

Utilization of Liquid Organic Fertilizer to Improve Growth and Quality of *Kangkong* (*Ipomoea reptans* Poir.)

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ABSTRACT

The Indonesian government provides fertilizer subsidies to increase the productivity of the agricultural sector and the welfare of farmers. However, the farmers in Indonesia use inorganic fertilizers more. Continuous use of inorganic fertilizers is harmful to the environment and human health. The use of organic fertilizers as a healthier alternative to inorganic fertilizers needs to be increased to avoid sustainable negative impacts. One solution that can be done is by using liquid organic fertilizer (LOF). Previous studies have shown the use of LOF with various concentrations has a different effect on the growth of *kangkong*. This research aims to determine the effect of differences in LOF concentrations on the growth and quality of *kangkong*. This research uses an experimental method with a Randomized Block Design (RBD) using six treatments (P0: 0% (negative control), P1: 1%, P2: 2%, P3 : 3%, P4: 4%) and the positive control used NPK 16-16-16. Each treatment consists of five replicates. Data were analyzed using SPSS version 22 followed by Duncan's test if there were data with significant differences at the 5% test level ($P \leq 0,05$). The results showed that the application of LOF significantly affected the growth of root compactness and stem diameter at 21 DAP and 28 DAP, but had no significant effect on other parameters. Based on this study, it was found that the use of LOF concentrations that could increase root compactness and stem diameter was 1%.

1. Introduction

The Indonesian government provides fertilizer subsidies to increase the productivity of the agricultural sector and the welfare of farmers. Fertilizer subsidies provided include inorganic and organic fertilizers. However, the pattern of farmers' use of fertilizers in Indonesia is more dominated by inorganic fertilizers, where as many as 86.5% of farmers in Indonesia use inorganic fertilizers (Setiono, 2019). Continuous use of inorganic fertilizers is harmful to the environment and human health. Soil conditions and nutrients can be damaged. Soil with this condition causes the microbes that play a role in dissolving phosphate and potassium cannot live. In addition, plant roots become unable to grow and develop properly, so that overall plant growth is disrupted. Inorganic fertilizers are carcinogenic to humans, so it is necessary to reduce the use of inorganic fertilizers. According to Ward (2009), nitrate that found in inorganic fertilizers can cause cancer. Apart from the negative impacts produced by inorganic fertilizers, reducing the use of inorganic fertilizers is also necessary because of the increase in energy and fertilizer prices globally which has an impact on the threat of a global food and energy crisis (Ministry of Agriculture of the Republic of Indonesia, 2022).

Kangkong is a type of vegetable that is favored by Indonesians because it tastes delicious and is affordable. *Kangkong* has a high nutritional content, because it contains vitamin A, B, C, and iron which are useful for human health, growth, and development (Mayani et al., 2015). According to Kurniawan et al. (2020), *kangkong* has potential as an antioxidant, antidiabetic, and anti-obesity for humans. Apart from that, *kangkong* also contains protein, calcium, phosphorus, and minerals (Syefanis et al., 2019). According to data from the Badan Pusat Statistik (2022), the average consumption of *kangkong* per capita per day from all districts/cities in Indonesia reaches 6.103 kg. The low percentage of growth in *kangkong* production with the high interest in public consumption can have an impact on the lack of availability of *kangkong* in Indonesia. Efforts to maintain *kangkong* production without negative impacts from the use of inorganic fertilizers can be done by using organic fertilizers in *kangkong* production.

Organic fertilizers can be in the form of manure, compost, green manure, and liquid organic fertilizer. According to Assefa and

Tadesse (2019), the use of organic fertilizers has many advantages for the agricultural sustainability component. The raw materials used for making organic fertilizers are very easy to obtain, because they utilize organic waste in the surrounding environment (Junior et al., 2017). Liquid organic fertilizer can improve soil conditions that have been damaged and contain nutrients that are easily absorbed by the soil, so that it can restore nutrient deficiency conditions in the soil, increase crop production, and improve crop quality (Febrianna et al., 2018).

Research on the use of liquid organic fertilizer on *kangkong* has been reported. Arif (2018) found that the use of palm sap liquid organic fertilizer (*Arenga pinnata* Merr.) at a concentration of 40% had a significant effect on the growth of *kangkong*. However, Istiqomah (2020) reported that the use of water hyacinth liquid organic fertilizer (*Eichornia crassipes*) showed that the results of using fertilizer had a significant and best effect at a concentration of 60%. Based on this description, researchers wanted to know the effect of different concentrations of liquid organic fertilizer on the growth and quality of *kangkong*.

2. Methodology

2.1 Time and place of study

This research was conducted from January to March 2023 at Greenhouse of the Biology Study Program, Faculty of Mathematics and Natural Sciences, Udayana University, Jimbaran, Badung, Bali. The chlorophyll content testing was carried out at the Integrated Research Laboratory of the Faculty of Mathematics and Natural Sciences, Udayana University.

2.2 Tools and materials

The material used in this research was the LP-1 variety of *kangkong* produced by PT. East West Indonesia Cap Panah Merah, liquid organic fertilizer and compost produced by Dewandaru Flora Organic Farm, fertile soil, NPK 16-16-16 fertilizer, water, and 80% ethanol. The tools used were plastic containers, seedling trays, labels, polybags 10x15 cm, small shovel, sprayer, measuring tape, calipers, digital scales, oven, plastic bags, blender, test tubes, filter paper, funnels, centrifugation tubes, analytical balance, UV-Vis Spectrophotometer, stationery, and camera.

2.3 Methods

Research design

A randomized block design (RBD) was used in this research with six different treatments. Each treatments have five replications that consisted of three plant units, so that 90 experimental units were obtained. The treatment in this study, namely P0: 0% (negative control), P1: 1%, P2: 2%, P3: 3%, P4: 4% using liquid organic fertilizer volume per volume concentration (v/v), and P5 (positive control) using inorganic fertilizer type NPK 16-16-16.

Seed Seedling

LP-1 *kangkong* seeds were selected first by soaking them in water for 6 hours. Seeds that sank and were not damaged with same size and color then selected as many as 90 seeds. The LP-1 *kangkong* seeds that have been selected are then sown in seedling trays with soil that has been mixed with compost using a ratio of 1:1. Dewandaru Flora Organic Farm's compost consists of plant waste, chicken manure, and rhizobacteria. The seeds were sown for 10 days until the first 2 leaves appeared and the stems were 7-8 cm high before being transferred to polybags.

Planting

Seedlings that are 10 days old are planted in polybags with soil mixed with compost. The weight of the media used in each polybag is 250 g with a ratio of soil and compost of 1:1. Transfer of seedlings to polybags is done with a small shovel. The media is first perforated with a small shovel as deep as 3-5 cm, then the *kangkong* seedlings are planted and the roots are covered with the media. The spacing used was 10 x 5 cm, according to Robiansah et al. (2017).

Plant Care

Seedlings are watered once a day in the morning or evening. Watering the seedlings is done with a sprayer. The volume of watering for each seedling is 100 mL. Watering the seeds is not done at the same time the seeds are given treatment. This is done to avoid soluble treatment carried by water. Weeding is done manually by removing the weeds when weeds are found around the *kangkong* plants. The purpose of weeding is to avoid competition in the absorption of nutrients between *kangkong* and weeds.

Application of Fertilizer

Fertilization is done every seven days starting from the age of 7 DAP, 14 DAP, and 21 DAP. Fertilizer application was carried out with a sprayer which was given to the soil media as much as 100 mL according to the treatment of each experimental unit. The

treatment in this study, namely P0: 0% (negative control), P1: 1%, P2: 2%, P3: 3%, P4: 4% using volume per volume concentration (v/v). The positive control (P5) was the application of dissolved NPK 16-16-16 inorganic fertilizer according to the product guidelines where each experimental unit was given 0.45 g of fertilizer which had been dissolved in 100 mL of water.

Parameter Observation

The parameters observed in this study were the growth and quality parameters of *kangkong*. Growth parameters included number of leaves (strands), disease percentage (%), chlorophyll content (mg/Kg), plant height (cm), stem diameter (cm), root length (cm), fresh weight (g), and dry weight (g). *Kangkong* quality parameter include root compactness.

Harvest

Harvesting is done after *kangkong* is 30 DAP which is calculated from the time the *kangkong* seedlings are transferred to polybags. Harvesting is done by removing the *kangkong* from soil. The harvested *kangkong* is cleaned of soil and the roots are soaked in water to keep them fresh.

2.4 Data analysis

Data analysis was performed with SPSS version 22 using one way ANOVA. If data with significant differences were obtained at the 5% test level ($P \leq 0.05$), data analysis was continued with Duncan's test to determine differences between treatments.

3. Results and Discussion

3.1 Results

Number of Leaves

The number of leaves observed at the age of 7 DAP, 14 DAP, 21 DAP, and 28 DAP is shown in Figure 1. Based on the results of the analysis of variance (ANOVA) it was found that the treatment of giving different LOF concentrations did not significantly affect the number of leaves of *kangkong* at the age of 7 DAP, 14 DAP, 21 DAP, and 28 DAP. The growth of *kangkong* is characterized by an increase in the number of leaves on *kangkong*. Growth in the number of leaves is best shown by using LOF 1%. The LOF 1% treatment produced 4.57% more leaves than the negative control treatment at 28 DAP. The NPK 16-16-16 treatment produced the least number of leaves compared to the other treatments.

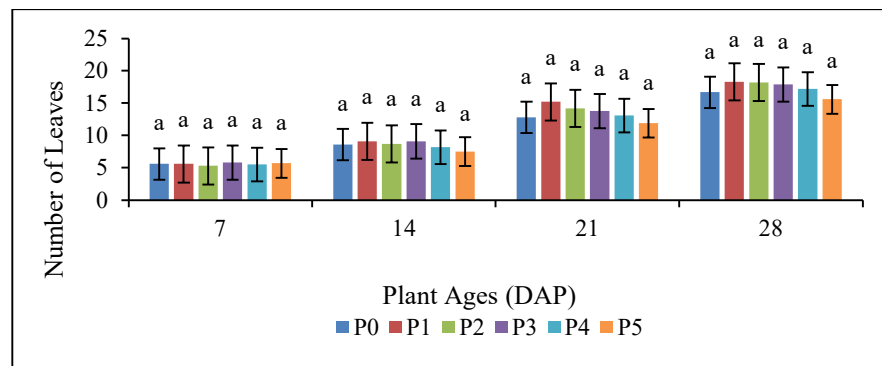


Figure 1. The effect of different treatments on the average number of leaves of *kangkong*

Note: P0 = Negative control (0%) P3 = LOF 3%
P1 = LOF 1% P4 = LOF 4%
P2 = LOF 2% P5 = NPK 16-16-16

Disease Percentage

The disease observed in this study was white rust disease which is characterized by indented upper leaf surfaces with small nodules that protrude on the leaf surface. The percentage of disease in *kangkong* leaves with treatment P0 (40%) had the highest percentage of white rust disease, followed by treatments P2 (30%), P3 (20%), and P4 (20%) (Table 1). The disease appears when the *kangkong* are 7 DAP and increases when the *kangkong* are 14 DAP. The increase in disease at 14 DAP caused the separation of disease-infected *kangkong* from healthy plants. This separation causes the spread of white rust disease to stop and the percentage of white rust disease until the age of 28 DAP remains.

Table 1. The effect of different treatments on the percentage of white rust disease in *kangkong*

Treatment	Disease Percentage	
	7 DAP	14 DAP
P0	0%	40%
P1	0%	10%
P2	10%	30%
P3	0%	20%
P4	10%	20%
P5	0%	10%

Note: P0 = Negative control (0%) P3 = LOF 3%
 P1 = LOF 1% P4 = LOF 4%
 P2 = LOF 2% P5 = NPK 16-16-16

Chlorophyll Content

The chlorophyll content of *kangkong* leaves showed different results. Figure 2. shows that treatment P5 has the largest amount of chlorophyll content (3442.033 mg/Kg). As for the treatment P3 (2851.105 mg/Kg) and P1 (2824.272 mg/Kg) the total chlorophyll content was greater than the negative control (2692.608 mg/Kg). Treatments P4 (2676.634 mg/Kg) and P2 (2552.907 mg/Kg) yielded a lower total chlorophyll content compared to the negative control.

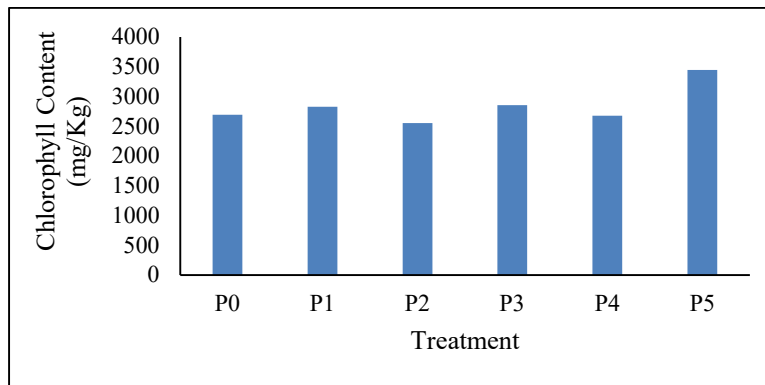


Figure 2. The effect of different treatments on total chlorophyll content in *kangkong* 30 DAP

Note: P0 = Negative control (0%) P3 = LOF 3%
 P1 = LOF 1% P4 = LOF 4%
 P2 = LOF 2% P5 = NPK 16-16-16

Plant Height

The use of different concentrations of liquid organic fertilizer had an insignificant effect on the height of *kangkong* at 7 DAP, 14 DAP, 21 DAP, and 28 DAP. Based on Figure 3. it can be seen that *kangkong* that was given LOF 1% treatment produced the highest plant height. Giving LOF 1%, 2%, and 4% produced better plant height compared to the negative control. LOF 1% and 2% also produced better *kangkong* height compared to NPK fertilizer treatment.

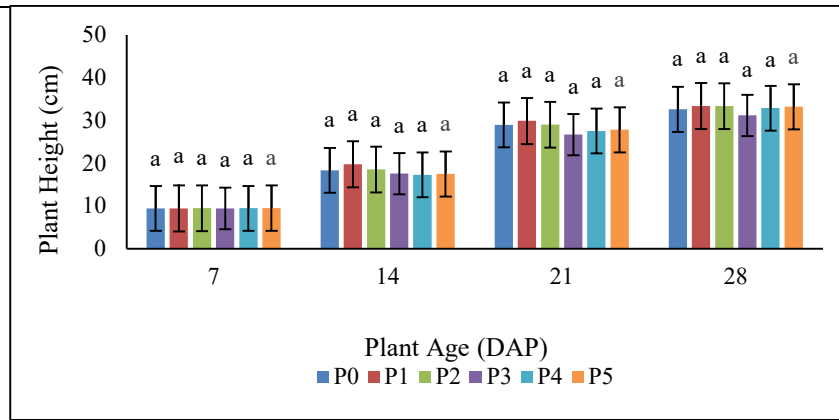


Figure 3. The effect of different treatments on the average number of plant height of *kangkong*

Note: P0 = Negative control (0%) P3 = LOF 3%
 P1 = LOF 1% P4 = LOF 4%
 P2 = LOF 2% P5 = NPK 16-16-16

Stem Diameters

The results of the analysis of variance (ANOVA) showed that the treatment with different concentrations of LOF insignificant effect on the stem diameter of *kangkong* at 7 DAP and 14 DAP, but had a significant effect at 21 DAP and 28 DAP. The LOF 1% treatment resulted in the largest stem diameter of *kangkong* (0.481 cm) at 28 DAP (Figure 4). Application of LOF 1% to *kangkong* yielded stem diameters of *kangkong* that were significantly different from the treatment with NPK 16-16-16 fertilizer and not significantly different from other treatments. Stem diameter with LOF 1% showed better results (0.481 cm) compared to the application of NPK 16-16-16 (0.389 cm).

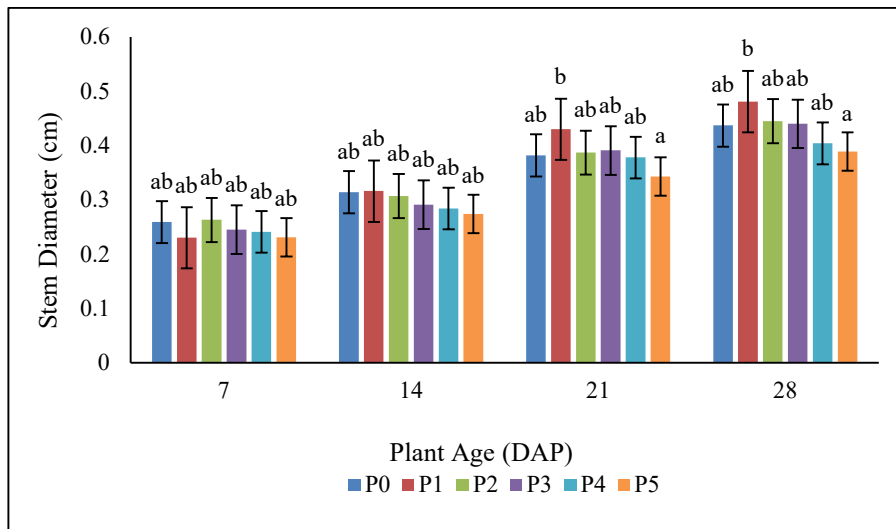


Figure 4. The effect of different treatments on the average number of stem diameters of *kangkong*

Note: P0 = Negative control (0%) P3 = LOF 3%
 P1 = LOF 1% P4 = LOF 4%
 P2 = LOF 2% P5 = NPK 16-16-16

Root Length

The use of various concentrations of liquid organic fertilizer had an insignificant effect on the root length of *kangkong* at time of harvest. After the Duncan test with a level of 5% ($P \leq 0.05$) the results are shown in Table 2. Based on Table 2, it can be seen that treatment P0 was significantly different from P2 and was not significantly different from other treatments. Treatment P0 had the largest average root length (21.33 cm), while P2 had the smallest average root length (17.87 cm).

Table 2. The effect of different treatments on the average root length of *kangkong*

Treatments	Root Length (cm)
P0	21.33 ^b

P1	19.03 ^{ab}
P2	17.87 ^a
P3	19.26 ^{ab}
P4	18.9 ^{ab}
P5	20.06 ^{ab}

Note: Numbers followed by the same letter in the same column were not significantly different according to Duncan's advanced test at 5% level ($P \leq 0.05$)

Root Compactness

Root compactness is indicated by the number of root branches, root density, and root diameter. *Kangkong* given LOF 1% treatment had better root compactness compared to other treatments (Table 3).

Table 3. The effect of different treatments on root compactness of *kangkong*

Treatment	Root Compactness		
	+	++	+++
P0	40%	50%	10%
P1	20%	30%	50%
P2	50%	20%	30%
P3	30%	30%	40%
P4	50%	10%	40%
P5	30%	50%	20%

Note: + = Less compact
 ++ = Normal
 +++ = Compact

The majority of P1 roots have many dense root branches with large diameters (Figure 5). Normal root compactness was most abundant in the negative control (P0) and positive control (P5) treatments. Normal root compactness is indicated by the presence of dense root branches with large diameters which are also dominated by numerous small diameter root branches (Figure 5). *Kangkong* plant roots with less compactness were found in the P2 and P4 treatments. As much as 50% of the P2 and P4 treatment data samples had less dense roots with small diameters and were dominated by a large number of fine root branches.



Figure 5. The effect of different treatments on root compactness of *kangkong* at 30 DAP
 Note: From left to right: P0 (negative control (0%)), P1 (LOF 1%), P2 (LOF 2%), P3 (LOF 3%), P4 (LOF 4%), and P5 (NPK 16-16-16)

Wet Weight and Dry Weight

The wet weight and dry weight parameters measured in this study were observed when the plants had been harvested, which was 30 DAP. The dry weight was observed after the *kangkong* was baked in the oven and it has reached a constant weight. Based on the results of analysis of variance (ANOVA) on wet weight, it was found that the treatment with different LOF concentrations had insignificant effect on the wet weight and dry weight of *kangkong* (Table 4). *Kangkong* with the largest average wet weight and dry weight were found in *kangkong* given LOF 1% treatment. This shows that the application of LOF 1% produced the best wet weight and dry weight of *kangkong*, while the LOF 4% treatment showed the lowest results of wet weight and dry weight compared to other treatments.

Table 4. Wet and dry weight of *kangkong* 30 DAP with different treatments

Treatment	Wet Weight (g)	Dry Weight (g)
P0	11,1 ^a	1,587 ^a
P1	12 ^a	1,61 ^a
P2	9,4 ^a	1,325 ^a
P3	9,2 ^a	1,308 ^a
P4	8,9 ^a	1,298 ^a
P5	9,8 ^a	1,391 ^a

Note: Numbers followed by the same letter in the same column were not significantly different according to Duncan's advanced test at 5% level ($P \leq 0.05$)

Liquid Organic Fertilizer (LOF) Content

LOF Dewandaru Flora Organic Farm is a liquid organic fertilizer produced by Dewandaru Flora Organic Farm Munduk Paku, Senganan, Tabanan, Bali. This LOF contains 10% fish waste, 10% potato, 1% *Piper caninum* leaf extract, Rhizobacter, and water. LOF Dewandaru Flora Organic Farm can be used to increase growth, yield, flowering, and suppress disease in rice, vegetables, flowers, and fruit. This LOF contains several elements of N, P, K, as well as other compounds (Table 5) such as growth hormones which can support the growth and development of plants.

Table 5. Nutrient content of liquid organic fertilizer (LOF)

Parameters	Value	Unit
N (Nitrogen)	1,10	%
P (Phosporus)	221,12	mg/L
K (Potassium)	39,21	mg/L
Organic-C	0,95	%

3.2 Discussion

Treatment of different concentrations of liquid organic fertilizer (LOF) did not significantly affect the number of leaves and plant height at 7 DAP, 14 DAP, 21 DAP and 28 DAP. However, the provision of LOF 1% tends to increase the growth of the number of leaves and plant height of *kangkong*. The increase in the growth of *kangkong* can be seen from the increase in the number of leaves (Figure 1). This is in accordance with Idris' research (2020), that the use of LOF produced by farmers in the Tani Subur group also tends to increase the growth of the number of leaves in *kangkong*, although it has no significant effect. Muliawan et al. (2021) also reported that adding LOF increased the height growth of *kangkong*, although the difference was not significantly different. This is in accordance with the plant height data obtained (Figure 3). Results that were not significantly different could be affected by differences in liquid organic fertilizer concentrations that were too low.

The LOF 1% treatment yielded better leaf count, chlorophyll concentration, plant height, stem diameter, and root compactness compared to the negative control (Figure 1-5). This could be due to the higher nitrogen content in the media treated with LOF 1% compared to the negative control. The negative control did not have any treatment, so that the nitrogen content that could be utilized from the planting medium was less than the LOF 1% treatment. Provision of LOF containing fish waste and rhizobacteria provides more nitrogen elements that can be used in the process of growth and chlorophyll formation. According to research by Kusuma et al. (2021), fish waste in LOF contains nitrogen elements which are obtained from the ammonification process through the breakdown of amino acids and proteins into ammonia (NH₃).

The presence of rhizobacteria increases the nitrogen content in the soil. Rhizobacter converts nitrogen in the atmosphere (N₂) into ammonia through nitrogen fixation which can be used by plants to increase productivity. The presence of rhizobacteria in LOF can produce phytohormones in the form of Indole Acetic Acid (IAA) which increase auxin levels in plants, thereby increasing the ability to absorb nutrients in the soil, stimulating plant growth and development (Rehan et al., 2023). The IAA hormone can also increase root biomass (Hamid et al., 2021). According to Zapata-Sifuentes et al. (2022), the presence of the IAA hormone is associated with cell division and differentiation which improves the structure of the root system, resulting in *kangkong* which has dense roots with large diameters (Figure 5).

The LOF 1% treatment gave better leaf number, plant height, stem diameter, and root compactness compared to the positive control using NPK 16-16-16 (Figure 1, 3-5). This can be caused by the effect of NPK fertilizer which does not contain microbes, so that the absorption of nutrients by *kangkong* with this treatment is not good. The results obtained are in line with the research of Pangaribuan et al. (2019), where the provision of LOF made from a mixture of lamtoro leaf extract, banana bunches, and coconut fiber increased the ability to absorb nutrients in sweet corn plants. The high nutrient content in NPK also causes the concentration of nutrients in the soil, so that the growth and development of *kangkong* is disturbed. This is in line with research by Alborno and Lieth (2015) which was conducted on lettuce plants, where a high nutrient supply did not increase plant productivity.

The concentration of this nutrient also occurs in the treatment of giving LOF, where giving higher concentrations of LOF does not always increase the growth and development of *kangkong*. This is shown in the results of observations on the number of leaves, plant height, stem diameter, and the compactness of the *kangkong* roots. The unfavorable observation results could be due to the influence of the concentration of LOF that was too high, causing the rhizobacteria in the *kangkong* plant media to produce more IAA hormones. The more IAA hormone produced, it will be followed by the high production of the ethylene hormone as well. According to Bhat et al. (2023), the presence of too much ethylene hormone in plants can result in stunted growth in plants. In addition, high LOF concentrations can also cause a plasmolysis process in *kangkong* due to the difference in the concentration gradient between *kangkong* and the soil. Plasmolysis causes the cell membrane of the *kangkong* plant to detach from the cell wall, so that the *kangkong* plant cannot grow and develop properly.

The results of observations of stem diameter (Figure 4) and root compactness (Table 3) showed that LOF 1% administration had a significant effect on stem diameter at 21 DAP and 28 DAP, as well as root compactness. This is due to the presence of rhizobacteria and the content of potato waste contained in the LOF used. Rhizobacter plays a role in supporting plant growth, one of which is increasing stem diameter. This is because rhizobacteria can dissolve insoluble potassium in the soil and convert it into available potassium (Hamid et al., 2021). The role of rhizobacteria is to increase the potassium content in the soil, thereby encouraging the growth of stem diameter. Rhizobacter also acts as a biostimulant which increases plant growth by producing IAA hormones which can increase root biomass. In addition, potato waste in LOF also provides the potassium needed for stem diameter growth. According to Mufid (2018), potatoes are a good source of potassium with a content of 600 mg of potassium per potato.

The percentage of white rust disease that attacks *kangkong* appears at 7 DAP and increases at 14 DAP (Table 1). White rust disease attacks the leaves and causes the growth of *kangkong* infected with the disease to be stunted and the leaves quickly wither and die (Britannica, 2023). Plants that have been infected with white rust disease will increase the spread of the disease. This causes the spread of the disease at 14 DAP quite rapidly. This rapid increase in disease has led to the need to separate *kangkong* infected with disease from healthy plants. Separation of infected *kangkong* is done by placing the plants on a different table from healthy

kangkong, so that there is no contact between the two plants. This separation causes the spread of white rust disease to stop and the percentage of white rust disease until the age of 28 DAP remains.

The increase in the percentage of white rust disease which was quite high at 14 DAP could be due to the effect of watering the plants by spraying, so that the fungal spores were easy to spread (Semangun et al., 2010). In addition, an increase in the percentage of disease can be triggered by the spacing of *kangkong*. Tight spacing causes humidity to increase and disease to spread more easily to other plants. In accordance with the research of Opod et al. (2021), the density of spacing causes an increase in humidity around chrysanthemum plants, making it easier for fungal spores to infect plants.

LOF treatment could not directly stop the spread of white rust disease in *kangkong*. However, giving LOF allows *kangkong* to gain immunity against white rust disease. LOF contains rhizobacteria which have antifungal activity against several phytopathogens (Goswami and Deka, 2020). Rhizobacter provides protection to plants from pathogens through the production of antibiotics, hydrolytic enzymes, hydrogen cyanide, and other compounds (Vafa et al., 2021). Rhizobacter is able to suppress disease by inhibiting the synthesis of pathogenic cell walls and affecting the structure of pathogenic cell membranes (Jiao et al., 2021). Research by Rudrappa et al. (2010) showed that the presence of rhizobacteria also allows for the activation of plant defense systems that are able to provide immunity to plants against pathogen attacks. This makes it possible that white rust disease cannot infect all *kangkong* at 14 DAP. The LOF used also contains *Piper caninum* leaf extract which can inhibit the spread of white rust disease. According to research by Suriani et al. (2020), *Piper caninum* leaf extract has antifungal activity which is evidenced by a decrease in the intensity of the disease and the fungus that infects rice is inhibited after administration of LOF containing *Piper caninum* leaf extract.

Observation of chlorophyll content (Figure 2) showed that NPK treatment resulted in a greater amount of chlorophyll content than LOF treatment. This is because the nitrogen content in NPK fertilizer is more than that of LOF. LOF contains as much as 1.10% nitrogen (Table 5), while NPK fertilizer contains 16% nitrogen. This causes the chlorophyll content in *kangkong* treated with NPK fertilizer to be more than LOF. According to Putri (2019), the presence of the nitrogen affects the amount of chlorophyll formed in the leaves. Although NPK provides a better total chlorophyll content compared to LOF treatment, the use of chemical-based NPK is not healthy for consumer consumption. The mixture of chemicals contained in NPK fertilizers can be absorbed by plants. This will become toxic if consumed by humans in excessive amounts (Kumar and Keshar, 2017). In addition, excessive use of inorganic fertilizers can affect soil pH, soil organic carbon content, cause damage to the soil, and even cause greenhouse gas emissions (Pahalvi et al., 2021). This causes NPK to be unsuitable for use in the long term, even though it provides a high total chlorophyll content.

The results of observations of root length showed that the treatment with different LOF concentrations had no significant effect on the root length of *kangkong* (Table 2). After Duncan's follow-up test was carried out with a level of 5% ($P \leq 0.05$) the results for P0 were significantly different from P2 and not significantly different from other treatments. The P0 treatment had the largest average root length which could be caused by the influence of the presence of a small amount of nutrients in the soil. The presence of a few nutrients triggers the growth of lateral roots to help plants absorb more water and nutrients in the soil, so that the nutritional needs of *kangkong* can be met (Baiyin et al., 2021). The P2 treatment had the smallest average root length because this treatment was affected by a disease with the second highest percentage (30%) which caused leaf necrosis and stunted plants. This causes the growth of P2 *kangkong* to be stunted, so that the roots cannot grow properly even though the presence of nutrients in the soil can meet the needs of the plants. This is in accordance with research conducted by Opod et al. (2021) on chrysanthemum plants, where the presence of white rust disease inhibits development and weakens plants.

Based on the results of analysis of variance (ANOVA) on wet weight, it was found that the treatment with different LOF concentrations had no significant effect on the wet weight and dry weight of *kangkong* (Table 4). Giving LOF 1% produced better wet weight and dry weight compared to the negative control. This can be due to the influence of the content of rhizobacteria in LOF which can increase nitrogen in the soil which is needed in the process of growth and development, thereby supporting the growth of stems, roots and leaves. Increasing the growth of stems and leaves will increase the wet weight and dry weight of the *kangkong*. Yanti et al. (2022) reported the most efficient rhizobacter isolates for increasing the number of leaves and plant height as well as the wet weight and dry weight of shallot bulbs.

The LOF 4% treatment showed the smallest wet weight and dry weight results. This can be seen in the growth data of P4 plants, namely the number of leaves, stem length, and stem diameter which tend to be small compared to other treatments. Low plant growth causes the overall plant weight is also low. The low growth of *kangkong* is due to the concentration of LOF given. High LOF concentrations lead to high rhizobacter concentrations and will induce more ethylene to form. High ethylene concentrations will inhibit plant growth (Bhat et al., 2023). High LOF concentrations can also cause plasmolysis processes. In addition, the roots of P4 plants that are less compact have a small surface area, so their ability to absorb nutrients is not good. This will also affect the growth of the *kangkong* plant and the overall weight of the *kangkong* plant.

4. Conclusion

Application of liquid organic fertilizer (LOF) did not significantly affect the number of leaves, plant height, root length, and stem diameter of *kangkong* (*Ipomoea reptans* Poir.) at 7 DAP and 14 DAP. Variations in LOF concentrations also did not significantly affect the quality of *kangkong*, namely disease percentage, total chlorophyll content, fresh weight, and dry weight. Application of LOF with a concentration of 1% had a significant effect on root cohesiveness and stem diameter growth of *kangkong* at 21 DAP and 28 DAP, and tended to increase the number of leaves, plant height, wet weight and dry weight of *kangkong*. The use of LOF with a concentration of 3% can produce a fairly good total chlorophyll content of *kangkong*, although it is lower than the use of inorganic fertilizers, namely NPK 16-16-16.

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