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THE EFFECT OF PHYTOREMEDIATION OF *Wolffia arrhiza* ON THE PERFORMANCE OF NILE NILE FISH *(Oreochromis niloticus)* CULTIVATION

Pengaruh Fitoremediasi *Wolffia arrhiza* Terhadap Kinerja Budidaya Ikan Nila (*Oreochromis niloticus*)

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ABSTRACT

Water quality in fish farming significantly impacts the growth of the fish being farmed. Decreased air quality is caused by organic waste from uneaten feed and fish metabolites, largely dominated by nitrogen and phosphorus compounds. A solution to address the problem of improving air quality is phytoremediation (a wastewater treatment effort using plants). W. arrhiza is a potential phytoremediator. The aim of this study was to determine the effect of W. arrhiza phytoremediation on tilapia cultivation performance. This study employed a quantitative approach, using W. arrhiza as a test plant in varying amounts: P0 (control), P1 (50 g/m2), P2 (150 g/m2), and P3 (250 g/m2), with tilapia as the test fish. The study was conducted at the Fish Farmers Group Cing Mina Fish Farming Group Bogor Regency. The results of the study conducted for 30 days showed that the maintenance of tilapia with a phytoremediation system using W. arrhiza had a significant effect on the survival rate and feed conversion ratio ($P<0.05$), but had no significant effect on the growth of standard length, absolute weight growth and daily growth rate ($P>0.05$). Treatment P3 showed the highest values in the parameters of survival rate and feed conversion ratio with values of 94.17±0.76% and 1.3±0.09. While the absolute weight growth and absolute growth rate of the test plants had the highest values in treatment P1 with values of 834±97.68 g and 27.80±3.26 g.

Keywords: Phytoremediation; tilapia; *Wolffia arrhiza*; growth

ABSTRAK

Kualitas air pada budidaya ikan sangat mempengaruhi pertumbuhan ikan yang dibudidayakan. Penurunan kualitas air disebabkan oleh limbah organik dari sisa pakan yang tidak termakan dan hasil metabolit ikan, limbah tersebut umumnya didominasi oleh senyawa nitrogen dan senyawa fosfor. Solusi untuk mengatasi masalah dalam memperbaiki kualitas air adalah fitoremediasi (upaya pengolahan air limbah menggunakan tanaman). Tanaman yang berpotensi sebagai fitoremediator adalah *W. arrhiza*. Tujuan penelitian adalah untuk mengetahui pengaruh fitoremediasi *W. arrhiza* terhadap kinerja budidaya ikan nila. Penelitian ini menggunakan pendekatan kuantitatif, dengan menggunakan tanaman uji *W. arrhiza* dengan yang jumlah berbeda yaitu P0 (kontrol), P1 (50 g/m^2), P2 (150 g/m^2) dan P3 (250 g/m^2), ikan uji yaitu Ikan Nila. Penelitian dilaksanakan di Kelompok Pembudidaya Ikan Cing Mina Fish Farm Kabupaten Bogor. Hasil penelitian yang dilakukan selama 30 hari menunjukkan bahwa pemeliharaan ikan nila dengan sistem fitoremediasi menggunakan *W. arrhiza* memberikan pengaruh nyata terhadap tingkat kelangsungan hidup dan rasio konversi pakan ($P<0.05$), akan tetapi tidak berpengaruh nyata terhadap pertumbuhan panjang baku, pertumbuhan berat mutlak dan laju pertumbuhan harian ($P>0.05$). Perlakuan P3 menunjukan nilai tertinggi pada parameter tingkat kelangsungan hidup dan rasio konversi pakan dengan nilai 94,17±0,76% dan 1,3±0,09. Sedangkan pertumbuhan berat mutlak dan laju pertumbuhan mutlak tanaman uji mempunyai nilai tertinggi terdapat pada perlakuan P1 dengan nilai 834±97,68 g dan 27,80±3,26 g.

Kata Kunci: Fitoremediasi; ikan nila; *Wolffia arrhiza*; pertumbuhan

INTRODUCTION

According to Tariningsih & Tamba (2018), a serious problem facing tilapia fish farming is the high mortality rate of fry during the production process, reaching an average of 57%. Furthermore, the growth rate of fry during rearing is often suboptimal, as evidenced by the longer time required (from 45 to 60 days) to reach an average weight of 10 grams, compared to an initial average weight of 3 grams.

Water quality declines with the increase in tilapia production, which requires artificial feed to stimulate growth and production. Tilapia growth, survival, and feed conversion ratio are influenced by both internal and external factors. Internal factors affecting growth include genetics, age, and disease resistance. External factors affecting growth include feed management and water quality (Setyowati et al., 2007). Water quality in fish farming significantly impacts the growth of the cultivated fish. The primary problem is the decline in water quality caused by organic waste from uneaten feed and fish metabolites, which are generally dominated by toxic inorganic nitrogen compounds. Besides nitrogen compounds, phosphorus compounds are another source.

Therefore, a solution is needed to address the limited land, water, and feed resources. One wastewater treatment method that can be implemented is phytoremediation. Phytoremediation is an effort to treat wastewater using plants. A plant with potential as a phytoremediator is W. arrhiza. In this study, the effect of water quality resulting from W. arrhiza phytoremediation on the growth performance of tilapia. Growth performance parameters calculated included standard length growth, absolute weight growth, daily growth rate, survival rate, and feed conversion ratio in tilapia. Growth performance parameters on test plants were also calculated, including absolute weight growth and absolute growth rate. The purpose of this study was to determine the effect of W. arrhiza phytoremediation on tilapia cultivation performance.

RESEARCH METHODS

Place and Time

This research was conducted from May to June 2021. The research was conducted at the Cing Mina Fish Farm Fish Farming Group located in Babakan Ciomas Village, RT/RW. 001/009, Parakan Village, Ciomas District, Bogor Regency, West Java.

Tools and Materials

The tools used in the research include: maintenance tanks, air pumps, PVC pipes, water inlet hoses, aeration units, digital rulers, small digital scales, large digital scales, and fish and plant sampling tools (trays, fine scoops, plastic mica, and small scoops). The materials used for the research are: Tilapia (Oreochromis niloticus) with a length range of 4.31–4.67 cm and a weight of 1.59–1.96 g, Wolffia arrhiza, and fish feed. Tilapia seeds were obtained from fish farming groups in Bogor Regency. Meanwhile, the test plants W. arrhiza were obtained from the Azolla Farm in Purwodadi, Grobogan Regency, Central Java.

Research Design

This study used a Completely Randomized Design (CRD) with 4 treatments and 3 replications for each treatment, namely as follows:

1. P0 (Control): without W. arrhiza
2. P1: Wolffia arrhiza in the amount of 50 g/m^2
3. P2: Wolffia arrhiza in the amount of 150 g/m^2
4. P3: Wolffia arrhiza in the amount of 250 g/m^2

The research design is in the form of a plan of the experimental pond with the placement of each treatment and replication.

Types of Parameters and Their Observations

The growth parameters measured for the test fish were standard length growth, absolute weight growth, daily growth rate, survival rate, and feed conversion ratio. For the test plants, the parameters measured were absolute weight growth and absolute growth rate. Parameter measurements for the test fish were conducted at the beginning and end of cultivation, while for the test plants, absolute weight growth was conducted weekly, and absolute growth rate was conducted at the beginning and end of cultivation. The parameter calculation procedure is as follows:

Growth of Standard Length of Test Fish

The standard length growth is obtained from the difference between the final standard length and the initial standard length using the formula from (Apriani, 2015).

$$P = Pt - Po$$

Information:
P = Standard length growth (cm)
Pt = Average length of fish at the end of maintenance (cm)
P_o = Panjang rata-rata ikan pada awal pemeliharaan (cm)

Absolute Weight Growth of Test Fish

Absolute weight gain is obtained from the difference between the final absolute weight and the initial absolute weight using the formula from (Apriani, 2015).

$$W = Wt - Wo$$

Information:
P = Standard length growth (g)
Pt = Average length of fish at the end of maintenance (g)
P_o = Average length of fish at the start of maintenance (g)

Specific Growth Rate (SGR) of Test Fish

Specific Growth Rate is calculated using the formula (Schulz et al., 2005) as follows:

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

Information:
SGR = daily growth rate (%)
Wo = fish body weight at the start of maintenance (g)

Wt = fish body weight at the end of maintenance (g)
t = maintenance time (days)

Survival Rate of Test Fish

Survival calculations were performed by collecting data on the number of fish at the beginning and end of the culture. Fish survival during the culture period was calculated using the following formula (Fauji, 2017):

$$SR = \frac{Nt}{No} \; x\; 100\%$$

Information:
SR = Survival Rate (%)
Nt = Number of fish at the end of maintenance (tail)
No = Number of fish at the start of stocking (tail)

Test Fish Feed Conversion Ratio

The feed conversion ratio is determined by collecting data on the weight of feed consumed, the weight of dead fish, and the initial and final weights of the reared fish. This data is then calculated using the following formula (Chilmawati et al., 2018):

$$FCR = \frac{F}{((Wt+D)-Wo)}$$

Information:
FCR = Feed conversion ratio
F = Weight of feed eaten (g)
Wt = Biomass of test fish at the end of maintenance (g)
Wo = Biomass of test fish at the start of maintenance (g)
D = Weight of dead test fish (g)

Absolute Weight Growth of Test Plants

Absolute weight gain is obtained from the difference between the final absolute weight and the initial absolute weight using the formula from (Apriani, 2015).

$$W = Wt - Wo$$

Information:
w = Absolute weight growth of test plants;
wt = Biomass at time t; and
w0 = Initial biomass.

Absolute Growth Rate of Test Plants

The growth of W. arrhiza was calculated based on the biomass increase factor and the number of culture days using the Eppley formula (1977) in Amalia, (2014):

$$LPM = \frac{ln\ wt\text{-}w0}{t}$$

Information:
LP = Absolute growth rate of Wolffia arrhiza;
wt = Biomass at time t;
w0 = Initial biomass; and
t = Trial time

Feeding Procedure

Tilapia fish are fed floating pellets at a rate of 10% of their biomass weight per day. Feeding is based on weekly fish weight measurements. Feeding frequency is three times daily: at 6:00 AM, 12:00 PM, and 5:00 PM. The feeding process is shown in Figure 1.

Figure 1. Feeding Procedure; (a) Weighing the amount of feed for maintenance, (b) Feeding fish during the maintenance period.

Test Fish Measurement Procedure

Fish weight, length, and biomass were measured every seven days to determine the amount of feed provided. Sampling was also conducted to determine the condition of the fish being raised. Fish samples were taken in the morning. Twenty fish were taken from each rearing tank using a fine-mesh net and placed in a bucket filled with water. This was done carefully to avoid injury to the test fish, which could lead to disease. The measurement process for the test fish is shown in Figure 2.

Figure 2. Sampling of Test Fish Growth; (a) Sampling of test fish growth, (b) Process of measuring length and weight, (c) Harvesting of test fish to calculate the final population.

Test Plant Observation Procedure

The W. arrhiza measurements were conducted simultaneously with the measurements of the test fish samples. Measurements were made using a digital scale with an accuracy of 0.1 g. Test plants were collected using a small, fine-mesh net from all containers for each treatment. The total number of test plants collected was the entire population in each treatment. The test plants to be weighed were first drained with a fine-mesh net for one minute to reduce the water content, thus optimizing the weighing process. They were then placed in a plastic container that had been previously calibrated on a digital scale. The weights were then recorded on the provided form. The test plant observation process is presented in Figure 3.

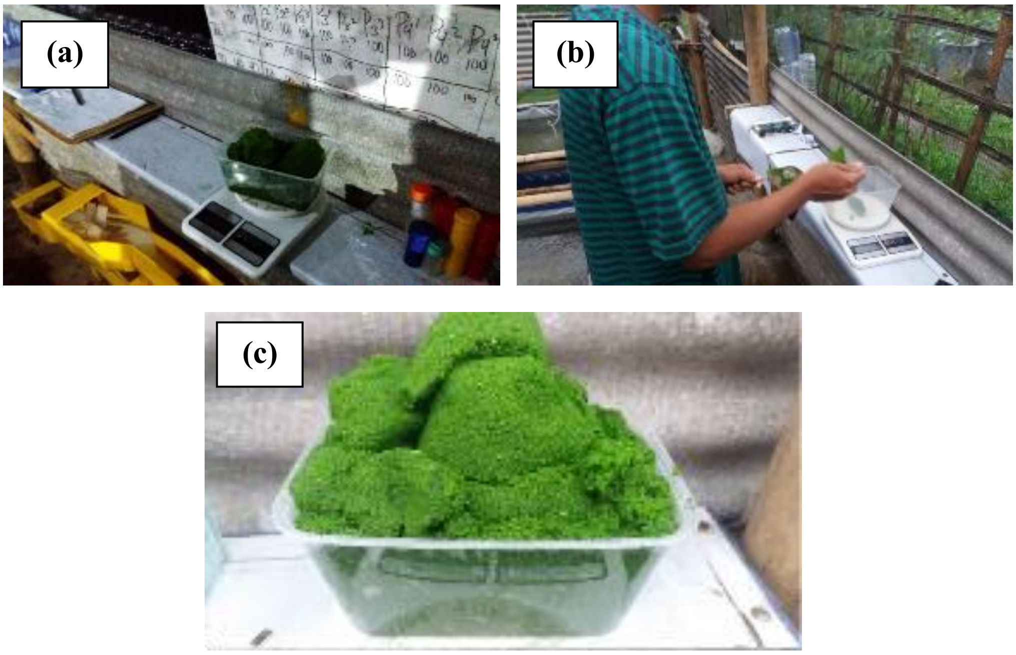

Figure 3. Observation of Test Plants; (a) Test plant weighing tool, (b) Test plant weighing process, (c) Test plants that have been weighed.

Data Analysis

In the analysis of the growth performance data of fish and test plants, the data were tabulated and processed using Microsoft Excel 2013 software. The data analysis technique in this study used SPSS v.24 software regarding the effect of treatment on the parameters to be observed was tested using analysis of variance (Single Factor ANOVA) at a 95% confidence level. Data normality and homogeneity tests were conducted before conducting the analysis of variance (ANOVA). The Least Significant Difference (LSD) was conducted to determine the best treatment after it was known that there were significant differences between treatments. Meanwhile, the analysis of the results of observations of the W. arrhiza test plants was carried out descriptively quantitatively and qualitatively.

RESULT

Growth Performance of Test Fish

During the rearing period, the tilapia demonstrated good performance. This is evident in the average final weight, final total length, standard length growth, absolute weight growth, daily growth rate, survival rate, and feed conversion ratio of the tilapia, as presented in Table 1.

Bold 1. Measurement Results of Growth Parameters, Survival Rate, and Feed Conversion Ratio for Each Treatment

Parameter	Unit	Treatment			
		P0	P1	P2	P3
Average Initial Weight	g±SD	1,96±0,22	1,68±0,14	1,93±0,25	1,59±0,04
Average Final Weight	g±SD	6,62±1,96	5,99±0,40	7,66±1,82	5,85±0,18
Average Initial Length	cm±SD	4,59±0,11	4,46±0,06	4,67±0,13	4,31±0,05

Average Final Length	cm±SD	6,82±1,14	6,13±0,15	6,60±0,35	6,06±0,13
Standard Length Growth	cm±SD	2,23±1,06[a]	1,68±0,13[a]	1,94±0,23[a]	1,75±0,17[a]
Absolute Weight Growth	g±SD	4,66±1,75[a]	4,31±0,45[a]	5,73±1,59[a]	4,27±0,23[a]
Daily Growth Rate	%±SD	15,55±7,14[a]	14,35±1,85[a]	19,09±6,51[a]	14,22±0,92[a]
Survival Rate	%±SD	85,50±2,29[a]	90,00±2,65[ab]	91,28±0,69[b]	94,17±0,76[bc]
Feed Conversion Ratio	-±SD	1,6±0,15[c]	1,6±0,03[bc]	1,5±0,05[b]	1,3±0,09[a]

Description P0 (control) = without W. arrhiza; P1 = W. arrhiza with an amount of 50 g/m2; P2 = W. arrhiza with an amount of 150 g/m2; P3 = W. arrhiza with an amount of 250 g/m2; Different superscript letters indicate significantly different results at the 5% test level.

The average length of tilapia fish studied at the start of rearing in treatments P0, P1, P2 and P3 was 4.59 ± 0.11, 4.46 ± 0.06, 4.67 ± 0.13 and 4.31 ± 0.05 cm. Meanwhile at the end of maintenance the values were 6.82 ± 1.14, 6.13 ± 0.15, 6.60 ± 0.35 and 6.06 ± 0.13 cm, respectively. Descriptively, the average growth in standard length in treatments P0, P1, P2 and P3 was 2.23 ± 1.06, 1.68 ± 0.13, 1.94 ± 0.23 and 1.75 ± 0.17 cm, respectively. The standard length growth of fish ranges from 1.68 ± 0.13- 2.23 ± 1.06 cm. The lowest standard length growth value was found in treatment P1 with a value of 1.68±0.13 cm, while the highest standard length growth value was found in treatment P0 with a value of 2.23±1.06 (Figure 3.3.). Based on the results of the analysis of variance (ANOVA), it showed that there was no significant difference (P>0.05) between the treatments and the standard length growth value of tilapia.

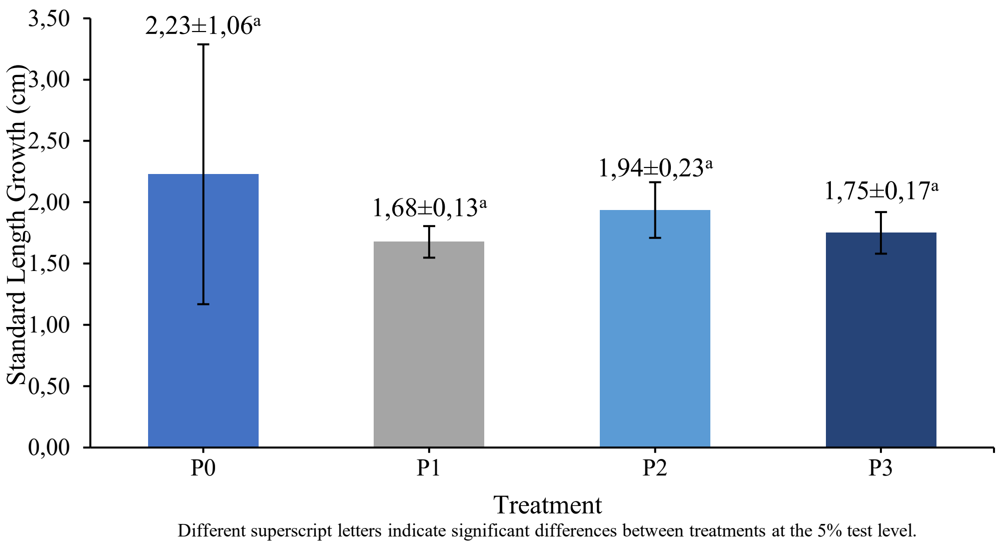

Figure 4. Average growth in raw length of tilapia during the 30 day rearing period. P0 (without W. arrhiza), P1 (50 g/m^2), P2 (150 g/m^2, P3 (250 g/m^2)

This study showed an increase in the weight of tilapia fish measured before the study until the end of the study. Descriptively, the average absolute weight growth in treatments P0, P1, P2 and P3 were 4.66 ± 1.75a, 4.31 ± 0.45a, 5.73 ± 1.59a and 4.27 ± 0.23a g, respectively. The absolute weight growth of fish ranged from 4.27 ± 0.23-5.73 ± 1.59 g. The lowest absolute weight growth value was found in treatment P3, while the highest absolute weight growth value was found in treatment P2, as presented in Figure 4. Based on the results of the analysis of variance (ANOVA), there was no significant difference (P> 0.05) between the treatments with the absolute weight growth value of tilapia fish in all treatments.

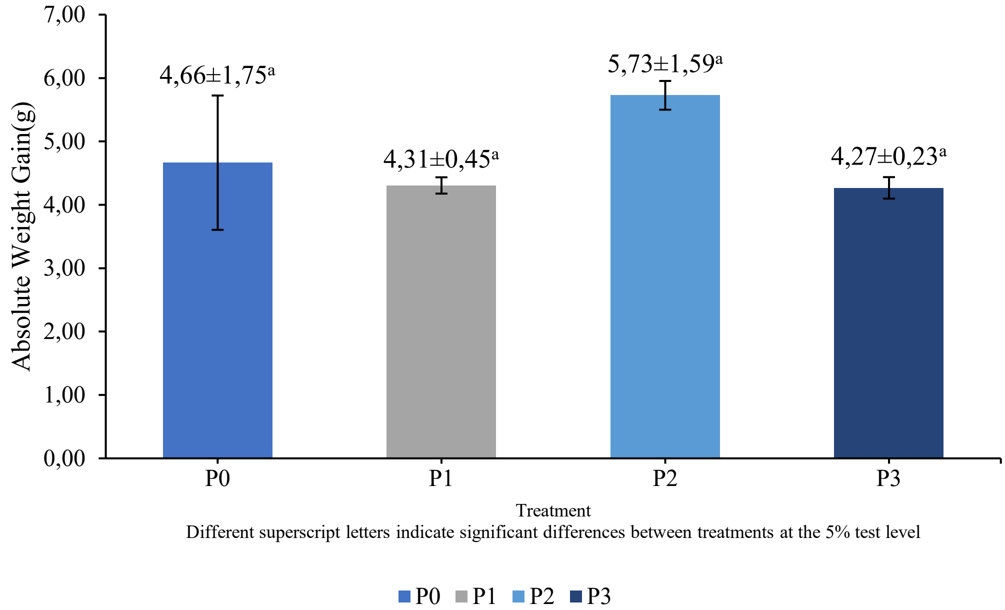

Figure 5. Average Absolute Weight Growth During 30 Days of Maintenance. P0 (without W. arrhiza), P1 (50 g/m^2), P2 (150 g/m^2, P3 (250 g/m^2)

The same thing also happened to the daily growth rate of tilapia. The average daily growth rate values in treatments P0, P1, P2, and P3 were 15.55±7.14, 14.35±1.85, 19.09±6.51, and 14.22±0.92, respectively. The daily growth rate of fish ranged from 14.22±0.92 to 19.09±6.51%. Descriptively, it shows that the daily growth rate in P3 was lower than that in P0, P1, and P2. Meanwhile, the highest daily growth rate value was found in treatment P2. Furthermore, the results of the analysis of variance (ANOVA) showed that there was no significant difference (P>0.05) between treatments in the daily growth rate of tilapia. The daily growth rate of tilapia in each treatment is presented in Figure 5.

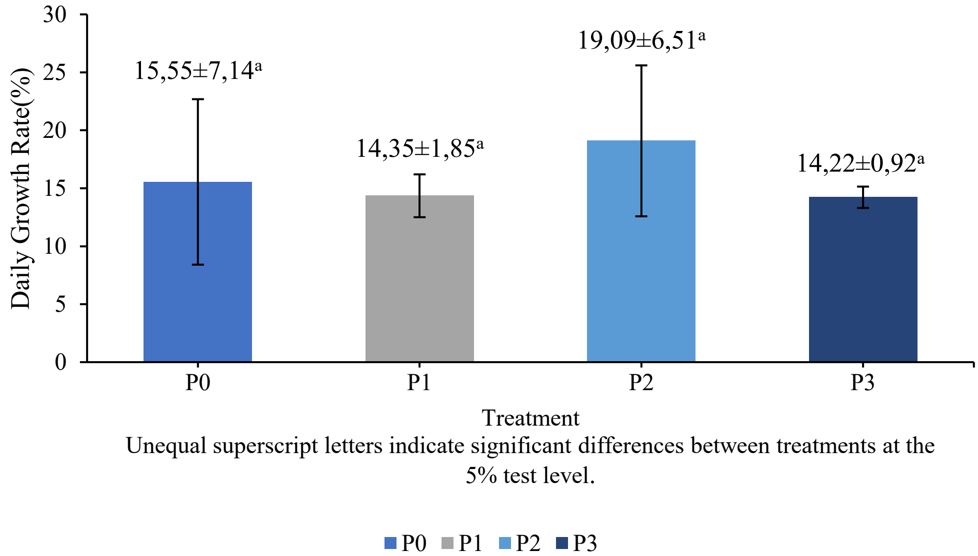

Figure 6. Average Daily Growth Rate of Tilapia Fish During 30 Days of Maintenance. P0 (without W. arrhiza), P1 (50 g/m^2), P2 (150 g/m^2, P3 (250 g/m^2)

The survival rate of tilapia fish reared for 30 days ranged from 85.50±2.29 to 94.17±0.76%. The survival rate values in treatments P0, P1, P2, and P3 were 85.50±2.29, 90.00±2.64, 91.28±0.69, and 94.17±0.76, respectively. The highest survival rate of tilapia fish was found in treatment P3 at 94.17% and the lowest in treatment P0 at 85.50%. Meanwhile, based on the results of the analysis of variance (ANOVA), there was a significant difference (P<0.05) between the treatments and the survival rate of tilapia fish. The results of the BNT further test showed that the average value in treatment P0 was significantly different compared to the survival rate in treatments P2 and P3 (P<0.05), but did not show a significant difference with treatment P1 (P>0.05). Treatment P1 was significantly different from treatment P3 (P<0.05), but not significantly different from treatments P1 and P2 (P>0.05). Treatment P2 was not significantly different from treatment P3 (P>0.05). The survival rates for each treatment are presented in Figure 6.

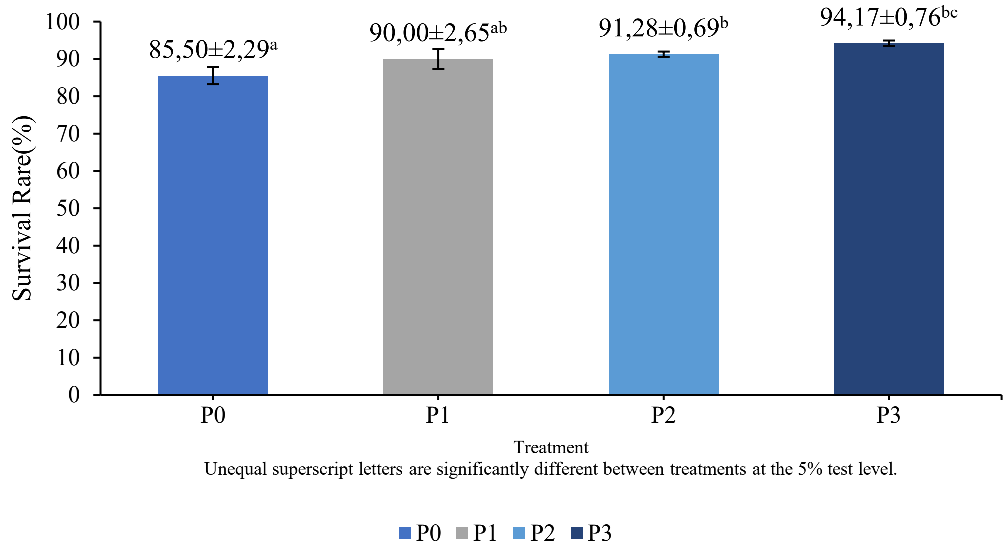

Figure 7. Average Survival Rate of Tilapia During 30 Days of Maintenance. P0 (without W. arrhiza), P1 (50 g/m^2), P2 (150 g/m^2), P3 (250 g/m^2)

In addition to its positive effect on growth, the phytoremediation system also has a positive effect on the survival of cultivated tilapia, as shown in Figure 7. During the maintenance period, the phytoremediation system (P1, P2, and P3) with different amounts, was able to provide survival values of 90.00 ± 2.65, 91.28 ± 0.69, and 94.17 ± 0.76%, respectively, compared to no treatment, which was only 85.50 ± 2.29%. Fish mortality that occurred in each treatment was influenced by several factors, one of which was the supply of dissolved oxygen. According to Swingle (1969) in (Boyd, 1990), at DO levels < 0.3 mg/L, only a few types of fish can survive short exposure. At DO levels in the range of 0.3-1.0 mg/L, prolonged exposure can result in fish death. At DO levels in the range of 1.0-5.0 mg/L, fish can survive, but their growth is impaired. Meanwhile, at DO levels >5.0 mg/L, almost all aquatic organisms prefer these conditions. According to Khasanah et al. (2021), at oxygen concentrations below 4 mg/L, fish appetite decreases and growth slows. If dissolved oxygen concentrations are 3-4 mg/L for a long period, fish will stop eating and growth will be stunted. During the study, the treatment with a dissolved oxygen concentration of 7.7±0.42 mg/L had the lowest survival rate, as shown in Table 1.

Descriptively, the feed conversion ratio in treatment P3 was lower than P0, P1, and P2 with a value of 1.3 ± 0.09. Descriptively, the values of P0, P1, P2, and P3 were 1.6 ± 0.15, 1.6 ± 0.03, 1.5 ± 0.05, and 1.3 ± 0.09, respectively. The results of the analysis of variance (ANOVA) showed a significant difference (P < 0.05) between the treatments in the feed conversion ratio. The results of the LSD test showed that the average value in treatment P3 was significantly different from the feed conversion ratio in treatments P0, P1, and P2 ($P < 0.05$). In treatment P2, it was significantly different from treatment P0 ($P < 0.05$), but not significantly different from treatment P1 ($P > 0.05$). Meanwhile, treatment P1 was not significantly different ($P > 0.05$) from treatments P2 and P0. The feed conversion ratio in each treatment is presented in Figure 8.

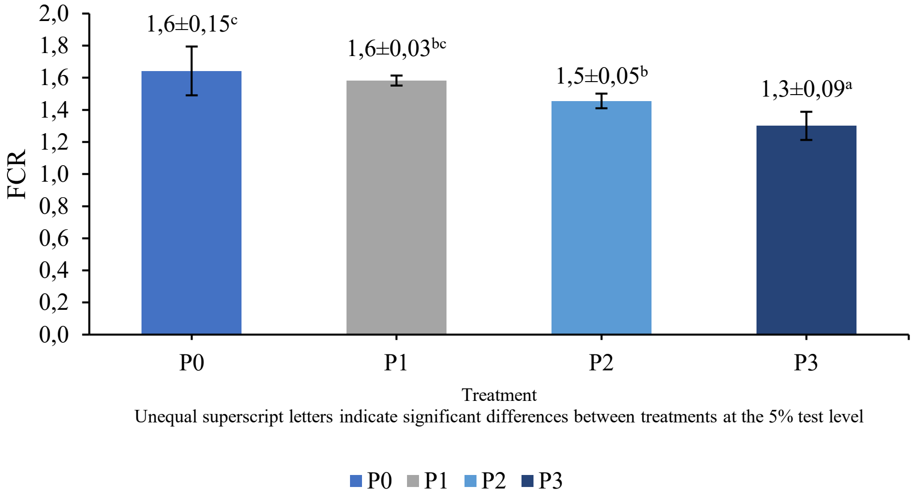

Figure 8. Average Feed Conversion Ratio of Tilapia During 30 Days of Rearing Period. P0 (without W. arrhiza), P1 (50 g/m^2), P2 (150 g/m^2), P3 (250 g/m^2)

The increase in tilapia biomass is the conversion of the amount of feed converted into fish biomass. Fish weight gain during cultivation is inseparable from the feed provided. Feed utilization can be measured by the amount of feed provided during cultivation. The feed conversion ratio (FCR) is used to determine the conversion rate of consumed feed to increased fish biomass growth (Hermawan et al., 2014). The results of the feed conversion ratio calculation indicate that the treatment with the addition of 250 g/m2 of W. arrhiza produced a lower FCR value compared to other treatments. This value aligns with the statement by Hermawan et al. (2014) that a lower FCR value indicates more efficient use of fish feed for growth, while a higher FCR value indicates less efficient feed consumption.

It can be seen that the pond treatment without W. arrhiza showed a higher feed conversion rate (P0 = 1.6) than the pond with the phytoremediation system using W. arrhiza (P3 = 1.3). This condition is suspected because the P3 treatment is associated with more optimal water quality conditions compared to the control treatment (P0 = without W. arrhiza). According to Widanarni et al., (2009), good water quality will increase appetite and feed intake. In line with growth and survival, environmental factors can be a determinant of the rate of feed conversion to biomass. In accordance with the statement of Agustono et al., (2009), which states that the highest growth and survival rates are in line with a better feed conversion ratio compared to other treatments. According to Putra et al., (2011) in (Tariningsih & Tamba, 2018), feed, in this case, the quality and quantity of feed significantly influence growth. Good water quality will also affect the metabolic rate and energy assimilation for growth. The application of phytoremediation methods in tilapia cultivation can reduce the value of the feed conversion ratio. In line with the results of the research obtained, namely that good water quality can increase growth through a high feed conversion ratio to fish body biomass, which overall affects the survival of the cultivated fish.

Growth Performance of Test Plants

The growth performance measurements of the test plants were not statistically analyzed, but rather descriptively based on biomass measurements. The results of absolute weight and absolute length growth measurements of the tilapia reared fish increased from the beginning to the end of the study. This can be seen in Table 2.

Table 2. Results of Measurements of Test Plant Growth Parameters in Each Treatment

Parameter	Unit	Treatment			
		P0	P1	P2	P3
Absolute Weight Growth	g±SD	000±00,00	834±97,68	785±63,30	346±96,65
Daily Growth Rate	g/hari±SD	00,00±0,00	27,80±3,26	26,18±2,11	11,54±3,22

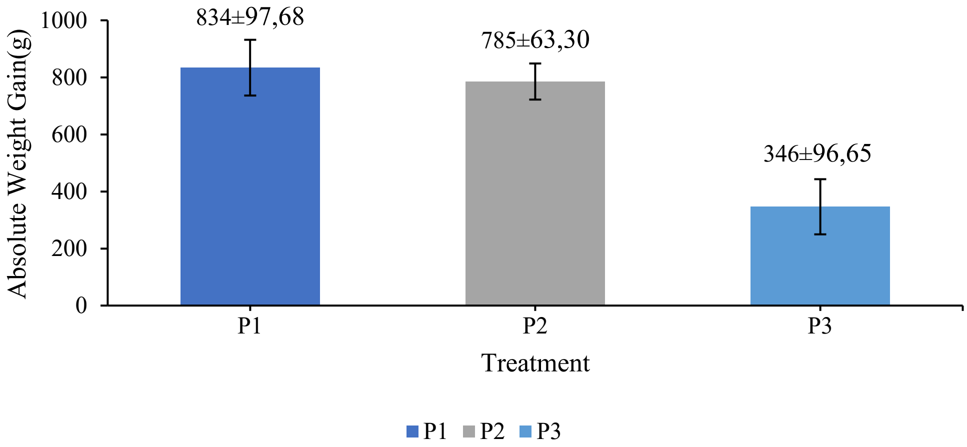

Figure 9. Average Absolute Weight Growth of W. arrhiza During 30 Days of Maintenance. P1 (50 g/m^2), P2 (150 g/m^2, P3 (250 g/m^2)

Based on the measurements as seen in Figure 9, the absolute weight growth values in treatments P1, P2, and P3 were 834±97.68, 785±63.30, and 346±96.65 g, respectively. Measurements of the average absolute weight growth at the end of maintenance showed that treatment P1 had a higher value compared to treatments P2 and P3 with a value of 834±97.68 g, while the lowest value was in treatment P3 with a value of 346±96.65 g. In treatment P2, the value was 785±63.30 g, close to the value of P1.

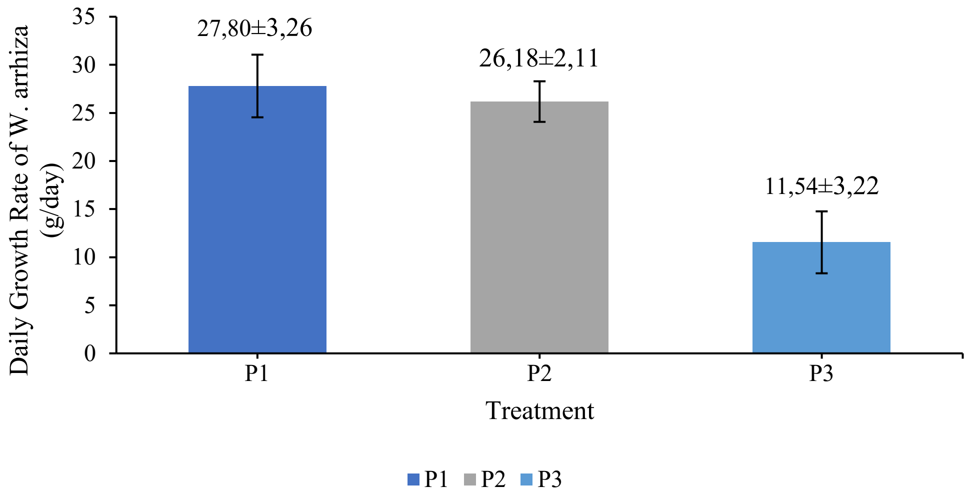

Figure 10. Average Daily Growth Rate of W. arrhiza during the 30 Day Maintenance Period. P1 (50 g/m^2), P2 (150 g/m^2, P3 (250 g/m^2)

Based on the results of measurements during maintenance as shown in Figure 10, the results of measuring the daily growth rate of plants were obtained. The daily growth rates of plants in treatments P1, P2 and P3 were respectively 27.80 ± 3.26, 26.18 ± 2.11 and 11.54 ± 3.22 g/day. The highest daily plant growth value was in treatment P1 with a value of 27.80 ± 3.26 g/day, then the lowest daily growth value was in treatment P3 with a value of 11.54 ± 3.22 g/day.

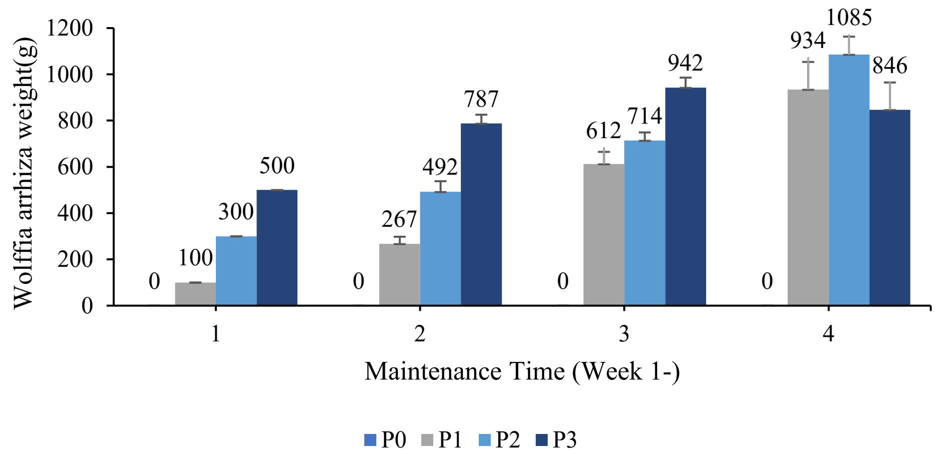

Figure 11. Average Change in W. arrhiza Weight During 30 Days of Maintenance Period. P0 (without W. arrhiza), P1 (50 g/m^2), P2 (150 g/m^2), P3 (250 g /m^2)

In treatment P1, the biomass weight of W. arrhiza increased from the 1st week of measurement to the 3rd week of measurement with values of 267, 612 and 934 g. Treatment P2 also experienced an increase in biomass values from week 1 to week 3 with values of 492, 714 and 1085 g. Meanwhile, treatment P3 experienced an increase in the 1st to 2nd weeks with values of 787 and 942 g, then decreased again in the 3rd week with a value of 846 g. as seen in Figure 11

DISCUSSION

Mortality is the percentage of the number of fish that die from a population. As seen in Table 2, the survival rate in the control treatment was only 85.50±2.29%. The SR value is smaller than the other treatments. This is in accordance with the research of Saptoprabowo (2000) in Hermawan et al., (2014), which shows that fish growth decreases in line with increasing stocking density of 5-20 fish/L and shows the opposite when the stocking density is low. The study is also in accordance with the opinion of Handajani (2002) in Hermawan et al., (2014) who stated that the higher the density of fish, the more it will affect the behavior and physiology of fish regarding movement space which causes growth, food utilization and survival to decrease. Nurlaela et al., (2010) stated that the difference in stocking density of 5-20 fish/m2 causes growth to decrease, the decrease in growth occurs due to competition for movement space, dissolved oxygen and food. Another explanation for the effect of stocking density is that stress, resulting from higher stocking densities, increases maintenance energy, which reduces the energy allocated for growth. These statements suggest that low stocking densities can maximize standard length growth. In treatments P2 and P3, the standard length growth rate remained within optimal values. This value exceeds the value found in research conducted by Nirmala & Rasmawan (2010), which ranged from 0.23 to 0.56 cm over 40 days of maintenance.

Absolute weight growth is the daily weight gain of fish during maintenance. Absolute weight gain is expressed in grams per day. The absolute weight gain value is the difference between the final weight and the initial weight. The absolute weight growth rate during the 30-day maintenance period is shown in Figure 4. It is clear that the highest absolute weight growth rate of tilapia until the end of the maintenance period was demonstrated by treatment P2, although analysis of variance (ANOVA) results showed no significant difference between the treatments ($P<0.05$).

The best daily growth rate was found in treatment P2 with the amount of W. arrhiza given as much as 150 g/m2. Although there was no significant difference between the treatments with the daily growth rate, the value of the treatment with the addition of W. arrhiza was above the control value. This is thought to be due to the aeration process in all treatments so that the dissolved oxygen levels in all treatments were high as presented in Table 1, thus causing the appetite of the test fish to increase as stated by Islami et al., (2017) who stated that the increase in fish appetite was triggered by high dissolved oxygen concentrations. The concentration of dissolved oxygen supplied by the aeration system throughout the time and the low accumulation of metabolic waste through phytoremediation affected the daily growth rate of tilapia (Taufik, 2012). Another cause of the daily growth rate was the concentration of nitrogen compounds in the water, in the treatment with the addition of W. arrhiza, the ammonia concentration was still at a low level, although there was a fairly high increase, this occurred in all treatments. On the other hand, high ammonia concentrations will have an impact on reducing growth through several mechanisms, namely reducing oxygen uptake due to gill damage, requiring more energy for the detoxification process, osmoregulation disorders, and physiological tissue damage (Raharjo, 2018).

Treatment P2 experienced an increase in weight from the beginning of the study, with a daily growth rate of 19.09%. The high growth in treatment P2 was due to a decrease in the toxicity of unionized ammonia. Growth in treatment P3 was lower than that of treatments P0, P1, and P2, with a specific growth rate of 14.22%. This is suspected to be due to the infrequent excretion of metabolic waste and dissolved organic matter and the accumulation of these wastes through aeration, as evidenced by the cloudy and odorous water during the study. Fish will reduce food intake in conditions of low dissolved oxygen, which impacts growth, and vice versa. Excess ammonia in waters impacts the growth rate, reproduction, and immunity of aquatic biota. Excessive nitrate concentrations will also cause an increase in blood methemoglobin, which reduces oxygen carrying capacity, commonly known as methemoglobinemia (Jamal et al., 2013). Excessive phosphate concentrations can cause plankton population explosions, which in turn reduce dissolved oxygen levels in the water.

Plant growth is one parameter in determining the productivity of test plants. The growth of test plants is influenced by various factors, namely sunlight intensity, water temperature, environmental temperature, pH, nutrient concentration, and plant type. In the phytoremediation concept, the effectiveness of the system is also indicated by the successful growth of aquatic plants. This can be seen from the increase in the weight of W. arrhiza biomass weighed during the biomass observation process. The increase in the weight of W. arrhiza varies in each treatment. If we look again, the lowest increase in the weight of W. arrhiza is in treatment P3 with 346 ± 96.65 g. This is because the growth of W. arrhiza in treatment P3 is not supported by the increase in the area of the container used (the area of the container remains constant) resulting in many W. arrhiza plants dying.

CONCLUSION

The application of the phytoremediation system using Wolffia arrhiza had a positive effect on the survival and growth of tilapia, where the control treatment without plants produced the lowest survival rate (85.50±2.29%) due to high stress and competition for movement space. The best absolute weight growth performance and daily growth rate were achieved by treatment P2 (150 g/m² W. arrhiza) at 19.09% due to the optimal aeration system increasing fish appetite and the effectiveness of phytoremediation in suppressing ammonia toxicity. Conversely, treatment P3 showed the lowest growth rate (14.22%) due to the accumulation of metabolic waste and excess nitrogen compounds that reduced feed intake. The suboptimal environmental conditions in P3 also hampered the productivity of phytoremediator plants, as indicated by the lowest increase in W. arrhiza biomass weight (346±96.65 g) due to the limited area of the container that triggered mortality in the plant itself.

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