACT

Curly kale has a high nutritional content that benefits the human body's health. This plant appeals to many individuals. Using agricultural waste processed by fermentation to produce liquid organic fertilizer is an effective option for safe products and can reduce the hydroponic cultivation cost of curly kale. This study aimed to investigate liquid organic fertilizer application technology from various agricultural wastes, vinasse, leucanea leaves, and banana peels. These waste materials are additional hydroponic nutrients close to the hydroponic nutrients (AB Mix) that can increase the yield and quality of curly kale plants. Using a randomized block design, this study involved conducting ten treatments repeated three times from April to June 2022 at the screen house of Villa Puncak Tidar, Malang. The study found that the nutritional composition of AB Mix 75% + (25% LOF Vinasse + Banana Peels + Leucaena leaves) had results close to the shoot fresh weight, root fresh weight, and shoot root ratio of the 100% AB Mix treatment. The total chlorophyll content approaching the 100% AB Mix treatment results was the AB Mix 75% + (25% LOF Vinasse + Banana Peels) treatment. The AB Mix 50% + (50% LOF Vinasse + Banana Peels) treatment produced the highest levels of antioxidants and showed an increase of 15.79%, compared to the 100% AB Mix treatment of 67.63%.

Keywords: Kale, agricultural wastes, hydroponic, yield, quality.

INTRODUCTION

Kale is a green leafy vegetable that belongs to the cabbage family Brassicaceae alongside cabbage, broccoli, cauliflower, and sprouted cabbage. Kale has received more attention because of its high phytochemical content. The price of hydroponic kale in Indonesia is very high, because this vegetable can meet more nutritional needs than other vegetables. However, only the upper middle class knows the benefits and consumes kale. Along with the development of a healthy lifestyle trend among Indonesian and the world, people are starting to like kale and call this plant the „queen of vegetables" because of its complete nutritional content. Kale is enriched with prebiotics and dietary fiber, potentially reducing the risk of diseases such as digestion, obesity, cancer, heart disease, and diabetes (Migliozzi et al., 2015). One serving of kale (100 g) has 49 calories and contains prebiotic carbohydrates that help fight obesity. Kale contains significant amounts of vitamins A, C, and K and the nutritional minerals potassium, calcium, and magnesium (Reda et al., 2021).

The nutrients commonly used to cultivate hydroponics are AB Mix fertilizers which are relatively expensive. Alternatively, using vinasse agricultural waste, leucaena leaves, and banana peels processed by fermentation to produce liquid organic fertilizer is an effective choice that is safe for the environment. Producing liquid organic fertilizer is expected to meet the need for expensive AB mix nutrition while continuing to supply consumer demand for chemical-free vegetables. Furthermore, this liquid organic fertilizer can also increase the yield and quality of kale curly plants, especially the levels of antioxidants in curly kale. Much agricultural waste worldwide can be used as a source of plant nutrients. Vinasse, leucaena leaves, and banana peels are agricultural wastes that are environmentally friendly and can be used as raw materials for liquid organic fertilizer after being processed by fermentation. Liquid organic fertilizer has advantages such as macro and micro nutrient content and the ability to absorb nutrients quickly due to nitrogen content. Thus, liquid organic fertilizer is a growth nutrient from decomposer microorganisms.

Vinasse is one of the raw materials for liquid organic fertilizer. Vinasse is dark in color and produces a lot of organic matter, such as nitrogen and potassium, after fermentation to convert molasses into ethanol from sugarcane. Sugarcane vinasse contains an acid suspension, has a high COD value with an unpleasant odor, and has a dark brown color. Producing 1 L of bioethanol from sugarcane can generate 12 L of vinasse (Cassman et al., 2018). The nutritional content of vinasse is 4.2 gL^{-1} nitrogen, 3.0 gL^{-1} phosphorus, and 17.5 gL^{-1} potassium. The macronutrients in leucaena leaves are nitrogen 3.84%, phosphorus 0.22%, potassium 2.06%, calcium 1.31%, magnesium 0.33%, and 0.51% SO_4^-. Meanwhile, micronutrients consist of 191 ppm Mn, 171 ppm Fe, 33 ppm Zn, and 15 ppm Cu (Febriani, 2020). Besides vinasse, banana peels can also be used as a basis for liquid organic fertilizer. Kusumaningtyas et al. (2020) have stated that organic fertilizer from banana peels potentially serves as a source of K and N. Potassium has a vital role in accelerating the photosynthesis process. Moreover, potassium can increase the growth and leaf area, CO2 assimilation, and translocation of photosynthetic products. Banana peels are rich in nutrients, especially potassium, to support microbial growth in the banana peel fermentation phase. Liquid fertilizer from banana peels contains C-organic nutrients 0.55%, N-total 0.18%; P_2O_5 0.043%; K_2O 1.137%; C/N 3.06% (Nasution, 2013).

The third liquid organic fertilizer ingredient is leucaena leaves. Using leucaena leaves as liquid organic fertilizer can increase the nitrogen content in organic fertilizers. Liquid organic fertilizer from leucaena leaves can be used as a nutrient for the growth of decomposer microorganisms (Ratrinia et al., 2014). Kusumaningtyas et al. (2020) said that the leaves of the leucaena tree contain high levels of nitrogen, phosphorus, potassium, carbon, and oxygen to support plant growth. Leucaena leaves contain 19.0 gkg^{-1} calcium, 2.16 gkg-1 phosphorus, and 17.0 gkg^{-1} potassium. Leucaena leaves contain macronutrients, namely 3.84% nitrogen, 0.22% phosphorus, 2.06% potassium, 1.31% calcium, 0.33% magnesium, and 0.51% SO_4^-. The content of each nutrient element serves to grow plants and increase their productivity. Using liquid organic fertilizers in hydroponic cultivation is environmentally friendly. These liquid organic fertilizers are an effective choice to meet the high nutritional needs of kale, reduce the high cost of Ab mix nutrients and supply high consumer demand for vegetables. This liquid organic fertilizer is free of chemicals that can increase the yield and quality of kale plants, especially the antioxidant levels in curly kale. This study aimed to investigate liquid organic fertilizer application technology from various agricultural wastes as an additional hydroponic nutrient. The liquid organic fertilizer can approach the results of hydroponic nutrition (AB Mix 100%), the benefit of which is increasing the quantity and quality of curly kale plants.

MATERIALS AND METHODS

This research was conducted from April 2022 to June 2022 at the screen house of Villa Puncak Tidar, Malang, which is located at an altitude of 600 meters above sea level with a minimum temperature of 25°C and a maximum temperature of 30°C. This study used some materials, such as curly kale (*Brassica oleracea* var. Sabellica) seeds, rockwool, 10 kg of leucaena leaves, 10 L of vinasse from PT Madu Baru, and 10 kg of kepok banana peel, water, molasses, brown sugar, promi, EM_4, AB Mix. The study employed a randomized block design with ten nutritional composition treatments repeated three times. The nutritional composition consists of ten combinations:

- N1: AB Mix 100%,
- N2: AB Mix 75% + (25% LOF Vinasse + Banana Peels),
- N3: AB Mix 75% + (25% LOF Vinasse + Leucaena leaves),
- N4: AB Mix 75% + (25% LOF Vinasse + Banana Peels + Leucaena leaves),
- N5: AB Mix 50% + (50% LOF Vinasse + Banana Peels),
- N6: AB Mix 50% + (50% LOF Vinasse + Leucaena leaves),

- N7: AB Mix 50% + (50% LOF Vinasse + Banana Peels + Leucaena leaves),
- N8: AB Mix 25% + (75% LOF Vinasse + Banana Peels),
- N9: AB Mix 25% + (75% LOF Vinasse + Leucaena leaves), and
- N10: AB Mix 25% + (75% LOF Vinasse + Banana Peels + Leucaena leaves).

Observations were made destructively at the harvest age of 60 DAP, including fresh shoot weight, root weight, shoot root ratio, chlorophyll content, and antioxidant levels.

Leaf chlorophyll levels

The chlorophyll content in leaves was measured using the Arnon method destructively at harvest 60 days after planting (Kumari et al., 2018). Arnon's formula is as follows:

$$\text{Chlorophyll a (mg g-1)} = [(12.7 \times \text{A663}) - (2.6 \times \text{A645})] \times \text{ml acetone mg leaf-1} \quad (1)$$

$$\text{Chlorophyll b (mg g-1)} = [(22.9 \times \text{A645}) - (4.68 \times \text{A663})] \times \text{ml acetone mg leaf-1} \quad (2)$$

$$\text{Total Chlorophyll} = \text{Chlorophyll a} + \text{Chlorophyll b} \quad (3)$$

where: A663 – absorbance value at wavelength 663;
A645 – absorbance value at wavelength 645.

Antioxidant level measurement (%)

Antioxidant testing was performed by quenching free radicals using DPPH (1,1-diphenyl-2-picrylhidrazyl). The level of antioxidant activity (TAA) was calculated using the formula:

$$\text{TAA (\%)} = (\text{Abs blank} - \text{Abs sample}) / (\text{Abs blank}) \times 100\%) \quad (4)$$

Data analysis

Observational data were analyzed using analysis of variance (F test) at a 5% level. If the observed data from the treatment has a significant effect, then this study will run the BNT test at a 5% level.

RESULTS AND DISCUSSION

Shoot fresh weight

Observations were made on the shoot fresh weight of the curly kale plant without roots. This study found that the 100% AB Mix treatment resulted in the heaviest weight of 169.44 grams compared to other treatments. Using the composition AB Mix 75% + (25% LOF Vinasse + Banana Peels + Leucaena leaves) shows the results of the portion weight consumed by curly kale closest to AB Mix 100%. Providing nutrition with the composition AB Mix 25% + (75% LOF Vinasse + Banana Peels), AB Mix 25% + (75% LOF Vinasse + Leucaena leaves), and AB Mix 25% + (75% LOF Vinasse + Banana Peels + Leucaena leaves) resulting in a lower consumption weight compared to other nutritional compositions. The more nutrients given to kale with the composition of agricultural waste, the lesser the consumption weight of curly kale is (Table 1).

On the basis of the average curly kale plants' shoot fresh weight, this study found that the nutrient composition treatment by adding 25% liquid organic fertilizer was not significantly different from the 100% AB Mix treatment (Table 1). The highest mean of fresh weight was the 100% AB Mix treatment, which was 169.44 grams. The results of consumption weight approaching the highest consumption weight of curly kale AB Mix 100% included AB Mix 75% + (25% LOF Vinasse + Banana Peels) 129.18 grams, AB Mix 75% + (25% LOF Vinasse + Leucaena leaves) 135, 68 grams, and AB Mix 75% + (25% LOF Vinasse + Banana Peels + Leucaena leaves) 142.33 grams. According to Nata et al. (2020), fresh shoot weight results from energy capture in the fresh plant shoot. Shoot fresh weight is influenced by water content and photosynthate accumulation during growth in plant cells and tissues. If photosynthate increases, the freshness of the plant shoot will also increase. In the nutritional composition with the addition of 50% and 75% liquid organic fertilizer, the average shoot fresh weight at pH 4–5.1, i.e. acidic, tends to give lower crown fresh weight compared to pH concentrations of 5 and 5.5. An isolated root environment and deposits of nutrients cause this situation. Both of these interfere with the process of photosynthesis and absorption of nutrients by plants as well as affect the fresh shoot weight of curly kale (Williams & Nelson, 2014). Appropriately preparing the composition of macronutrients and micronutrients is very important for plant growth and development in various physiological processes. It is a cofactor needed by several enzymes of primary and secondary metabolism (Janpen et al., 2019). The nutritional composition of 75%

AB Mix with the addition of 25% liquid organic fertilizer has the right and optimal composition of macronutrients and micronutrients to produce shoot fresh weight that is no different from the 100% AB mix treatment.

The results of the analysis of liquid organic vinasse fertilizer in this study contained 0.425% N, 0.32% K, 0.004% Mg, 20.19% Fe, 0.16% Cu, 15.36 Mn, 2.27% C-Organic, pH 4.30, 3.91% BO, and 5.40% C/N. Banana peel liquid organic fertilizer for the analysis of this study contained 0.22% N, 0.28% K, 0.006% Mg, 2.80% Fe, 13.59% Mn, 0.76% C-Organic, pH 4.01, 1.32% B-O, and 3.47% C/N. Meanwhile, the leucaena leaves liquid organic fertilizer in the study contained 0.03% N, 0.10% K, 0.005% Mg, 17.48% Fe, 1.69% Zn, 15.02% Mn, 0.87% C-Organic, pH 4.04, 1.50% BO-O, and 29.1% C/N. The micro elements of iron (Fe), manganese (Mn), and copper (Cu) are the elements that entirely dominate the contents of these three liquid organic fertilizers. These elements can complement AB mix nutrition to produce an optimal combination of nutrient treatment from AB Mix and liquid organic fertilizer. The content of nitrogen, potassium, and magnesium is relatively high in the AB mix solution and is balanced with nitrogen, potassium, and magnesium in low liquid organic fertilizers ranging from 0.10–0.40% to produce a balanced nutrient composition

Root fresh weight

The results of the mean fresh weight of the roots showed that the 100% AB Mix treatment resulted in a higher fresh weight, 42.65 cm. Applying the composition AB Mix 75% + (25% LOF Vinasse + Banana Peel + Leucaena leaves) showed the results of the fresh weight of kale roots closest to the AB Mix 100%. Providing nutrition to kale with an increasing composition of agricultural waste tends to reduce the yield of fresh weight of curly kale roots (Table 1). According to Msimbira et al. (2020), plants can absorb nutrients more optimally by providing nutrient solutions with a pH range of 5.6–6.0. At a pH value range of 6, the nutrient solution is more concentrated so that the solution cannot be absorbed by the roots to the maximum. This situation is caused by the osmotic pressure inside the cell which becomes smaller than the osmotic pressure outside the cell. The pH of the nutrient solution with the nutrient composition of 25% liquid organic fertilizer does not exceed 6 so that the roots are able to absorb nutrients more optimally.

AB Mix 100% treatment has a pH value of 5.6 with TDS 1877 ppm, AB Mix 75% + (25% LOF Vinasse + Leucaena leaves) has a pH of 6.1 with TDS 1877 ppm, AB Mix treatment 75% + (25% LOF Vinasse + Banana Peel) has a pH 6 with TDS 1871 ppm, and AB Mix 75% + (25% LOF Vinasse + Leucaena leaves+ Banana Peel) has a pH of 5.6 and TDS 1877 ppm. The quality of the nutrient solution decreases as the concentration of the nutrient solution increases. The higher the level of concentration setting, the more acidic the conditions of the nutrient solution are. Moreover, some of its nutrient content becomes unavailable to plants (Wulansari, 2012). This statement follows the results of fresh root weight (Table 1), which decreased in the composition of 50% liquid organic fertilizer with a pH value of 5.5–5.6 and 75% a pH value ranging from 4–5.1. The higher the pH of liquid organic fertilizer composition, the more acidic it is; thus, the roots are not optimal in absorbing nutrients. This situation resulted in a lower consumption weight and fresh root weight than the 75% Ab mix and the addition of 25% liquid organic fertilizer composition.

In addition to pH and nutrient solution concentration in ppm, absorption of phosphorus (P) and potassium (K) nutrients also has an influence and is related to root growth. Root growth is closely related to the uptake of phosphorus and potassium. This statement is supported by Jiang et al. (2012), who concluded that the plants treated with high phosphorus and potassium significantly supported root volume. Consequently, root hairs and lateral root hairs can obtain nutrients such as phosphorus and potassium. They scour a larger volume of soil and increase the absorbency of the root surface. The branching pattern of the plants, total root length, root hair elongation, and lateral root formation allow for greater soil volume when treated with high phosphorus. In the study by Jiang et al. (2012) according to the research results, the highest root fresh weight was in the 100% AB Mix treatment, where the composition of the nutrient solution with the addition of 25% liquid organic fertilizer had a high content of phosphorus and potassium (Table 1). AB Mix has a potassium content of 36.4%. Meanwhile, liquid organic fertilizer has a much lower potassium content, namely 0.28% banana peel, 0.10% leucaena leaves, and 0.32% vinasse. The phosphorus content in banana liquid organic fertilizer is 9.45

ppm, leucaena leaves is 68.4 ppm, and vinasse is 31.1 ppm. These contents are pretty low compared to the phosphorus content in the ab mix, which is 4.5%. Ohshiro et al. (2016) stated that potassium has a vital role in increasing plant absorption and catalytic in regulating the functions of various minerals in plants and increasing the efficiency of plant N uptake. The role of potassium in water absorption by plant roots is to control water movement from root cells to xylem tissue (Nabilah, 2019).

Shoot root ratio

The shoot/root ratio's observational variable measures whether the plant grows larger towards the shoot or creates roots. The plants with higher root growth will cause a smaller ratio value. As such, the 100% Ab Mix treatment resulted in a larger shoot/root ratio in the root formation. This finding was not significantly different from the AB Mix 75% + (25% LOF Vinasse + Banana Peels), AB Mix 75% + (25% LOF Vinasse + Leucaena leaves), AB Mix 75% + (25% LOF Vinasse + Banana Peels + Leucaena leaves) (Table 1). The results of the shoot/root ratio produce a large average. As a result, it can be said that the shoots/roots make more carbohydrates. The ratio of shoot to the roots increases the solution concentration. This finding is in accordance with the results of research by You et al. (2014) where the shoot/root ratio of the invasive aquatic plant *E.crassipes* increased along with nutrient levels and temperature. This condition occurs because nutrients are a limiting factor for plant growth in low resources.

Meanwhile, carbon is a relatively limiting nutrient resource to support plant growth under the conditions of high resources. This statement is corroborated by Hoang et al. (2019), who reported that the plants with higher fertilizer concentrations allocate a more significant fraction of carbohydrates for shoot growth compared to those with lower concentrations. The plants with high fertilizer concentrations can produce more leaf area.

Chlorophyll

Optimal plant growth is determined not only by root growth but also by chlorophyll content. Chlorophyll is positively correlated with photosynthesis and plant yields. In general, the chlorophyll content of curly kale plants is greater than the nutritional composition with the use of a composition of 25% liquid organic fertilizer. The nutritional composition of liquid organic fertilizers, 50%, and 75%, showed a decrease in chlorophyll content (Figure 1). According to Wortman (2015), the reduced level of the greenness of the leaves (chlorophyll) is caused by reduced nitrogen in the solution. This situation makes the low Ec value with high pH. This statement is in line with the results of checking the pH of the nutrient solution in each treatment. The nutritional composition of providing 50% liquid organic fertilizer

Table 1. Average yield variables due to nutritional composition treatment at 60 DAP

Treatment	Shoot fresh weight (g)		Root fresh weight (g)		Shoot root ratio	
AB Mix 100%	169.44	c	42.65	c	4.02	e
AB Mix 75% + (25% LOF Vinasse + Banana Peels)	129.18	c	40.4	bc	3.2	de
AB Mix 75% + (25% LOF Vinasse + Leucaena leaves)	135.68	c	41.92	c	3.24	de
AB Mix 75% + (25% LOF Vinasse + Banana Peels + Leucaena leaves)	142.33	c	42.11	c	3.26	de
AB Mix 50% + (50% LOF Vinasse + Banana Peels)	67.36	b	30.56	ab	2.17	bc
AB Mix 50% + (50% LOF Vinasse + Leucaena leaves)	75.67	b	32.76	abc	2.37	cd
AB Mix 50% + (50% LOF Vinasse + Banana Peels + Leucaena leaves)	70.88	b	32.9	abc	2.2	bc
AB Mix 25% + (75% LOF Vinasse + Banana Peels)	20.54	a	27.89	a	0.8	a
AB Mix 25% + (75% LOF Vinasse + Leucaena leaves)	32.02	ab	25.75	a	1.26	a
AB Mix 25% + (75% LOF Vinasse + Banana Peels + Leucaena leaves)	47.36	ab	34.7	abc	1.4	ab
LSD 5%	45.9		10.24		0.9	

Note: Numbers in the same column accompanied by the same letter showed no significant difference in the 5% LSD test.

produces pH values ranging from 7.1 to 7.3 and chlorophyll values from 154.82 to 211.13. Meanwhile, the nutritional composition by applying 75% liquid organic fertilizer produced a pH value ranging from 7.73–7.8 with a chlorophyll value of 192.12–245.78. The 100% AB Mix nutritional composition treatment has a pH value of 5.6 with a chlorophyll value of 221.67. The nutritional composition by applying 25% liquid organic fertilizer produced a pH value between 5.6–6.1 and the highest chlorophyll value, 230.81–263.67. The factors that influence the formation of chlorophyll are genetics, light, oxygen, carbohydrates, nutrients (nitrogen, magnesium, iron), water, and temperature. The chlorophyll content decreases in the nutrient composition solution when giving 50% and 75% liquid organic fertilizer. This decrease occurs due to missing elements of N, Mg Fe, and Zn to form the chlorophyll needed by curly kale vegetables.

Meanwhile, the curly kale plants with 100% AB mix and 25% liquid organic fertilizer treatment could produce sufficient N, Mg Fe, and Zn elements to form chlorophyll. Vinasse organic fertilizer has a low nitrogen content of 0.42%, followed by 0.22% banana peel liquid organic fertilizer and 0.03 leucaena leaves liquid organic fertilizer. The Mg content in vinasse liquid organic fertilizer is also low at 0.004, banana peel liquid organic fertilizer at 0.005, and 0.005% leucaena leaves liquid organic fertilizer. However, it can be said that the chlorophyll yield is optimal, because it is offset by the nitrogen content in the AB mix, which is relatively high, namely in the form of 24% N-NO3, 3.7% N-NH4, and the Mg content in the AB mix which is also high, namely 4.6 %.

This finding is consistent with the results of total chlorophyll, where the composition of AB Mix 75% + (25% LOF Vinasse + Banana Peels) has the highest yield. Nitrogen plays a vital role in compiling chlorophyll: the nitrogen element absorbed by plants is in the form of ammonia, and then ammonia is converted to glutamic acid, catalyzed by the enzyme glutamine synthase. Glutamic acid is the primary material for the biosynthesis of amino acids and nucleic acids. The formation of chlorophyll requires glutamic acid as a porphyrin ring precursor (Nabilah, 2019). Other elements that also play a role in the formation of chlorophyll are magnesium (Mg), iron (Fe), and Zenk (Zn). According to Chen et al. (2017), the need for Mg elements in stem and leaf vegetables is 75 ppm. Mg^{2+} is the most important ion for photosynthesis because 15–35% of the total plant Mg is bound in chloroplasts, especially as a constituent of chlorophyll which is a vital component in the energy transfer process. This is consistent with the results of total chlorophyll, where the composition of AB Mix 75% + (25% LOF Vinasse + Banana Peels) has the highest yield. The role of nitrogen in compiling chlorophyll occurs through a process: the element nitrogen absorbed by plants is in the form of ammonia, and then ammonia changes to glutamic acid, catalyzed by the enzyme glutamine synthase. The function of glutamic acid is as a primary material

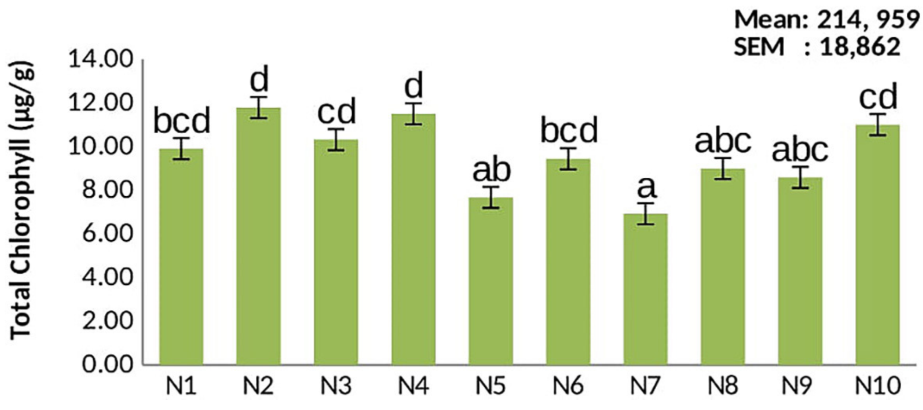

Figure 1. Total chlorophyll of curly kale.

Note: N1 – AB Mix 100%, N2 – AB Mix 75% + (25% LOF Vinasse + Banana Peels), N3 – AB Mix 75% + (25% LOF Vinasse + Leucaena leaves), N4 – AB Mix 75% + (25% LOF Vinasse + Banana Peels + Leucaena leaves), N5 – AB Mix 50% + (50% LOF Vinasse + Banana Peels), N6 – AB Mix 50% + (50% LOF Vinasse + Leucaena leaves), N7 – AB Mix 50% + (50 % LOF Vinasse + Banana Peels + Leucaena leaves), N8 – AB Mix 25% + (75% LOF Vinasse + Banana Peel), N9 – AB Mix 25% + (75% LOF Vinasse + Leucaena leaves), N10 – AB Mix 25% + (75% LOF Vinasse + Banana Peels + Leucaena leaves).

for the biosynthesis of amino acids and nucleic acids. The formation of chlorophyll requires glutamic acid as a porphyrin ring precursor (Nabilah, 2019). The elements that also play a role in the formation of chlorophyll are magnesium (Mg), iron (Fe), and zinc (Zn). According to Chen et al. (2017), the need for Mg elements in stem and leaf vegetables is 75 ppm. Mg_2^+ is the most important ion for photosynthesis. About 15–35% of the total plant Mg is bound in chloroplasts, especially as a constituent of chlorophyll which is a key component in the energy transfer process.

One of the irreplaceable roles of Mg in plant cells is as the central atom of chlorophyll. In plants, the first step to carry out chlorophyll synthesis is the insertion of Mg_2^+ into protoporphyrin IX, catalyzed by Mg-chelatase, the reaction of which is dependent on ATP. Mg-chelatase is a heterotrimeric enzyme composed of subunits BchI, BchD, and BchH in photosynthetic bacteria, or ChlI, ChlD, and ChlH in plants. It utilizes Mg^{2+}, ATP, and protoporphyrin IX as cofactors and substrates. AB Mix has a relatively low Zn and Fe content of 0.000012% and 0.000198%. The Fe content in liquid organic fertilizer vinasse and banana peels was relatively high: 20.19% and 17.48. Meanwhile, the highest Zn content was in liquid organic fertilizer vinasse and banana peel: 2.35% and 2.16%. This is consistent with the results of total chlorophyll, where the composition of AB Mix 75% + (25% LOF Vinasse + Banana Peel) has the highest yield. The nutrient content of zinc (Zn) in plants is essential in forming chlorophyll for photosynthetic activity. The increase in the chlorophyll content is caused by zinc, which acts as a structural and catalytic component of proteins, enzymes, and cofactor for the normal development of pigment biosynthesis (Samreen et al., 2013). In plants, the elemental iron (Fe) is involved in synthesizing chlorophyll. It is essential for maintaining the structure and function of chloroplasts because Fe is directly involved in the photosynthetic activity of plants and affects their productivity. According to Rout et al. (2015), iron, an inseparable integral part of proteins and enzymes, plays an essential role in fundamental biological processes such as photosynthesis, chlorophyll synthesis, respiration, nitrogen fixation, absorption mechanisms, and DNA synthesis through the action of ribonucleotide reductase. The iron (Fe) and chlorophyll concentrations correlated well with the greenness of the leaves

Antioxidant

Observation of antioxidant levels was carried out when the plants were harvested at the age of 60 HST. The quality of curly kale can be seen from its antioxidant content. The AB Mix 50% + (50% LOF Vinasse + Banana Peels) treatment showed a higher antioxidant content than the treatment and increased by 15.79% from the 100% AB Mix treatment (Table 2). The observations of antioxidant levels were carried out when the curly kale plants were harvested at the age of 60 HST. The results showed the highest antioxidant content in the 50% AB Mix + 50% LOF treatment. According to Yaldiz et al. (2018), organic farming products deliver the highest phenolic content compared to conventional (inorganic) techniques. This is related to higher pathogenic pressure in organic farming, which has biotic pressure, and causes an increase in phenolic levels grown organically.

Biological fertilizers significantly increase the levels of phenolics and flavonoids in organically grown basil plants. The addition of biological

Table 2. Average antioxidant levels due to nutritional composition treatment at 60 DAP

Treatment	Antioxidant (%)
AB Mix 100%	67.63
AB Mix 75% + (25% LOF Vinasse + Banana Peels)	81.58
AB Mix 75% + (25% LOF Vinasse + Leucaena leaves)	73.82
AB Mix 75% + (25% LOF Vinasse + Banana Peels + Leucaena leaves)	71.62
AB Mix 50% + (50% LOF Vinasse + Banana Peels)	83.42
AB Mix 50% + (50% LOF Vinasse + Leucaena leaves)	82.81
AB Mix 50% + (50% LOF Vinasse + Banana Peels + Leucaena leaves)	81.27
AB Mix 25% + (75% LOF Vinasse + Banana Peels)	74.87
AB Mix 25% + (75% LOF Vinasse + Leucaena leaves)	78.73
AB Mix 25% + (75% LOF Vinasse + Banana Peels + Leucaena leaves)	63.90

fertilizers to compost at 50% or 75% results in a significant increase in total phenolic and total flavonoid content compared to inorganic fertilizers or organic fertilizers alone. These results are similar to those of the highest antioxidant levels in curly kale plants in the 50% AB Mix + 50% LOF treatment. Yaldiz et al. (2018) stated that adding biological fertilizers increased the phenolic content in green beans. This is because of the multibiofertilizer acts as a growth booster for rhizobacteria. In addition, microorganisms fix N_2 and supply it to plants while synthesizing siderophores. They play a key role in dissolving minerals such as phosphorus and iron. The nitrogen content affects the antioxidant levels in curly kale plants. Aina et al. (2019) mention a strong relationship between levels of macronutrients (i.e., nitrogen, phosphorus, and potassium) and phenolics, flavonoids, and other bioactive compounds. This statement is corroborated by the results of Ibrahim et al. (2013) that organic fertilizers increase the activity of antioxidants and bioactive compounds in Kacip Fatimah (*Labisia pumila Benth*).

CONCLUSIONS

Liquid organic fertilizer application technology can be obtained from various agricultural wastes as additional hydroponic nutrients. This liquid organic fertilizer has results close to those of hydroponic nutrition (AB Mix 100%). These results can be carried out by using the AB Mix 75% + (25% LOF Vinasse + Banana Peels + Leucaena leaves) treatment to increase the yield and quality of curly kale. AB Mix 50% and 25% in various liquid organic fertilizer compositions significantly reduced the yield and quality of curly kale.

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