THE EFFECT OF DIFFERENT TYPES OF WATER PLANTS IN *RECIRCULATING AQUACULTURE SYSTEM* (RAS) ON GROWTH OF TILAPIA (*Oreochromis niloticus)*

Triansyah Putra [1], Iskandar [2], Junianto[2], Roffi Grandiosa Herman[2]

[1)] Student of the Faculty of Fisheries and Marine Sciences, Padjadjaran University
[2)] Lecturers of the Faculty of Fisheries and Marine Sciences, Padjadjaran University

ABSTRACT

Tilapia (*Oreochromis niloticus*) is a type of freshwater fish that is widely cultivated. Along with the increasing public interest in tilapia and technological developments, tilapia cultivation has been carried out intensively. Intensive aquaculture requires fish to be at stocking densities and at high feeding rates, causing water quality problems. The use of *Recirculating Aquaculture Systems* (RAS) in intensive cultivation is able to maintain water quality. This study aims to determine the best types of aquatic plants in RAS for the growth of tilapia seeds. The research was carried out at the Ciparanje Wet Laboratory and Experimental Pond, FPIK UNPAD in February - March 2021. The test fish used were tilapia with a length of about 7 - 9 cm and a weight of about 8 - 10 g. The feed used is commercial feed with a protein content of 31 – 33%. Feeding was carried out at 08.00 and 16.00 WIB with 3% fish biomass. This study used an experimental method with RAL with 4 treatments and 3 replications. Treatment A (Control, without plants), treatment B (cotton fiber, bioball, activated charcoal and kale), Treatment C (cotton fiber, bioball, activated charcoal and watercress) and Treatment D (cotton fiber, bioball, activated charcoal and water spinach). The results showed that the use of different aquatic plants had a significant effect ($P<0.05$) on FCR, absolute weight growth, height and number of plant leaves and had no significant effect ($P>0.05$) on SR. The best treatment in this study was B with an SR value of 91.11 ± 3.85%, absolute weight 10.09±0.58 g, FCR 1.72±0.03 plant height 50.67±8.14 cm and total 22.67±5.03 leaves. Water quality during the study was in a reasonable range for tilapia cultivation where the use of aquatic plants was able to maintain good water quality.

Keywords: *Absolute weight growth, Feed Conversion Ratio, Height and number of leaves, Kale, Recirculating Aquaculture Systems, Specific Growth Rate, Survival Rate, Tilapia*

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1. INTRODUCTION

Tilapia (*Oreochromis niloticus*) is a type of freshwater fish consumption that is widely cultivated. Tilapia is liked by the community because it is easy to maintain, can be consumed by all levels of society and the taste of the meat is delicious and thick, making this fish an important commodity. Along with the increasing public interest in tilapia and technological developments, tilapia cultivation has been carried out intensively. The cultivation process requires fish to be in conditions of high density and a large number of feeding processes [1].

High stocking density demands a high amount of feed given to fish, resulting in a buildup of organic matter in the container. The accumulation of organic matter will cause the formation of compounds that are toxic to fish, thereby accelerating the decline in water quality. In conditions of limited water, the decrease in water quality is very dangerous for the survival of fish. This can be overcome by implementing a recirculation system which in principle is the reuse of water that has been removed from cultivation activities.

Recirculating Aquaculture Systems (RAS) is a fishery production system that recycles water used to meet water quality requirements for aquaculture [2]. The purpose of the recirculation system is to improve water quality. The movement of water from the recirculation system will result in a more even distribution and physical environmental factors such as temperature, oxygen, pH and others, and even distribution of feed [3].

The recirculation system is usually combined with filter media to process the waste produced by fish or leftover feed so that it is not toxic to fish. Filters commonly used are physical, biological, chemical and plant filters. The physical filter serves to filter out relatively large coarse impurities such as feces, mucus, leftover feed and others. The biological filter functions as a bacterial house that functions as an organism processing nitrogen compounds in water, while the aquatic plant filter functions in the absorption of nitrogen from feces and feed residues.

Aquatic plants are part of the vegetation of the earth's inhabitants, whose growth media is water. There are several plants that are often used in aquaponics systems including kale, watercress, and water spinach [4]. kale, lettuce, and water spinach can be used as waste phytoremediator agents. In addition, kale, lettuce, and water spinach have economic value and can be harvested and consumed.

Water spinach, lettuce, water spinach includes plants with roots that are not too strong and are one of the requirements to be maintained in an aquaponic system [5]. The root system of kale is riding and growing with quite a lot of branching [6]. The root system of the water spinach has a taproot and root branches that are elliptical in shape spreading in all directions [7]. Lettuce has a tap and fibrous root system [6].

The use of a combination of physical, chemical, and biological filter media alone is not enough to reduce the existing ammonia, so research is needed to find the best types of aquatic plants in reducing ammonia. The addition of aquatic plant species with the most effective combination of filter media (physics, chemistry, biology) will be able to improve water quality in the tilapia hatchery aquaculture recirculation system.

2. MATERIALS AND METHODS

2.1 Place and Time

The research was carried out at the Ciparanje Wet Laboratory and Experimental Pond, Faculty of Fisheries and Marine Sciences, Padjadjaran University. The research was conducted from February 2021 to March 2021 at the Faculty of Fisheries and Marine Sciences, Padjadjaran University.

2.2 Tools and Materials

The tools used during this research are as follows; Aquariums, digital water pump scales, gutters, fiber tubs, *water checkers*, pH meters, filters, ammonia *test kits*, nitrate *test kits*, nitrite *test kits*, jars, label paper, stationery, and documentation tools.

The materials used during this research are as follows; Tilapia seeds, Bioball, dacron/cotton fiber, activated charcoal, aquatic plants (kale, watercress, water spinach), and commercial fish feed hi-provite 781-1 with a protein content of 31-33%.

2.3 Research Methods

Methods The experimental method is a planned effort to reveal new facts or strengthen new theories and even refute existing research results [8]. The research method used in this study was an experimental method with a completely randomized design (CRD) with four treatments and three replications. The research focuses on the role of biofilters in the recirculation system on the quality of tilapia aquaculture water.

This study consisted of three types of biofilters that were applied to tilapia aquaculture ponds. (*Oreochromis niloticus*) and one control without the use of a biofilter. The treatments in this study were:

1. Treatment A = Control (cotton fiber, bioball, activated charcoal)
2. Treatment B = Cotton fiber, activated charcoal, bioball, kangkong plant
3. Treatment C = Cotton fiber, activated charcoal, bioball, watercress plant
4. Treatment D = Cotton fiber, activated charcoal, bioball, water spinach

2.4 Research Procedures

The procedures carried out in this research are as follows; The preparation of container and filter media, maintenance of test subject (fish), water quality inspection, and growth observations.

2.5 Research Parameters

Research Parameters in this study are measurements of water quality, and aspects of tilapia and aquatic plants growth.

Parameters of water quality data measured are as follows:

Table 1. Water Quality

No	Parameter	Unit	Measuring Instrument
1	Temperature	°C	Thermometer
2	Dissolved oxygen	mg/L	DO Meter
3	pH	-	pH Meter
4	Ammonia	mg/L	Ammonia *test kit*
5	Nitrite	mg/L	Nitrite *test kit*
6	Nitrate	mg/L	Nitrate *test kit*

Tilapia growth data are measured with certain formulas which are as follows:

Survival *rate* (SR) is the percentage of the number of living organisms at the end of a certain time. The calculation of the survival formula is as follows [9]:

$$SR = x\ 100\%$$

Information:
SR = Survival Rate (%)
Nt = Number of Fish at time t (tail)
No = Number of fish at the beginning of the study (tail)

The calculation of absolute weight gain of tilapia fry is as follows [9]:

$$W = Wt - Wo$$

Information:
W = Weight gain of fish (g)
Wt = Final weight of fish at time t (g)
Wo = Initial weight of fish (g)

The feed conversion ratio was calculated by the following formula [11]:

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

Information:
FCR = *Feed Conversion Ratio*
Wo = Weight of test animals at the beginning of the study (g)
Wt = Weight of test animals at the end of the study (g)
D = Number of fish caught dead (tail)
F = Amount of feed consumed (g)

Aquatic plants growth was conducted destructively. Observation parameters include; plant height, number of leaves and plant weight.

1. Number of leaves per plant (strands)
   Observation of the number of leaves was measured by counting the leaves that had fully opened. Observations were made once a week.
2. Plant height (cm)
   Variable plant height was measured with a ruler. Measurements were made from the base of the stem to the growing point of the plant. Measurements are carried out once a week.

2.6 Data Analysis

Water quality data will be analyzed descriptively, the data obtained in the form of tilapia growth were analyzed for variance (F test) at the 95% confidence level to see the effect. If the analysis of variance obtained a significant difference (P <0.05%) then Duncan's multiple distance test was conducted to determine the differences between treatments, and the observational data of aquatic plants were analyzed by descriptive method by describing the condition of the plants during the study.

3. RESULTS AND DISCUSSION

3.1 Survival Rate

Results of the calculation of tilapia survival during the study can be seen in Table 2.

Table 2. Tilapia Survival Rate per Treatment

Treatment	Survival Rate(%)
A	82.22±7.70 a
B	91.11±3 ,85 a
C	86,67±6.67 a
D	88,89 ±3.85 a

Description : Treatment A : Control (cotton fiber, bioball and activated charcoal); Treatment B : Cotton fiber, bioball, activated charcoal and kale; Treatment C: Cotton fiber, bioball, activated charcoal and watercress; and Treatment D: Cotton fiber, bioball, activated charcoal and water spinach

In Table 2 it can be seen that the percentage survival rate for 42 days of rearing in each treatment ranged from 82.22% - 91.11%. The highest survival rate was found in treatment B (watercress plant) which was 91.11% followed by treatment D (water spinach), treatment C (watercress plant) and A (control) which were 88.89%, 86 respectively. ,67% and 82.22%. Based on the analysis of variance, it showed that the use of different plant species in the recirculation system did not significantly affect the survival rate (p>0.05).

The survival rate that did not differ much between treatments was due to the influence of the recirculation system with the use of filters on the media for rearing tilapia. The recirculation system can improve water quality in the rearing media which is very influential for the life of tilapia. In addition to water quality, fish survival is influenced by various factors including feed, fish age, environment, and fish health conditions [12].

The high survival rate in treatment B by using a water spinach biofilter compared to other treatments because of the kale plant which can make water quality in the tilapia rearing media well maintained, especially suppressing ammonia levels so that fish are not stressed and make fish appetite increase and can suppress mortality rate in fish. In addition, feed and fish excretion products will be used as fertilizer for plants so that no water and food residue is wasted (zero waste) [13]. This is in line with research conducted by Effendi [14] that the survival rate of catfish treated with kale as a phytoremediator with a recirculation system was higher than that of water spinach and controls.

Based on the survival value during the study, it is known that the survival rate of tilapia is in the good category according to Mulyani [15]. Survival rate > 50% is in the good category. The survival limit for tilapia production in pond water is 75% [16].

3.2 Absolute Weight Growth

Observations on the increase in absolute weight of tilapia in each treatment during the 42-day rearing period showed that the use of plants in the recirculation system had a different effect on the growth of tilapia. The absolute weight growth of tilapia during the 42-day rearing period can be seen in Table 3 and below.

Table 3. Growth of Absolute Weight of Tilapia per Treatment

Treatment	Absolute Weight Growth (g)
A	7.54 ±0.68 a
B	10.09 ±0.58 b
C	8.27 ±0.38 a
D	8.45 ±0 ,54 a

Description : Treatment A : Control (cotton fiber, bioball and activated charcoal); Treatment B : Cotton fiber, bioball, activated charcoal and kale; Treatment C: Cotton fiber, bioball, activated charcoal and watercress; and Treatment D : Cotton fiber, bioball, activated charcoal and water spinach.

Based on Table 3, it can be seen that during the 42 days of maintenance, each treatment showed a different increase in absolute weight. The absolute weight growth of tilapia during the study showed the highest value in treatment B (watercress plant) of 10.09 g, followed by treatment D (water spinach) with a value of 8.45 g, in treatment C (watercress plant) with a value of 8.27 g and the lowest was in treatment A (control) with a value of 7.54 g. Based on Duncan's follow-up test, treatment B (kangkung) was the best treatment.

Fish growth occurs because of the availability of feed in sufficient quantities, where the feed consumed is greater than the basic needs for survival [17]. The high and low growth of fish is also very dependent on the maintenance media, space for movement and water quality. Poor water quality can make fish stressed which results in reduced fish appetite and disruption of the metabolic system. The results of the study using water spinach, the weight gain of tilapia was 21.59 ± 4.28 g and the increase in length was 3.21 ± 0.68 cm [18]. Water quality during maintenance with an aquaponic system using kale plants obtained temperatures ranging from 29.4-32 ^{o}C, pH ranging from 6.54-8.2, DO ranging from 3.6-4.8. So it can be concluded that the high growth in treatment B (water spinach) compared to other treatments was due to the optimal filtration process so that the water quality in the treatment was very good and also the provision of feed according to the needs of tilap ia became a factor that supported the growth of tilapia.

3.3 Feed Conversion Ratio (FCR)

The feed conversion *ratio* is the ratio between the amount of feed given and the total weight of the fish produced. The smaller the feed conversion value, the better the feed utilization rate, and vice versa, the greater the feed conversion value, the lower the feed utilization rate. The results of the calculation of the *Feed Conversion Ratio* obtained during the study can be seen in Table 4 below.

Table 4. Tilapia Feed Conversion Ratio per Treatment

Feed	Conversion Ratio (%)
A	2.04 ±0.12 b
B	1.72 ±0.03 a
C	1.99 ±0.07 b
D	1.98 ±0 ,13 b

Description : Treatment A : Control (cotton fiber, *bioball* and activated charcoal); Treatment B : Cotton fiber, *bioball*, activated charcoal and kale; Treatment C: Cotton fiber, *bioball*, activated charcoal and watercress; and Treatment D : Cotton fiber, *bioball*, activated charcoal and water spinach.

Based on Table 4, it is known that the FCR values in each treatment are as follows; Treatment A (control) was 2.04, treatment B (water spinach) was 1.72, treatment C (watercress plant) was 1.99 and treatment D (water spinach) was 1.98. Treatment B resulted in the lowest FCR value. Based on the analysis of variance, it was found that the use of different plants in the filter media gave a significant difference to the FCR value. The FCR value was then analyzed using Duncan's multiple distance test at a confidence level of 95% and the results showed that the best FCR value was in treatment B (kangkung).

The tilapia used in this study had an initial length of 8 cm with a density of 20 fish and the FCR result was 1.47. Utilization of feed for fish keepers with aquaponic recirculation is higher than conventional fish rearing [20]. Efficiency of feed utilization is related to growth, high efficiency values in aquaponic biofilter systems cause fish to utilize feed properly so that it is also good for fish growth.

Food conversion in fish between 1.5-8 means that the feed conversion value in all treatments can be said to be good [21]. Tilapia had an FCR of 0.8–1.6 [22]. The value of the feed conversion ratio in treatment B using water spinach showed the lowest value in this study, this shows the use of water spinach is able to reduce the feed conversion ratio through the process of improving water quality.

3.4 Water Quality

The quality was measured every 7 days in the morning at 08.00 WIB. The water quality measured in this study include; temperature, DO, pH, ammonia, nitrite and nitrate. Water quality during the study is presented in Table 5.

Table 5. Observation of Water Quality During Research

Water Quality	Treatment				Quality Standard
	A	B	C	D	
Temperature (^{o}C)	24.55 – 25.55	24.50 – 25.35	24.65 – 25 ,40	24.65 – 25.20	25 – 32 ^{o}C [16]
pH	6.53 – 7.10	6.60 – 7.03	6.60 – 7.03	6.60 – 7.00	6 – 8.5 [23]
DO (mg/L)	5, 20 – 7.10	5.27 – 7.07	4.97 – 6.97	5.57 – 6.93	3 mg/L [16]
Ammonia (mg/L)	0.0009 – 0.0017	0.0007 – 0.0014	0.0007 – 0.0016	0.0006 – 0.0017	<0.02 mg/L [16]
Nitrite (mg/L)	0.03 – 0.08	0.02 – 0.07	0, 02 – 0.08	0.02 – 0.07	<0.06 mg/L [24]
Nitrate(mg/L)	0.53 – 0.88	0.43 – 0.71	0.44 – 0.84	0 ,52 – 0.75	<10 mg/L [24]

Description : Treatment A : Control (cotton fiber, bioball and activated charcoal); Treatment B : Cotton fiber, bioball, activated charcoal and kale; Treatment C: Cotton fiber, bioball, activated charcoal and watercress; and Treatment D : Cotton fiber, bioball, activated charcoal and water spinach

3.5 Plant Growth

Plant growth parameters measured included height and number of leaves. Measurement of plant height and number of leaves was conducted quantitatively.

Below is table of average plant height per treatment during research:

Table 6. Average Plant Height per Treatment

Plant	Height (cm)
B	50.67 ± 8.14 b
C	11.50 ± 0.50 a
D	12 ,17 ± 1.04 a

Description : Treatment A : Control (cotton fiber, bioball and activated charcoal); Treatment B : Cotton fiber, bioball, activated charcoal and kale; Treatment C: Cotton fiber, bioball, activated charcoal and watercress; and Treatment D: Cotton fiber, bioball, activated charcoal and water spinach

Based on Table 6 observations of the height of kale, watercress and water spinach experienced growth during the study with the final average height for kale plants of 50.67 cm, final average height watercress plant by 11.50 cm, the final average height of water spinach is 12.17 cm. This shows that plants in aquaponics systems are able to utilize nitrogen for the growth of aquatic plants. The aquaponics system allows plants to grow by utilizing the elements of aquaculture waste from tilapia rearing, namely ammonia from undigested feed residue and tilapia body metabolic waste that is released which can then be utilized by plants.

The growth of kale using an aquaponic system showed the best results compared to watercress and water spinach. This is presumably because the roots of the kale are stringier and longer than those of watercress and water spinach. water spinach has a faster growth of about 0.025 g/day and has a fast weight of growth [40]. In terms of roots, kale is more optimal for absorbing ammonia and nitrate.

Below is table of average number of leaves during the study:

Table 7. Number of Leaves Average of Plants per Treatment

Treatment	Number of leaves (strands)
B	22.67 ±5.03 b
C	7.67 ±0.58 a
D	11.33 ±058 a

Description : Treatment A : Control (cotton fiber, *bioball* and activated charcoal); Treatment B : Cotton fiber, *bioball,* activated charcoal and kale; Treatment C: Cotton fiber, *bioball,* activated charcoal and watercress; and Treatment D: Cotton fiber, *bioball,* activated charcoal and water spinach.

Based on table7 observations of the average number of leaves above the treatment using kale was the treatment with the highest number of leaves. The average number of leaves in the treatment using kale plants was 22.67 leaves, treatment using watercress plants was 7.67 leaves and treatment using water spinach was 11.33 leaves . The increase in plant height can support the addition of the number of leaves along with the increasing age of the plant [41]. The results showed that the taller the plant, the more leaves. Leaf formation by plants is strongly influenced by the availability of nitrogen and phosphorus nutrients in the medium and those available to plants [42].

4. CONCLUSIONS

The use of cotton fiber, bioball, activated charcoal and water spinach plants in rearing tilapia (*Oreochromis niloticus*) with *Recirculating Aquaculture System* resulted in optimal water quality conditions and gave a survival value of 91.11%, growth absolute weight of 10.09 g. , and feed conversion ratio of 1.72, as well as favorable water quality conditions.

To find out more about the effect of water spinach on the growth of tilapia and water quality during rearing in the *Recirculating Aquaculture System* (RAS), it is recommended to increase stocking density and conduct it on a large scale.

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