

The Effect of Liquid Organic Fertilizer Made from Catfish Waste on the Biomass of *Lemna* sp in the Maintenance Media of Kissing Gourami (*Helostoma temminckii*) on Peat Water

Pengaruh Pemberian Limbah Ikan Patin (POC) terhadap Biomassa *Lemna* sp dalam Media Pemeliharaan Ikan Tambakan (*Helostoma temminckii*) pada Air Gambut

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ABSTRACT

Peat water is acidic and nutrient-poor, thus less supportive for aquatic organisms. *Lemna* sp. has potential as both a phytoremediator and natural feed, but its growth depends on nutrient availability. Catfish waste can be fermented into liquid organic fertilizer (POC), rich in nitrogen, phosphorus, and potassium. This study aimed to examine the effect and optimal dosage of catfish-waste POC on the biomass of *Lemna* sp in peat water used for rearing kissing gourami (*Helostoma temminckii*). The research was conducted for 30 days, from March to April 2025, at the Environmental Quality Laboratory of Aquaculture, Faculty of Fisheries and Marine, Universitas Riau. The experimental method used a Completely Randomized Design (CRD) with five treatments and three replications. The treatments were: P0 (control, without POC), P1 (1.75 mL/L), P2 (2.0 mL/L), P3 (2.25 mL/L), and P4 (2.5 mL/L). The best result was obtained in treatment P3 (2.25 mL/L), with water quality values of temperature 26–30.4°C, pH 3.8–7.2, dissolved oxygen 4.54–7.37 mg/L, nitrate 0.39–15.86 mg/L, phosphate 3.06–6.05 mg/L, and CO₂ 5.0–10.0 mg/L. This treatment also produced a biomass increase of *Lemna* sp. of 107.6 g and a specific growth rate of 5.05%.

Keywords: *Lemna* sp, Catfish Liquid Organic Fertilizer, Kissing Gourami

ABSTRAK

Air gambut bersifat asam dan miskin hara sehingga kurang mendukung kehidupan organisme akuatik. *Lemna* sp. berpotensi sebagai fitoremediasi dan pakan alami, namun pertumbuhannya bergantung pada ketersediaan unsur hara. Limbah ikan patin dapat difermentasi menjadi pupuk organik cair (POC) yang kaya nitrogen, fosfor, dan kalium. Penelitian ini bertujuan mengkaji pengaruh serta dosis terbaik POC limbah ikan patin terhadap biomassa *Lemna* sp. dalam media pemeliharaan ikan tambakan pada air gambut. Penelitian ini dilaksanakan selama 30 hari dari bulan Maret s.d. April 2025 yang berlokasi di Laboratorium Mutu Lingkungan Budidaya Fakultas Perikanan dan Kelautan Universitas Riau. Metode penelitian yang digunakan adalah metode eksperimen dengan penambahan POC limbah ikan patin pada wadah pemeliharaan dengan dosis berbeda yang dilakukan dengan menggunakan Rancangan Acak Lengkap (RAL) menggunakan 5 taraf perlakuan dan ulangan sebanyak 3 kali. Perlakuan dalam penelitian ini adalah: P0 : Tanpa pemberian POC (Kontrol), P1 : Pemberian POC 1,75 ml/L, P2 : Pemberian POC 2 ml/L, P3 : Pemberian POC 2,25 ml/L, P4 : Pemberian POC 2,5 ml/L. Perlakuan Terbaik ada pada perlakuan P3 (2,25 ml/L) dengan nilai kualitas air suhu 26-30,4°C, pH 3,8-7,2, oksigen terlarut 4,54-7,37 mg/L, nitrat 0,39-15,86 mg/L, fosfat 3,06-6,05 mg/L dan CO₂ 5,0-10,0 mg/L serta Pertambahan biomassa *Lemna* sp. sebesar 107,6 g dan laju pertumbuhan spesifik sebesar 5,05 %

Kata Kunci: *Lemna* sp, Pupuk Organik Cair Ikan Patin, Ikan Tambakan

INTRODUCTION

Peat water is widely distributed across lowland areas in Sumatra. Peatland utilization remains limited due to its poor water quality, which is less supportive of aquatic organisms, particularly because of its low pH. Peat water is acidic with a pH ranging from 3 to 5, characterized by slow organic matter decomposition and low nutrient content (Hasibuan et al., 2019). The improvement of peat water quality can be achieved through liming, fertilization, and using aquatic plants such as *Lemna* sp. *Lemna* sp. can enhance water quality and be a phytoremediator (Marda et al., 2015). This plant can help increase the low pH and dissolved oxygen (DO) levels, creating favorable conditions for aquatic organisms (Langkap, 2019). For optimal growth, *Lemna* sp requires adequate nutrient availability, particularly nitrogen (N), phosphorus (P), and potassium (K) (Dismayanti et al., 2024). One approach to increasing nutrient availability in peat water is applying liquid organic fertilizer (LOF) (Hasibuan et al., 2021).

Liquid organic fertilizer (POC) is an extract derived from decomposing organic materials such as plant residues, fishery industry by-products, and animal manure containing multiple essential nutrients. One potential source of POC is catfish waste (Kinanti et al., 2024). OF derived from catfish waste contains nitrogen, phosphorus, and potassium, crucial in various plant metabolic processes. Specifically, catfish waste-based liquid organic fertilizer contains 1.56% organic carbon, 0.35% nitrogen, 0.24% phosphorus, and 0.16% potassium (Wardana et al., 2024). These nutrients can enrich peat water's nutrient content and enhance aquatic plant growth.

In addition to improving water quality, *Lemna* sp has potential as both a primary and supplementary feed for fish due to its relatively high nutritional content, consisting of 27.68% protein, 41.95% nitrogen-free extract (NFE), 14–15% crude fiber, 2–3% lipid, and 18.01% ash (Firdaus et al., 2017). *Lemna* sp is commonly used as supplementary feed in aquaculture and serves as a natural feed source for herbivorous fish such as kissing gourami (*Helostoma temminckii*) (Asriyanti et al., 2018).

Kissing gourami is an omnivorous species that consumes various food items, including zooplankton, detritus, aquatic plants, and aquatic insects (Mariska et al., 2013). Local communities highly favor this species due to its high nutritional value, and it is widely consumed either in dried form (salted fish) or fresh. Furthermore, it is considered an economically important commodity with a market price ranging from IDR 25,000 to 35,000 / kg. Currently, kissing gourami production largely depends on wild catches, even though this species holds significant potential for aquaculture development.

Considering the potential and challenges described above, research is needed to evaluate the effect of catfish (*Pangasius* sp) waste-based liquid organic fertilizer on the biomass of *Lemna* sp in peat water culture media for kissing gourami. This study is expected to provide a scientific basis for using fishery organic waste as fertilizer to improve peat water quality while enhancing the production of natural feed. The findings are anticipated to serve as a reference for developing peatland aquaculture systems and contribute to food security by cultivating economically valuable local fish species.

MATERIALS AND METHODS

Time and Place

The study was conducted 30 days from March to April 2025 at the Aquaculture Environmental Quality Laboratory, Faculty of Fisheries and Marine, Universitas Riau. Nitrate, phosphate, and CO₂ measurements were conducted at the Marine Science Laboratory, Faculty of Fisheries and Marine, Universitas Riau.

Preparation of Liquid Organic Fertilizer

Preparing liquid organic fertilizer from catfish waste began with cleaning and preparing the necessary tools and materials. Effective Microorganisms (EM4) were first activated by mixing with molasses and distilled water at a ratio of 1:10, then incubated for 5 days under anaerobic conditions. Subsequently, 1.5 kg of catfish waste was homogenized and mixed with 3 L of distilled water, 750 g of molasses, and 30 mL/L of activated EM4. The mixture was fermented in a 5-L jerry can for 14 days, with daily gas release by loosening the lid. After fermentation, the LOF was analyzed in the laboratory, showing contents of 3.97% organic carbon, 0.26% nitrogen, 0.21% phosphorus, and 0.46% potassium.

Preparation of Experimental Containers

The experimental containers used in this study were cylindrical plastic buckets with an upper diameter of

60 cm, a bottom diameter of 48 cm, and a height of 45 cm. A total of 15 containers with a capacity of 100 L each were prepared. Before use, the containers were cleaned with a potassium permanganate (KMnO₄) solution, rinsed, and dried in sunlight. Each cleaned container was then filled with 60 L of peat water.

Fertilization Process

Fertilization was done by directly adding POC derived from catfish waste into 60 L of water containers. The treatments were as follows: P0 (control, without POC), P1 (1.75 mL/L), P2 (2.00 mL/L), P3 (2.25 mL/L), and P4 (2.50 mL/L). The culture water was aerated for 24 hours after fertilization. Fertilization was repeated every 7 days according to the respective treatment doses.

Maintenance of *Lemna* sp. and Kissing Gourami

The cultivation of *Lemna* sp and kissing gourami was initiated one day after fertilization. *Lemna* sp was introduced at a stocking density of 30 g per 60 L of water, following the method of Nisa (2023). Kissing gourami, which had an average size of 5–7 cm in length and an average weight of 8 g, were stocked at a density of 30 individuals per 60 L of water one day after fertilization.

Sampling

Sampling was conducted every 10 days to monitor the growth and biomass of *Lemna* sp and the length and weight of kissing gourami. The biomass of *Lemna* sp. was determined by weighing all plants in each container using an analytical balance. For kissing gourami, 15 individuals (50% of the total per container) were randomly sampled to measure length and body weight. Water quality parameters observed included temperature and pH (measured daily), transparency and dissolved oxygen (every 6 days), as well as nitrate, phosphate, and CO₂ concentrations (on days 1, 15, and 30 of the culture period).

Data Analysis

The data obtained, including *Lemna* sp biomass, growth, and survival of kissing gourami, were analyzed using SPSS software through a one-way ANOVA to determine the significant effects of treatments. When significant differences were observed ($P < 0.05$), the treatments were considered to have an effect, and further analysis was carried out using simple linear regression to evaluate the relationships among variables. The interpretation of the correlation coefficient (r) and determination coefficient (R^2) was used to assess the strength of the relationships, categorized from very weak to very strong.

Analysis of *Lemna* sp. Biomass Increase

According to Sogbesan et al. (2015), the formula used to calculate the increase in *Lemna* sp biomass was as follows:

$$W_n = W_t - W_o$$

Description:

- W_n : Absolute weight gain (g)
- W_t : *Lemna* sp biomass at the end of the experiment (g)
- W_o : *Lemna* sp biomass at the beginning of the experiment (g)

Analysis of the Specific Growth Rate of *Lemna* sp.

According to Effendie in Zufadhillah et al. (2018), the daily specific growth rate (SGR) can be calculated using the following formula:

$$SGR = \frac{\ln W_t - \ln W_o}{t} \times 100\%$$

Description:

- SGR : Specific Growth Rate (%)
- W_t : Average final biomass of *Lemna* sp (g)
- W_o : Average initial biomass of *Lemna* sp (g)
- t : Duration of rearing (day)

Analysis of Absolute Length Growth of Kissing Gourami

The formula used to calculate the absolute length growth of kissing gourami is as follows:

$$L = Lt - Lo$$

Description:

L : Absolute length growth (cm)
 Lt : Average final length of fish (cm)
 Lo : Average initial length of fish (cm)

Analysis of Absolute Weight Growth of Kissing Gourami

The formula used to calculate the absolute weight gain of kissing gourami is as follows:

$$Wg = Wt - Wo$$

Description:

Wg : Absolute weight gain (g)
 Wt : Average final weight of fish (g)
 Wo : Average initial weight of fish (g)

Analysis of the Specific Growth Rate of Kissing Gourami

According to Effendie in Zufadhillah et al. (2018), the daily specific growth rate (SGR) of fish can be calculated using the following formula:

$$SGR = \frac{\ln Wt - \ln Wo}{t} \times 100\%$$

Description:

SGR : Specific Growth Rate (%)
 Wt : Average final weight (g)
 Wo : Average initial weight (g)
 t : Duration of rearing (day)

Analysis of the Survival Rate of Kissing Gourami

Survival rate (SR) was calculated using the formula of Effendie in Zufadhillah et al. (2018):

$$SR = \frac{Nt}{No} \times 100\%$$

Description:

SR : Survival rate (%)
 Nt : Number of fish at the end of rearing (individuals)
 No : Number of fish at the beginning of rearing (individuals)

RESULT AND DISCUSSION

Water Quality

The water quality parameters measured in this study included temperature, transparency, pH, dissolved oxygen (DO), nitrate, phosphate, and CO₂. The results of water quality measurements throughout the experimental period are presented in Table 1.

Table 1. Average values of water quality parameters

Parameters	Result of Measurement				
	P0	P1	P2	P3	P4
Temperature (°C)	26-30.1	26-30.3	26-30.3	26-30.4	26-30.4
Transparency (cm)	23-32.1	14.8-16.3	14.6-17.1	13.3-15.3	12.3-14.6
pH	4.5-6.2	3.9-6.6	3.8-6.8	3.8-7.2	3.7-6.9
DO (mg/L)	4.71-6.45	4.56-6.54	4.51-6.91	4.54-7.37	4.45-6.89
Nitrate (mg/L)	0.28-7.06	0.29-7.02	0.34-12.25	0.39-15.86	0.47-13.62
Phosphate (mg/L)	0.84-2.44	1.37-3.47	2.26-8.01	3.06-6.05	4.24-5.45
CO ₂ (mg/L)	3.0-4.0	4.0-6.0	5.0-7.0	5.0-10.0	7.0-7.0

The data presented in Table 1 show that treatment P3 (application of 2.25 mL/L of liquid organic fertilizer from catfish waste) improved the water quality of the *H. temminckii* rearing medium. The water quality parameters under this treatment were maintained within the ranges of temperature (26–30.4°C), pH (3.8–7.2), dissolved oxygen (4.54–7.37 mg/L), nitrate (0.39–15.86 mg/L), phosphate (3.06–6.05 mg/L), and CO₂ (5.0–10.0 mg/L). These results indicate that adding liquid organic fertilizer derived from catfish waste improved water quality parameters in peat water used for kissing gourami culture.

Temperature influences the physical, chemical, and biological parameters of aquatic environments. During the observation period, water temperature remained relatively constant, ranging from 26 to 30 °C. Water transparency was measured to determine the extent of light penetration into the culture media, which can affect the photosynthetic activity of *Lemna* sp.

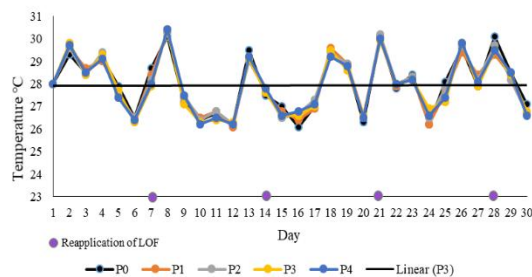


Figure 1. Temperature in the rearing containers

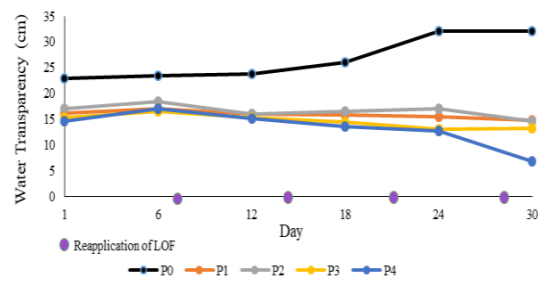


Figure 2. Water transparency in the rearing containers

Figure 1 shows that applying liquid organic fertilizer (POC) did not significantly affect water temperature, as temperature was primarily influenced by external environmental factors such as air temperature, sunlight intensity, and culture location. Dismayanti et al. (2024) also reported that the addition of POC derived from catfish waste did not affect the culture water temperature, which was controlled by environmental conditions. According to Fitriana & Kuntjoro (2020), *Lemna* sp can grow in water with a temperature range of 5–35°C, with an optimum range of 20–31°C for maximum growth. Similarly, the optimum temperature for kissing gourami growth is 20–35°C (Arifin et al., 2017). Based on the measured temperature data (26–30.4°C), it can be concluded that the temperature during the study was within the suitable range for the culture of both *Lemna* sp and kissing gourami.

Figure 2 presents the water transparency during the culture period. The results indicate that higher doses of POC from catfish waste decreased water transparency. This reduction in transparency was caused by the increase in *Lemna* sp biomass, which grew more rapidly due to the high nutrient availability from POC, thereby covering the water surface and limiting light penetration into the water column. In addition, dissolved and suspended organic matter from POC, including decomposition residues, contributed to water turbidity (Taradifa et al., 2022). However, the transparency values recorded during the study (12.3–14.6 cm) were still within a relatively safe range for kissing gourami growth, as sufficient light was still available to support basic biological activities such as movement and feeding. Siswanto et al. (2021) reported that transparency values approaching 10 cm can still be tolerated, provided a drastic reduction in dissolved oxygen does not accompany them. The decrease in water transparency was consistent with the increase in *Lemna* sp biomass, indicating that higher POC doses enhanced the productivity of the culture medium but also reduced water clarity.

pH and Dissolved Oxygen

The degree of acidity (pH) represents the level of acidity or alkalinity of aquatic environments, while dissolved oxygen (DO) indicates the concentration of oxygen gas in water.

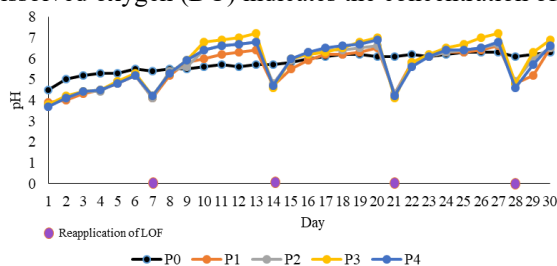


Figure 3. pH values during the experiment

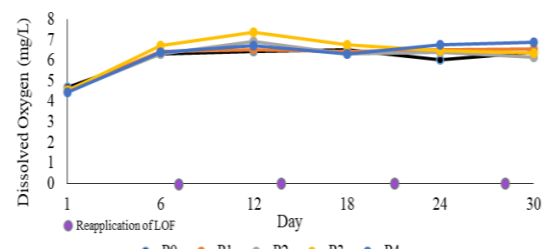


Figure 4. Dissolved oxygen (DO) levels

The decrease in pH observed in Figure 3 shows that the pH levels in treatments P1 to P4 declined throughout the experiment, likely due to the application of liquid organic fertilizer (POC) derived from catfish waste. The addition of POC tended to lower the pH of the water because of the organic acids formed during the fermentation process. Kristin et al. (2024) also reported that microbial fermentation in POC produces acidic compounds such as acetic acid and lactic acid, which contribute to reducing pH in culture media.

Despite the decrease, the measured pH values remained within the safe range for *H. temminckii* and

continued supporting *Lemna* sp growth. According to Arifin et al. (2017), kissing gourami can tolerate water pH levels ranging from 5 to 9, while Nisa (2023) reported that *Lemna* sp. grows optimally at pH 5.5–7.5.

As shown in Figure 4, DO concentrations across all treatments remained above 4 mg/L, which falls within the optimal range for both *Lemna* sp and kissing gourami. The highest DO concentration was recorded in treatment P3, which is likely associated with the increased biomass of *Lemna* sp under this treatment. Enhanced growth of *Lemna* sp contributed to higher oxygen production through photosynthesis. The nutrient content of the POC derived from catfish waste may have further stimulated the photosynthetic activity of *Lemna* sp, thereby increasing DO levels, especially during daylight when sunlight intensity was sufficient. This finding is consistent with Hutabarat et al. (2024), who stated that *Lemna* sp. significantly contributes to increasing DO concentration through intensive photosynthetic activity.

In addition to the contribution of *Lemna* sp, DO levels in the culture medium were also supported by the use of aerators that ensured proper air circulation. Afrijoni (2013) noted that the optimal DO range for kissing gourami growth is 3–7 mg/L. With DO concentrations in treatment P3 ranging between 4.54 and 7.37 mg/L, the culture medium in this study was considered suitable to support the metabolic activity and growth of kissing gourami.

Nitrate

Nitrate (NO_3) is the main form of nitrogen in natural waters and is a key nutrient for plant and algal growth.

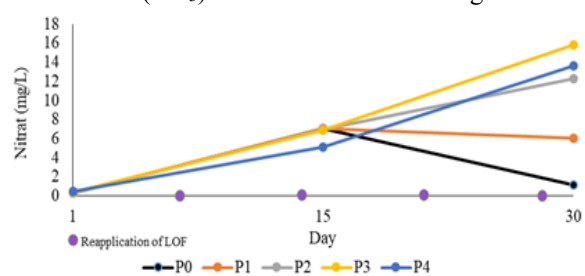


Figure 5. Nitrate concentrations

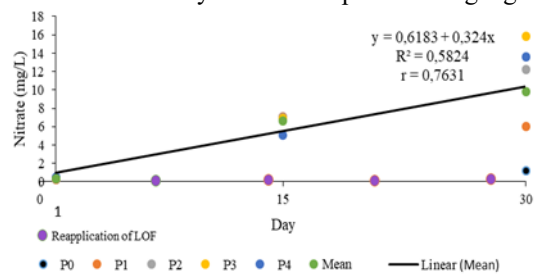


Figure 6. Effect of catfish waste liquid organic fertilizer (POC) on nitrate concentration

The nitrate concentration increased in all treatments until day 15, but displayed different patterns thereafter until day 30. Treatment P3 had the highest nitrate concentration, followed by P4 and P2. In contrast, P1 and the control (P0) showed a decline in nitrate levels after day 15. This indicates that liquid organic fertilizer (POC) derived from catfish waste enhanced nitrate concentrations through the nitrification process, in which nitrogen compounds are oxidized by microorganisms, with dissolved oxygen playing a key role in the culture medium. Higher POC doses provided more organic matter for nitrifying microbial activity, increasing nitrate production. Conversely, nitrate was likely absorbed more rapidly by *Lemna* sp or lost through denitrification at lower doses. The optimal dose, represented by P3, demonstrated a balance between nitrate production and utilization, supporting *Lemna* sp's maximum growth. This finding is consistent with Nur et al. (2023), who reported that applying POC significantly increased nitrate concentrations in aquaculture water.

The results showed a strong positive correlation between the rearing period and the increased nitrate (NO_3^-) concentration in the medium supplemented with liquid organic fertilizer derived from catfish waste. The regression equation was $y = 0.6183 + 0.324x$, with a correlation coefficient $r = 0.7631$, and a determination coefficient $R^2 = 0.5824$. The r -value indicates a high correlation, while the R^2 value suggests that 58.24% of the variation in nitrate concentration was explained by the rearing period, with the remaining variation influenced by other factors. The increase in nitrate concentration was consistent with the weekly application of POC, in which nitrogen compounds contained in the fertilizer were decomposed into nitrate. Optimal nitrate availability supported the growth of *Lemna* sp., as evidenced by the highest biomass increment observed in treatment P3, indicating sufficient nutrient availability for plant growth. However, further increasing the dose to 2.5 mL/L (P4) did not result in a significant biomass increase, suggesting the potential for nutrient saturation or deterioration of environmental quality that could inhibit the growth of *Lemna* sp.

Phosphate

Phosphate in *Lemna* sp plays an essential role in forming pyrophosphate compounds, which serve as a

primary energy source for plant growth and development. Therefore, phosphate availability in the experimental containers decreased as *Lemna* sp utilized it for respiration, photosynthesis, and energy transfer.

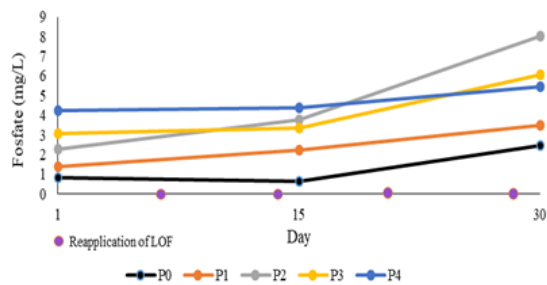


Figure 7. Phosphate concentrations during the experiment

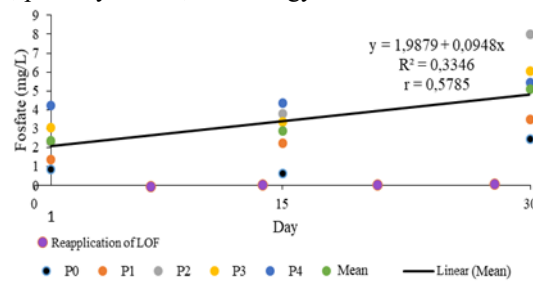


Figure 8. Effect of catfish waste liquid organic fertilizer (POC) on phosphate concentration

The phosphate concentration in the culture medium increased over time across all treatments, with the highest level observed in P4. However, this increase did not correspond to the highest biomass of *Lemna* sp, which was instead recorded in P3. This indicates that excessively high phosphate levels do not necessarily promote optimal growth of *Lemna* sp, possibly due to nutrient saturation or mild toxic effects. Treatment P3 is presumed to provide a more balanced nutrient composition suitable for the growth of *Lemna* sp, whereas the phosphate concentration in P1 remained within the normal threshold for freshwater aquaculture (<1 mg/L) (Arnando et al., 2022).

The regression analysis showed that the application of liquid organic fertilizer (POC) derived from catfish waste significantly affected the increase of phosphate (PO_4^{3-}) concentration in the culture medium, with a regression equation of $y = 1.9879 + 0.0948x$, $R^2 = 0.3346$, and $r = 0.785$, indicating a moderately significant correlation. The increase in phosphate concentration over time was influenced by the periodic addition of POC every seven days. Phosphate plays a crucial role in the growth of *Lemna* sp; however, in treatment P4, the highest phosphate concentration (5.45 mg/L) was associated with a decline in biomass, in contrast to treatment P3, which produced the highest biomass at a moderate phosphate range (3.06–6.05 mg/L). This finding suggests that excessive phosphate may reduce the growth efficiency of *Lemna* sp due to nutrient imbalance or competition with other microorganisms in the medium.

Carbon Dioxide (CO_2)

Carbon dioxide (CO_2) is one of the essential elements in the photosynthetic process of aquatic plants. As shown in Figure 9, the concentration of CO_2 in the rearing medium fluctuated during the experimental period. On day 15, an increase in CO_2 concentration was observed across all treatments, followed by a decline on day 30, except in treatment P3. The application of liquid organic fertilizer (POC) derived from catfish waste influenced the dynamics of CO_2 in the rearing medium, with the highest concentration recorded in treatment P3, which corresponded with the highest *Lemna* sp biomass. This indicates that the balance between nutrient supply and respiratory activity supported optimal photosynthetic processes, leading to significant plant biomass accumulation. CO_2 acts as the main substrate in the photosynthesis of *Lemna* sp., and its increase within the tolerance limit continued to support plant growth while remaining tolerable for kissing gourami (Opastriani, 2021). However, in treatment P4, signs of excessive CO_2 accumulation were observed, which resulted in a decline in pH and disruption of the inorganic carbon balance, potentially inhibiting plant growth. Furthermore, the excessive accumulation of CO_2 may also indicate enhanced decomposition of organic matter from incompletely degraded POC, which could reduce the overall quality of the rearing medium.

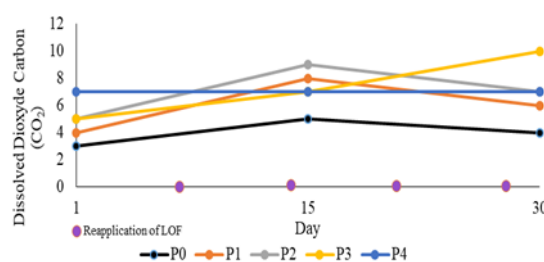


Figure 9. CO_2 concentrations during the experiment

Biomass Increment and Specific Growth Rate of *Lemna* sp

The observation of *Lemna* sp. biomass increment during the experiment with different doses of liquid organic fertilizer (POC) derived from catfish waste showed significant variations among treatments (Table 2).

Table 2. Average biomass gain and specific growth rate of *Lemna* sp

Treatment	Biomass Gain of <i>Lemna</i> sp (g)	Specific Growth Rate of <i>Lemna</i> sp (%)
P0 (control)	-15.70 ± 2.65 ^a	-2.51 ± 0.60 ^a
P1 (1,75 ml/L)	35.30 ± 4.85 ^b	2.56 ± 0.25 ^b
P2 (2 ml/L)	61.90 ± 3.41 ^c	3.72 ± 0.13 ^c
P3 (2,25 ml/L)	107.60 ± 10.46 ^d	5.05 ± 0.24 ^d
P4 (2,5 ml/L)	68.76 ± 3.70 ^c	3.95 ± 0.13 ^c

Note: Different superscript letters in the row indicate significant differences ($P < 0.05$).

The application of LOF significantly affected both biomass increment and the specific growth rate (SGR) of *Lemna* sp., with the best performance recorded at a dose of 2.25 mL/L (P3). This treatment produced the highest biomass of 107.60 g and an SGR of 5.05% daily. In contrast, the control treatment without LOF (P0) showed a significant decline in biomass, indicated by a negative growth value. This suggests that the absence of additional nutrients reduced the growth capacity of *Lemna* sp in nutrient-poor peat water (Hutajulu et al., 2025). These findings highlight the critical role of POC as a nutrient source to enhance the productivity of aquatic plants in marginal water systems (Syam et al., 2024).

The differences observed among treatments also reflect the direct influence of nutrient availability in the culture medium. Lower doses of POC (P1 and P2) reduced *Lemna* sp biomass, likely due to insufficient nutrient supply for optimal growth. On the other hand, the highest dose (P4) produced lower biomass compared to P3. This phenomenon is presumably caused by nutrient oversupply, which may induce osmotic stress, chloroplast damage, and the accumulation of toxic compounds such as ammonia that disrupt photosynthesis. Therefore, excessive nutrient input does not necessarily increase productivity; it can harm aquatic plants.

Environmental factors, such as sunlight intensity during the rearing period, also influenced the growth of *Lemna* sp, in addition to the direct effects of POC application. An optimal balance between nutrient availability from POC and favorable environmental conditions is essential to maximize biomass production. Furthermore, *Lemna* sp. was utilized as feed for kissing gourami. According to Andriani et al. (2018), *Lemna* sp. can serve as a fresh natural feed for freshwater herbivorous fish. Thus, the appropriate use of catfish-waste-derived POC enhances *Lemna* sp biomass and supports its application as a promising natural feed source in herbivorous fish culture systems such as tambakan.

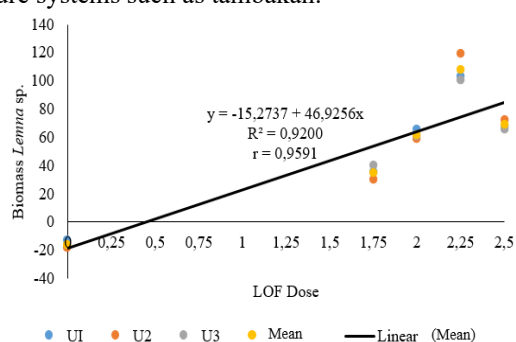


Figure 10. Effect of POC dosage on the biomass growth of *Lemna* sp.

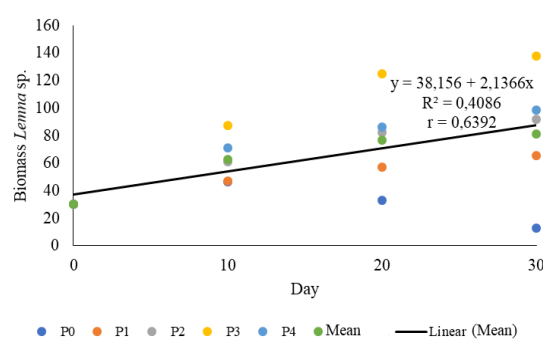


Figure 11. Effect of culture duration on the biomass growth of *Lemna* sp.

Figure 10 shows that the application of liquid organic fertilizer (POC) derived from catfish waste had a very strong relationship with the increase in *Lemna* sp. biomass, with a correlation coefficient (r) of 0.9591 and a coefficient of determination (R^2) of 0.9200. This indicates that the variation in LOF dosage explained 92% of the variation in *Lemna* sp. biomass increase, while other factors influenced the remaining 8%. According to Suprpto (2014), such an R value falls into the category of a very strong correlation, and an R^2 value above 0.67 indicates a strong relationship. In contrast, the relationship between culture duration and *Lemna* sp. biomass showed an r value of 0.6392 and an R^2 of 0.4086, suggesting a moderately strong relationship, but weaker than the effect of POC dosage. Thus, POC dosage from catfish waste was the dominant factor influencing biomass enhancement compared to culture duration.

Environmental conditions during the experiment also supported *Lemna* sp. biomass growth, particularly in light intensity. According to Zannah et al. (2023), adequate sunlight plays a crucial role in photosynthesis, which supports biomass accumulation. Light intensity affects chlorophyll production and the efficiency of carbon dioxide absorption by *Lemna* sp, thereby enhancing optimal growth. Conversely, insufficient light can hinder physiological processes, cause chlorosis, and slow cell division (Waruwu et al., 2024). The addition of POC significantly increased the biomass of *Lemna* sp compared to the control treatment (P0).

The higher increase in *Lemna* sp biomass with the addition of catfish-waste POC was likely due to its relatively complete nutrient content, particularly nitrogen, phosphate, and potassium. Chemical analysis of the POC revealed that it contained 3.97% organic carbon, 0.26% nitrogen (N), 0.21% phosphate (P), and 0.46% potassium (K). The relatively high organic carbon content suggests the potential of LOF as an energy source for microorganisms and as an improver of substrate quality, which indirectly supports the growth of *Lemna* sp.

Nitrogen is essential for protein synthesis and cell division (Toyama et al., 2018), phosphate is critical for ATP formation and energy metabolism (Sablii et al., 2025; Wang et al., 2021), while potassium plays a role in osmotic regulation and enzyme activation. Based on ANOVA results, the application of POC had a significant effect ($P < 0.05$) on increasing *Lemna* sp. biomass, with the P3 treatment showing the highest yield. The availability of N, P, K, and micronutrients such as Fe and Zn was crucial for achieving optimal growth.

Growth Performance and Survival of Kissing Gourami

The application of liquid organic fertilizer derived from catfish waste in kissing gourami culture media was able to stimulate the growth of *Lemna* sp, which served as an additional natural feed source for the fish, thereby supporting their growth and survival.

Table 3. Average absolute weight, absolute length, specific growth rate, and survival of kissing gourami

Treatment	Absolute Weight (g/individual)	Absolute length (cm/individual)	Specific Growth Rate (%)	Survival Rate (%)
P0 (control)	1.30 ± 0.07 ^a	0.52 ± 0.22 ^a	0.57 ± 0.05 ^a	84.4±1.90 ^a
P1(1,75 ml/L)	1.68 ± 0.12 ^b	0.97 ± 0.11 ^b	0.72 ± 0.07 ^b	87.7±1.96 ^{ab}
P2 (2 ml/L)	1.90 ± 0.22 ^b	1.19 ± 0.11 ^b	0.79 ± 0.08 ^b	88.8±1.96 ^{ab}
P3 (2,25 ml/L)	2.98 ± 0.08 ^d	2.30 ± 0.19 ^d	1.18 ± 0.02 ^d	93.3±3.30 ^b
P4(2,5 ml/L)	2.24 ± 0.19 ^c	1.64 ± 0.24 ^c	0.93 ± 0.08 ^c	89.9±3.35 ^{ab}

The administration of POC at different concentrations had a significant effect ($P < 0.05$) on the growth performance of kissing gourami, including absolute weight gain, absolute length gain, specific growth rate, and survival rate. The best performance was obtained at a concentration of 2.25 mL/L (P3), which produced an absolute weight gain of 2.98 g/fish and an absolute length gain of 2.30 cm/fish. This result was consistent with the increase in *Lemna* sp biomass, which directly contributed as a nutrient-rich natural feed and improved water quality. *Lemna* sp contains proteins, essential amino acids, and minerals that meet herbivorous fish's nutritional requirements, such as tambakan, while enhancing dissolved oxygen levels in the culture water. The abundant presence of *Lemna* sp thus supported optimal fish growth without complete dependence on artificial feed (Dwinanti et al., 2023).

In addition to absolute weight and length, LOF application increased the specific growth rate (SGR), with the highest value recorded in P3 at $1.18 \pm 0.23\%$ /day. A higher SGR indicates more efficient feed utilization by the fish, which was supported by the sustainable availability of *Lemna* sp as a natural food source. Properly managed *Lemna* sp growth ensured a continuous nutrient supply, whereas disruptions in its growth could limit fish development due to nutrient deficiencies. The SGR values in this study were higher than those reported from biofertilizer, which only reached 1.08% (Aisyah et al., 2024), indicating the effectiveness of POC from catfish waste in enhancing kissing gourami productivity.

The naturally nutrient-deficient peat water showed improved carrying capacity after supplementation with POC, which contains nitrogen, phosphorus, and dissolved organic carbon that act as water quality stabilizers and provide essential nutrients. Treatments with POC yielded higher survival rates than the control (without POC), demonstrating the role of POC in reducing environmental stress and supporting fish physiological functions. Istiqomah et al. (2016) reported that POC can neutralize extreme aquatic conditions, including water with high organic matter such as peat. The presence of *Lemna* sp in the system further enhanced water quality stability through the absorption of toxic compounds and oxygen production, while simultaneously providing natural feed. The synergy between LOF and *Lemna* sp. created a more balanced physico-chemical environment, ultimately contributing to the improved survival of kissing gourami.

CONCLUSION

The results of this study showed that liquid organic fertilizer (POC) derived from catfish waste significantly influenced the increase in *Lemna* sp biomass in kissing gourami rearing media using peat water. The best water quality parameters were observed in treatment P3, with temperature ranging from 26.0–30.4°C, pH 3.8–7.2, dissolved oxygen 4.54–7.37 mg/L, nitrate 0.39–15.86 mg/L, phosphate 3.06–6.05 mg/L, and CO₂ 5.0–10.0 mg/L. The optimal treatment was P3 (2.25 mL/L), which produced the highest *Lemna* sp biomass of 107.6 g and a specific growth rate of 5.05%. Applying catfish waste POC positively affected *Lemna* sp growth, where increasing POC doses tended to increase its biomass. Furthermore, treatment P3 also supported the growth performance of kissing gourami, yielding an absolute weight gain of 2.98 g, an absolute length growth of 2.30 cm, a specific growth rate of 1.18%, and the highest survival rate of 93.3%.

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