Application of Kumpai (Hymenachne sp.) Grass Liquid Organic Fertilizer on Swamp Water as Culture Medium of Pangasius Catfish (Pangasius sp.) With an Aquaponic System

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Abstract
Nutritional needs in an aquaponic system can be fulfilled through the application of liquid organic fertilizer. This study aimed to determine the best dose of kumpai grass liquid organic fertilizer on the culture of pangasius catfish and lettuce plants using a floating raft aquaponic system. This study used a Completely Randomized Design with four treatments and three replications. The treatments consist of liquid organic fertilizer (P_0), kumpai grass liquid organic fertilizer 3 µL L^{-1} per day (P_1), 5 µL L^{-1} per day (P_2), and 7 µL L-1 per day (P_3). Pangasius catfish with an initial length 5±0.5 cm and stocking density of 100 fish per m^3 was cultured for 42 days. The results showed that application of kumpai grass liquid organic fertilizer (LOF) 5 µL L^{-1} per day (P_2) was the best treatment with water quality at day 42 culture. Kumpai grass Liquid organic fertilizer provides essential nutrients, especially for cultivation media using swamp water. Besides maintaining water quality, it also supports the growth and sustainability of catfish and the harvest of lettuce plants.

Keywords: aquaponic, kumpai grass, liquid organic fertilizer

1. Introduction

An aquaponics system is the integration of recirculating aquaculture and hydroponics in one production system (Somerville et al. 2020). This system is a productive, innovative, and sustainable fish and vegetable production system (Mchunu et al. 2018). This system reduces environmental impacts and resource inputs by utilizing fish waste as a nutrient source for plants, fostering a mutually beneficial relationship between aquatic organisms and crops (Kwasi et al. 2021). The integrated aquaponics system can result in lower negative environmental impacts and resource consumption while providing food to a high demand (Paul & Sahu, 2025). The integration of fish culture and plants in a bio-green floating system significantly enhance water quality, improves fish health, and optimize fish production in an aquaculture system without water exchange (Sopawong et al. 2023).

Nutritional needs are very important in an aquaponic system, because they are not only needed by plants but also for pond productivity. Swamp fish pond has a problem related to submerged flat soil and water pH value, and result in low productivity of ponds (Jubaedah et al. 2020). Although in principle, the aquaponic system allows for the availability of nutrients from the aquaculture process, the use of swamp water as a water source for fish farming media with low productivity means that additional nutrients are needed. Increasing natural productivity is an essential element in making production costs more efficient, but also for the welfare of fish stocks, which develop more harmoniously when the proportion of feed available to the fish is varied (Arcade et al. 2024). The nutrient requirements of an aquaponics system can be met through the application of liquid organic fertilizer (LOF). Organic fertilizer is produced from renewable waste materials that must be feasible from a technical, economic, and environmental perspective (Fernández-Delgado et al. 2022). The use of organic fertilizers can increase crop production while maintaining environmentally sustainable agricultural practices (Albayati, 2026).

The materials of LOF are not only from waste materials, but also from local raw materials. Kumpai grass has the potential to be a liquid organic fertilizer material. Kumpai grass is a type of plant in swamp areas containing several elements including calcium (Ca) 0.190%, phosphorus (P) 0.181%, sodium (Na) 0.362%, iron (Fe) 0.005%, aluminum (Al) 13.442%, cobalt (Co) <0.005 mg L^{-1}, and selenium (Se) 0.0029 mg $^{L-1}$ (Muhakka et al. 2019). Kumpai grass has the advantage of adapting to aquatic environments so that it can grow well in swampy areas. Kumpai grass is referred to as a Weed of National Significance in Australia due to its invasive nature, which can replace native wetland vegetation and clog drainage channels (Australia Centre for International Agriculture Research, 2012). This demonstrates the abundant biomass potential of kumpai grass, making it a potential source of liquid organic fertilizer. This study aimed to determine the optimal dosage of liquid kumpai grass fertilizer for raising catfish and lettuce using a floating raft aquaponics system.

Materials and Methods

The experimental design used was a Completely Randomized Design (CRD) using four treatments with three replications. The treatments consist of no liquid organic fertilizer (P_0), liquid organic fertilizer dose 3 µL L^{-1} per day (P_1), 5 µL L^{-1} per day (P_2), and 3 µL L^{-1} per day (P_3).

The concrete ponds measuring 1mx1mx1m were cleaned and disinfected using potassium permanganate at a dose of 2.5 mg L^{-1} for 24 hours and rinsed with clean water. At the surface of ponds, a styrofoam measuring 80cm ×

80cm × 2cm, which had been perforated with a diameter of 6 cm, with as many as 16 holes, and a hole was given in the middle for the installation of the aerator. The 14 oz plastic cup used has 20 small holes in the bottom of the cup, and is placed on top of the styrofoam that has been perforated. with a distance of 20 cm between the glasses. Plastic cups that have been placed on styrofoam are inserted into the water for rearing catfish, with the bottom of the glass submerged in water to a depth of 5 cm. The water used as a medium for catfish culture is swamp water taken from the reservoir pond in the Aquaculture Laboratory and Experimental Pond, Aquaculture Study Program, Faculty of Agriculture, Universitas Sriwijaya. Before use, the water is incubated for 24 hours in a concrete pond measuring 4m × 3m × 0.9m. The water is given dolomite lime at a dose of 37.5 mg L^{-1} and incubated for 48 hours, then it is transferred into a culture pond with a water level of 70 cm. The pH value of the swamp water used is 4.91. After being given lime and incubated for 48 hours, the pH is 7.12.

Lettuce seeds were first sown in individual rockwool balls cut into 5 cm diameter circles. One lettuce seed was sown in each rockwool ball. Watering was done every morning for 14 days to maintain the moisture of the lettuce plants until they were ready to be planted. During the nursery period, fertilization was carried out using AB mix fertilizer. The use of AB mix fertilizer is done by combining 1 L of water with 5 mL of fertilizer A and 5 mL of fertilizer B. This solution is added to the rockwool medium containing the seeds, then placed in a location out of direct sunlight for one day to stimulate germination. After germination begins, the lettuce seedlings are moved to a sunny location until they develop 3-4 leaves. During the lettuce seeding process, the humidity of the rockwool medium must be maintained.

The production of fertilizer from kumpai grass begins with preparing kumpai grass taken from around the reservoir pond in the Aquaculture Laboratory and Experimental Pond, Aquaculture Study Program, Faculty of Agriculture, Sriwijaya University. The prepared kumpai grass is then washed and cleaned. The procedure for making liquid organic fertilizer refers to Cho (2016). Kumpai grass 600 g is cut into 5-6 cm lengths, then prepared with 6 L of rice washing water, 200 mL of probiotics, 200 mL of brown sugar water, and 100 g of leaf mold. All ingredients are placed in a fermentation container in the form of a 10 L plastic jar and stirred until all ingredients are evenly mixed. The container was then tightly closed. A Fermentation was carried out for 24 days. The fermented kumpai grass liquid organic fertilizer was filtered, and the water was collected. The analysis results of the Nitrogen, P_2O_5, K_2O, and C-Organic content of the kumpai grass LOF obtained 0.010%, 0.002%, 0.050%, and 0.580%, respectively. The kumpai grass liquid organic fertilizer (LOF) was added according to the dosage specified for each treatment.

Fish with a stocking density of 100 fish per m^3 (Poulsen et al. 2008), acclimatized for 1 day. The 14-day-old lettuce seeds were then transferred to plastic cups as a growing medium. The plastic cups containing the lettuce plants were then placed on top of styrofoam in the fish culture pond, as determined for each treatment. The pangasius catfish and lettuce were reared for 42 days. Commercial feed with a protein content of 39-41% was fed to the fish at satiation three times daily at 8:00, 12:00, and 16:00 WIB. During the rearing period, the pond was aerated but not subjected to any other irrigating activities, such as siphoning and water changes.

Observed parameters included water quality, including total dissolved solids (TDS), ammonia, nitrate, phosphorus, potassium, dissolved oxygen, pH, and temperature. Other parameters included absolute growth in length and weight, feed efficiency, survival, and total harvest weight of the lettuce plants. Analysis of water quality data (TDS, ammonia, potassium, dissolved oxygen, pH, and temperature), absolute growth, feed efficiency, survival of catfish, and total weight of lettuce harvest obtained were tested using analysis of variance at a 95% confidence interval. If there were significant results of the analysis of variance, post-hoc testing was carried out using the Least Significant Difference. Nitrate and total phosphorus data were analyzed descriptively.

Results

Water Quality

The results of the variance analysis and post hoc $LSD_{\square 0.05}$ test of total dissolved solids (TDS) on the initial and final days showed that different treatments in the form of application of LOF kumpai grass significantly affected the TDS value of water in fish cultivation media.

Table 1. TDS and ammonia concentration

Treatments	TDS (mg L^{-1})		Ammonia (mg L^{-1})	
	Initial day	Final day	Initial day	Final day
P_0	64.00±0.00^d	107.67±0.58^a	0.052±0.002	0.059±0.004
P_1	55.00±3.00^b	146.00±7.00^c	0.050±0.003	0.060±0.002
P_2	51.67±0.58^a	130.00±5.00^b	0.051±0.002	0.057±0.002
P_3	58.00±0.00^c	101.00±2.00^a	0.053±0.003	0.054±0.002
$LSD_{\alpha 0,05}$	2.88	8.33		

Numbers followed by different superscript letters in the interaction and main effects indicate significant differences in the $LSD_{\alpha\ 0.05.}$

The $LSD_{\square 0.05}$ test on the initial day showed that the treatment without application of kumpai grass LOF (P_0) produced a significantly higher TDS value compared to other treatments. On the final day, the TDS of the water in the culture media given kumpai grass LOF at a dose of 3 µL L^{-1} per day (P_1) was significantly higher than that of the other treatments. The application of kumpai grass LOF had no significant effect on ammonia levels in the

culture media on the initial and final days of fish culture. The ammonia concentrations tend to increase on the final day of culture.
The nitrate concentration (Table 2) obtained on the final day of culture at P_0, P_1, and P_2 tended to be high. Data from the results of measuring the phosphor of the water in the culture media on initial and final days of culture are shown in Table 3. The phosphor in the culture water treated with LOF (P_1, P_2, and P_3) tended to increase on the final day.

Table 2. Nitrate, phosphor and potassium

Treatments	Nitrate (mg L^{-1})		Phosphor (mg L^{-1})		Potassium (mg L^{-1})	
	Initial day	Final day	Initial day	Final day	Initial day	Final day
P_0	<0.809	28.02±1.12	0.30±0.25	0.28±0.00	$1.03±0.03^b$	$2.19±0.12^a$
P_1	<0.809	33.48±4.67	0.03±0.02	0.69±0.02	$1.23±0.09^c$	$3.40±0.20^c$
P_2	<0.809	28.45±0.98	0.05±0.02	0.90±0.25	$0.87±0.01^a$	$2.83±0.05^b$
P_3	<0.809	11.65±0.96	0.05±0.01	0.61±0.03	$1.32±0.04^c$	$2.35±0.12^a$
$LSD_{\alpha 0,05}$					0.10	0.25

Numbers followed by different superscript letters in the interaction and main effects indicate significant differences in the $LSD_{\alpha\ 0.05.}$

The results of the $LSD_{\square 0.05}$ test on the initial day showed that the potassium content of the water in the culture medium given 7 μL L_{-1} of kumpai grass LOF per day (P_3) was significantly higher than the P_0 and P_2 treatments, but not significantly different from the treatment given 3 μL L^{-1} of kumpai grass LOF per day (P_1). Meanwhile, on the final day, the potassium content of the water in the culture medium given 3 μL L^{-1} of kumpai grass LOF per day (P_1) was significantly higher than the other treatments.
The results of the $LSD_{\square 0.05}$ test on the initial day (Table 3) showed that the dissolved oxygen in the water of the culture media given LOF kumpai grass at a dose of 5 μL L^{-1} per day (P_2) was significantly higher than the other treatments, but not significantly different from the dissolved oxygen in the water of the culturemedia without the application of LOF kumpai grass (P_0). Meanwhile, on the final day, the dissolved oxygen in the water of the culture media given LOF kumpai grass at a dose of 5 μL L^{-1} per day (P_2) was significantly higher than the other treatments.
The results of the analysis of variance on initial days showed that the application of kumpai grass LOF in all treatments (P_0, P_1, P_2, and P_3) had no significant effect on the pH of the culture media water. Meanwhile, on the final days, the pH of the water in the culture medium supplemented with kumpai grass LOF at a dose of 7 μL L^{-1} per day (P_3) was significantly higher than the other treatments, but not significantly different from the treatment supplemented with kumpai grass LOF at a dose of 5 μL L^{-1} per day (P_2).

Table 3. Dissolved Oxygen (DO), pH and temperature

treatments	DO (mg L^{-1})		pH		temperature (°C)	
	Initial day	Final day	Initial day	Final day	Initial day	Final day
P_0	$5.30±0.10^{ab}$	$5.30±0.10^a$	7.19±0.05	$8.32±0.06^b$	$26.28±0.05^a$	$26.73±0.03^b$
P_1	$4.83±0.25^a$	$5.27±0.15^a$	7.22±0.03	$7.94±0.02^a$	$26.41±0.07^b$	$26.48±0.03^a$
P_2	$5.63±0.31^b$	$5.60±0.10^b$	7.27±0.08	$8.48±0.01^c$	$26.45±0.10^b$	$26.65±0.10^b$
P_3	$5.07±0.35^a$	$5.27±0.15^a$	7.31±0.10	$8.53±0.05^c$	$26.35±0.00^{ab}$	$26.98±0.03^c$
$LSD_{0,05}$	0.51	0.24		0.07	0.13	0.10

Numbers followed by different superscript letters in the interaction and main effects indicate significant differences in the $LSD_{\alpha\ 0.05.}$

The results of the $LSD_{\square 0.05}$ test on day initial day showed that the pH of the water in the rearing medium given LOF at a dose of 5 μL L^{-1} per day (P_2) was significantly higher than the treatment without LOF (P_0), but not significantly different from the treatments given kumpai grass LOF at a dose of 3 μL L^{-1} per day (P_1) and a dose of 7 μL L^{-1} per day (P_3). Meanwhile, on the final day, the pH of the water in the rearing medium given POC kumpai grass at a dose of 7 μL L^{-1} per day (P_3) was significantly higher than the other treatments.
The results of the $LSD_{\square 0.05}$ test on initial day showed that the temperature of the water in the rearing medium given LOF at a dose of 5 μL L^{-1} per day (P_2) was significantly higher than the treatment without LOF (P_0), but not significantly different from the treatments given kumpai grass LOF at a dose of 3 μL L^{-1} per day (P_1) and a dose of 7 μL L^{-1} per day (P_3). Meanwhile, on the final day, the temperature of the water in the rearing medium given LOF kumpai grass at a dose of 7 μL L^{-1} per day (P_3) was significantly higher than the other treatments.

Absolute Growth, Feed Efficiency and Survival of Fish
The results of the $LSD_{\square 0.05}$ test showed that the absolute weight and length growth of pangasius catfish in the treatment given kumpai grass LOF at a dose of 5 μL L^{-1} per day (P_2) was significantly higher than the other treatments. The high absolute weight and length growth of fish in the treatment given LOF 5 μL L^{-1} per day (P_2) treatment resulted in higher feed consumption compared to other treatments. This is consistent with the higher feed efficiency of the 5 μL L^{-1} per day (P_2) treatment given kumpai grass LOF compared to other treatments at the final days of the culture period (Table 4).

The results of the LSD□0.05 test showed that the fish feed efficiency in the treatment given kumpai grass LOF at a dose of 5 μL L^{-1} per day (P_2) was significantly higher than the other treatments. Although the feed efficiency value in the treatment given kumpai grass LOF at a dose of 7 μL L^{-1} per day (P_3) was lower than the other treatments, this value was also categorized as good. The results of the LSD□0.05 test showed that the survival of fish in the treatment given kumpai grass LOF at a dose of 5 μL L^{-1} per day (P_2) was significantly higher than in other treatments.

Table 4. Absolute growth, feed eficiency and survival rate of fish

Treatments	Absolute weight growth (g)	Absolute length growth (cm)	Feed eficiency (%)	Survival Rate (%)
P_0	11.97±0.15^{a}	6.12±0.01^{b}	84.29±1.40^{a}	96.43±0.72^{b}
P_1	12.84±0.15^{b}	6.03±0.17^{b}	93.15±2.54^{b}	97.14±0.00^{c}
P_2	14.84±0.15^{d}	8.53±0.35^{c}	101.08±1.62^{c}	100.00±0.00^{d}
P_3	13.81±0.10^{c}	5.54±0.02^{a}	94.75±0.12^{b}	90.00±0.00^{a}
$LSD_{\alpha 0,05}$	0.15	0.21	1.81	0.39

Numbers followed by different superscript letters in the interaction and main effects indicate significant differences in the $LSD_{\alpha\ 0.05.}$

Total weight of lettuce harvest

The results of the LSD□0.05 showed that the total weight of lettuce harvest in the treatment given kumpai grass LOF at a dose of 5 μL L^{-1} per day (P_2) was significantly higher than the other treatments.

Table 5. Total weight of lettuce harvest

Treatments	Total weight of lettuce (g)
P_0	75.0±4.0^{a}
P_1	159.5±51.5^{b}
P_2	416.5±36.5^{c}
P_3	125.0±12.0^{b}
$LSD_{\alpha 0,05}$	34.99

Numbers followed by different superscript letters in the interaction and main effects indicate significant differences in the $LSD_{\alpha\ 0.05.}$

Discussion

The increase in TDS is thought to be due to the addition of dissolved ions contained in the LOF provided. According to Boyd (2020), most of the weight of dissolved solids results from inorganic particles, and waters with large dissolved solids concentrations often are said to be highly mineralized. The TDS positively correlated with Pangasius hypophthalmus weight (Reecha et al. 2024).

The increase in ammonia, particularly in the culture media supplemented with LOF, is thought to be influenced by the decomposition of LOF during the culture period. Ammonia is a form of nitrogen produced from the decomposition of organic matter, including LOF. According to Boyd (2020), decomposing organisms convert organically bound nitrogen into ammonia during the decomposition of organic matter. Furthermore, the increase in ammonia, even in media without LOF (P0), is influenced by waste and fish farming activities, as well as the death of lettuce plants. Ammonia is the predominant type of nitrogen excreted (Munguti et al. 2021).

Ammonia and ammonium exist in a temperature and pH-dependent equilibrium. The proportion of NH_3 increases with greater temperature and pH. Elevated concentrations of un-ionized ammonia can be toxic to aquatic organisms. Organic fertilizers, chemical fertilizers, and feeds used in agriculture and aquaculture contain nitrogen in amounts ranging from <1% in some livestock manures to 45% in urea fertilizer and from 4 to 10% in feeds (Boyd, 2020). According to Pillay & Kutty (2005), the maximum permissible concentration of ammonia in the water supply of indoor fish hatcheries was 0.05 mg L^{-1}. Ammonia is the most toxic form of inorganic nitrogen produced in water. The ammonical nitrogen content in water is an index of the degree of its pollution. Ammonia in a fish culture pond should not exceed 0.1mg L^{-1} (Santhosh & Singh. 2017). Once ammonia concentrations in the water are high, fish are less able to excrete ammonia through gill diffusion, resulting in the accumulation of ammonia in fish tissues, which would finally affect fish health and growth (Yusoff et al. 2024).

The increase in nitrate is suspected to be due to the application of nitrogen-containing fertilizer during culture, the ammonification process, and the nitrification of leftover feed and fish feces. This causes an increase in nitrate not only in the culture water treated with LOF but also in the water in the media not treated with LOF. Organic nitrogen is decomposed to ammonia by microorganisms, and increased concentrations of ammonia and nitrate stimulate aquatic plant growth (Boyd, 2020). The presence of nitrate in water comes from the conversion of ammonia into nitrate with the help of Nitrosomonas sp. and Nitrobacter sp. bacteria in the nitrification process. The high nitrate concentration was mainly on the final day of culture. However, nitrate is not toxic to aquatic animals even in large concentrations. Its favourable range is 0.1 mg L^{-1} to 4.5 mg L^{-1} in culture water (Santhosh & Singh. 2017). The nitrate values obtained in the treatment given a dose of LOF 7 μL L^{-1} per day (P_3) tended to be lower than those of the other treatments. This is thought to be because the application of excessive doses of LOF will cause the denitrification process. Denitrification converts nitrogen compounds, such as nitrate, into nitrogen gas or nitrogen oxide through the activity of anaerobic microorganisms. This process will cause a decrease in nitrate levels in the water of the culture medium.

The application of LOF containing 0.002% phosphor caused an increase in the phosphor in the media water treated with LOF, higher than without the application of LOF. According to Boyd (2020), phosphorus is the most important nutrient limiting phytoplankton productivity. If phosphorus is added to the water, plant growth will increase. Concentrations of inorganic phosphorus in water bodies seldom exceed 0.1 mg L^{-1}, and total phosphorus concentration rarely is greater than 0.5 mg L^{-1}. Phosphorus is not toxic at elevated concentrations, but along with nitrogen, it can lead to eutrophication.

Theoretically, the higher the dose of LOF given, the higher the potassium value should be. However, in this study, the potassium value decreased as the dose of LOF given increased. The potassium value in all treatments, including those without LOF (P_0), tended to increase with the culture time. The increase in potassium values in treatments given fertilizer (P_1, P_2, and P_3) was caused by giving LOF during culture, which contained 0.050% pottasium. The increase in potassium values in all treatments, including those without LOF (P_0), is thought to be due to additions of potassium from uneaten food waste, fish feces, and dead plants. Fish feed contains small amounts of potassium, so in aquaponic systems, potassium must be added through fertilizer to meet the plant's nutritional needs (Siqwepu et al. 2020). Potassium is an essential mineral nutrient for the majority of plants for plant and animal growth (Boyd, 2020). Potassium levels in natural freshwater are typically <10 mg L^{-1}. Potassium is necessary for the algal growth and zooplankton production (Santhosh & Singh. 2017).

Changes in dissolved oxygen are caused by biological, physical, and chemical processes that occur during culture (Boyd, 2020). Furthermore, the addition of LOF during the cultivation period also causes fluctuations in dissolved oxygen levels in the water used for cultivation. This is because the addition of LOF can stimulate phytoplankton growth and aid photosynthesis, resulting in the production of dissolved oxygen in the water. The biological processes that influence dissolved oxygen concentration are photosynthesis by green plants and respiration by all aquatic organisms. Turbidity, sunlight, temperature, wind, nutrient load, and the stocking density also have a direct relation with dissolved oxygen (Santhosh & Singh. 2017). The dissolved oxygen value obtained during culture is the optimum value for pangasius catfish culture in ponds, namely >4 mg L^{-1} (National Standardization Agency, 2002).

pH is an important limiting factor in fish culture. It indicates the acid-base balance of the water. The suitable pH range for fish culture is between 6.7 and 9.5. Ideal pH for the growth of fish is between 7.5 and 8.5. Above and below this is stressful to the fish (Santhosh & Singh. 2017). During culture, the water pH increased due to the regular addition of LOF. The LOF contains organic acids produced by the fermentation process. In addition, the increase in pH is due to the decomposition process of various types of organic materials provided. The pH value of liquid organic fertilizer should not be alkaline because it indicates that organic acid compounds and amino acids are further converted into methane and ammonium (Abidin et al. 2024). Several studies have shown that fermented LOF has a low pH. Banana peel (Musa paradisiaca I.) liquid organic fertilizer fermented using Trichoderma sp. has a pH 4-6; the longer the fermentation, the lower the pH value (Sofiah et al. 2025). The pH value of tofu liquid waste with banana hump mol decomposer has a pH from 3.62 - 3.72 (Napoleon et al. 2023). The pH value is generally still within the optimal range, although there is a pH value on day 42 in the P3 treatment that is slightly higher than the maximum pH required. Despite the increase in water pH during fish culture, the value is still within the optimum range for catfish cultivation in ponds, namely 6.5-8.5 (National Standardization Agency, 2002).

Temperature changes that occur during cultureare caused by high air temperatures. According to Boyd (2020), temperature changes in water are influenced by solar radiation, air temperature, weather and climate. Although the temperature obtained increases and decreases, the temperature is still within the optimum range for raising catfish in ponds, namely 25-30°C (National Standardization Agency, 2002).

The feed efficiency in relation to growth and productivity then becomes an important criterion. The higher the feed efficiency, the more efficiently the fish utilize the feed consumed for their growth. Furthermore, fish growth is also influenced by the provision of LOF during fish culture. The application of LOF to fish culture media plays a role in providing essential nutrients, especially nitrate, which supports plankton growth, which then serves as additional natural food for fish. The addition organic fertilizer provides nutrients that can help increase the availability of natural food such as plankton, which contributes to fish growth (Ritonga et al. 2023). However, when the LOF was given at a higher rate than 5 μL L^{-1} per day (P_2), which was 7 μL L^{-1} per day (P_3), the absolute growth value of the fish tended to decrease. This is thought to be due to a decrease in nutritional values in the P_3 treatment, including nitrate, phosphorus, and potassium (Tables 2).

A good fish feed efficiency value is >50% (Craig & Helfrich, 2002). A high feed efficiency value indicates that the consumed feed can be utilized efficiently. The high feed efficiency value obtained was also caused by the addition of LOF during fish culture. This is because LOF contains the probiotic, which can help fish digest the food they are given. Probiotics stimulate immune reactions, decrease pathogenic loads, enhance digestion, and enhance water quality (Gadhiya et al. 2025).

The survival rate of the fish obtained was categorized as good. Based on the National Standardization Agency (2000), the survival rate of Siamese catfish at the seed stage (nursery II) cultured in aquariums or tanks was 85%. Fish survival is influenced by several factors, one of which is water quality. Water quality (ammonia, dissolved oxygen, pH and temperature) during culture still supports the survival of catfish.

The high total weight of lettuce harvest in the treatment given kumpai grass LOF at a dose of 5 μL L^{-1} per day (P_2) was due to the sufficiency of nutrients so that it was able to stimulate the growth of lettuce plants. This is because the higher the concentration of the nutrient solution, the more nutrients it contains so that the plant's needs for growth and development are met. The nutrients in LOF can quickly address nutrient deficiencies, eliminate nutrient leaching problems, and provide nutrients quickly. Nutrients are needed by plants to facilitate photosynthesis, growth, and reproduction. A balanced balance of nitrogen (N), phosphorus (P), and potassium (K) optimally facilitates photosynthesis in plants. The nitrogen, phosphorus, and potassium contained in LOF are essential for plant root structure, photosynthesis, cell growth, metabolic processes, water absorption, disease resistance, and chlorophyll production (Somerville et al. 2020).

Conclusions

Based on the results of the research, the application of liquid organic fertilizer of kumpai grass at a dose of 5 μL L^{-1} per day (P_2) is the best treatment to support optimal water quality, fish growth, and survival, and plant harvest in aquaponic systems. Kumpai grass liquid organic fertilizer increases the availability of nutrients to support the successful cultivation of catfish and lettuce plants in floating aquaponics systems.

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