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Study of Aquaculture Water Quality for Tilapia (*Oreochromis niloticus*) in the Aquaponic System at the Deju Farm Hatchery Unit

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Abstract

Tilapia (*Oreochromis niloticus*) is well known by freshwater fans, both in developing and developed countries. Utilization of space as much as possible can be an effort to increase the productivity of the cultivation activities carried out. The aquaponic system is a combination of aquaculture (fish farming) and hydroponic plant cultivation in one place. The basic principle of aquaponics is that it can be done at the same time by utilizing fish manure and fish food scraps as a source of nutrition for cultivated plants. The purpose of this activity is to provide information about the utilization of the aquaponic cultivation system and its effect on water quality while rearing tilapia is maintained. This research has been carried out at UPR Deju Farm which is located Jl. Mazmu, Indralaya Raya, Kec. Indralaya in October-November 2022. This activity used a comparative experiment consisting of P1 (kale plant), P2 (spinach plant), and P3 (lettuce plant). The results showed that the P1 treatment (kale plant) was the best treatment which produced temperatures ranging from 27-31°C, pH 7-8, dissolved oxygen 2.3 mg L^{-1}, ammonia 0.098-0.290 mg L^{-1}, and salinity 9.29 ppt, absolute length growth was 3.2 cm, absolute weight was 2.1 g, survival was 84%, and kale plant growth was 8.3 cm.

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Introduction

Tilapia (*Oreochromis niloticus*) is well known by freshwater fans, both in developing and developed countries. In Southeast Asia, tilapia is widely cultivated, especially in the Philippines, Malaysia, Thailand and Indonesia. In Indonesia, this fish has spread to almost all corners of the country. Tilapia is a fishery commodity that is popular with the public in meeting their needs for animal protein because it has thick flesh and tastes good. Tilapia is also a potential fish for cultivation because it is able to adapt to environmental conditions with a wide range of salinity (Hadi *et al.*, 2009). According to the Ministry of Maritime Affairs and Fisheries (2021), the value of tilapia production in 2020 will reach Rp. 29.19 trillion, but this has decreased compared to 2019 which reached a production value of Rp. 33.08 trillion. The decline in production value is thought to be caused by poor water quality resulting in increased pest or disease attacks.

The pace of development has increased rapidly every year, this has resulted in a decrease in the quality of the environment in the cultivation area, one of which is reduced water which is the growing medium for cultivated fish (Siregar *et al*., 2013). Another effect caused by development is the reduction in the area of fish cultivation, so intensive cultivation is carried out with a high increase in seed stocking density, but this can reduce water quality (Putra et al., 2013). Consistency in increasing the production of tilapia can be done through intensive cultivation by paying attention to various aspects supporting the survival of these fish such as water availability, cultivation area, and good environmental quality (Putra *et al*., 2011). Various metabolic processes that occur in the body of fish that play an important role in productivity and survival are influenced by various physical factors of water quality (Dauhan, 2014). Some physical factors that become water quality parameters in freshwater fish farming include temperature, pH (power of Hydrogen), dissolved oxygen (Dissolve oxygen), ammonia, and nitrate (Marlina, 2016).

Aquaponics is a combination of aquaculture (fish farming) and hydroponic plant cultivation in one place. The basic principle of aquaponics is that it can be done at the same time by utilizing fish manure and fish food scraps as a source of nutrition for cultivated plants (Nugroho *et al*., 2012). Aquaponics application is one of the alternative cultivation techniques used to overcome these problems. Technically, this technique is able to increase the production of fish cultivators by optimizing the function of water and limited space as a rearing medium. The basic concept of aquaponics is a combination of aquaculture technology with hydroponic technology in one system. Leftover feed and excrement resulting from fish metabolism in water which has the potential to reduce water quality will be used as fertilizer for recirculating aquatic plants. According to Nugroho et al. (2012), pond water is channeled into plant growth media as a vegetation filter that can clean toxic substances in the water so that the water that returns to the pond is clean and suitable for reuse as a medium for tilapia cultivation. The aquaponic system is a way to improve water quality and reduce water use for fish farming.

Deju Farm People Hatchery Unit (UPR), Indralaya Ogan Ilir cultivates tilapia fish in its commodity house. This business has been running for a long time and is still developing in increasing production results. Tilapia cultivation at UPR Deju Farm still uses an intensive and traditional cultivation system. UPR Deju Farm is frequently plagued by fish deaths, which cause production results to decrease and result in less than optimal income and results. According to Tugiyono (2009), biomarker analysis is a biological response to environmental pollution that provides the magnitude of exposure and toxic effects of pollutants, namely by calculating the physiological index. In this case, poor water quality may have caused the fish to become stressed, causing them to become sick and eventually die. The effect of poor water quality can be caused by excessive feeding, extreme weather, ponds that are less than sterile, parasites and disease. A polluted environment can cause a decrease in the quality of raw materials for water quality, this results in a decrease in the diversity of aquatic biota, one of which is the death of several fish species in aquatic ecosystems (Yuliani et al., 2015). Consequently, even if the problem isn't directly addressed, fish in Maintenance ponds may continue to die because of this effect. The aquaponic system is one solution to the problem that can be done at UPR Deju Farm. By implementing this aquaponic system, it will minimize the water quality in the maintenance pond because this aquaponic system is a means of filtering the maintenance pond so that the water quality in the pond will remain well controlled. The main goal of this system is to optimize water functions and water bioremediation using plants (Nugroho, 2012).

Deju Farm Hatchery Unit, Indralaya Ogan Ilir cultivates tilapia in its commodity house. This business has been running for a long time and is still developing in increasing production. Tilapia cultivation at UPR Deju Farm still uses an intensive and traditional cultivation system. One of the problems that is often found at UPR Deju Farm is fish mortality that occurs continuously, causing decreased production results and resulting in less than optimal income and results to be achieved. According to Tugiyono (2009) analysis of biomarkers as a biological response to environmental pollution which gives the amount of exposure and toxic effects of pollutants, namely by calculating the physiological index. These deaths can be caused by the influence of poor water quality, stressing the fish and slowly getting sick so that death occurs. The effect of poor water quality can be caused by excessive feeding, the effects of extreme weather, less sterile ponds, parasites and diseases. A polluted environment can cause a decrease in the quality of water quality raw materials, this results in a decrease in the diversity of aquatic biota, one of which is the death of several fish species in aquatic ecosystems (Yuliani *et al.*, 2015). This effect can make the water quality worse so that fish in maintenance ponds experience continuous death even if not handled directly there will be mass death of fish. The aquaponic system is one solution to the problem that can be done at UPR Deju Farm by implementing this aquaponic system so it will minimize water quality in the maintenance pond because this aquaponic system is a filter facility for the maintenance pond so that the water quality in the pond will remain well controlled. The main function of this system is to optimize the function of water and bioremediation of water that utilizes plants in fish farming systems (Nugroho, 2012).

Materials and Methods

Research Locations, Material Use and Research Design

This research was conducted in October-November 2022 at the Deju Farm Hatchery Unit, Indralaya, Ogan Ilir Regency.

Materials and tools

The research materials used in this study were tilapia (size 6 ± 1 cm), commercial feed (35% protein), kale plant (size 4±1 cm), lettuce plant (size 4±1 cm), spinach plant (size 4 ±1cm), fish salt, potassium permanganate, charcoal, and gravel. While the tools used in this study were aquariums, aerators, water quality checkers, rulers, slides, scales, PVC pipes and Styrofoam.

This study consisted of 3 treatments with a comparative experimental method consisting of:

P1 : Kale plant media

P2 : Lettuce plant media

P3 : Spinach plant media

Activity procedures

The maintenance containers in this study used aquarium media with a size of 50x30x35 cm^3 which had previously been soaked in 1 g of potassium permanganate per L (Mutiarasari, 2017) for 1 day to sterilize pathogens attached to the rearing containers. These pathogens can be bacteria, parasites, and chemical fluids from the glass glue used. This soaking process is very helpful for tilapia rearing process. Next, the container is cleaned and rinsed. Then the container is filled with 46 L of clean water and 1 g of fish salt per L is added (Sejati, 2011). Then deposit it for one day and siphon the dirt that has settled. To ensure that the temperature and pH are suitable for the fish being tested, the temperature and pH of the aquaculture water are measured once every three days.

The treatment containers used were three treatments, each aquaponic treatment with three different vegetables. This treatment uses different vegetable plants with the specified maintenance media, the vegetables are planted on charcoal and gravel media in a glass tube, then placed on a Styrofoam frame that is attached to the rearing medium, the plant density used is 5 plants per 5 cm^2. The vegetables used were 7 days after germination. Each of these treatments uses different vegetables but uses the same treatment.

Installation of frame media for aquaponics using Styrofoam. The Styrofoam was placed at the top of the pond, then a hole was given as a means for feeding, each edge of the pond was given a hole for a glass tube planting medium as a growing medium for aquaponics, then the glass tube was given charcoal and fine gravel to become a planting medium for vegetables. Each plant has a density of 5 plants per 5 cm^2. Each treatment in this field practice is carried out without changing water, so that bacteria and ammonia will accumulate, it will make the performance of aquaponic plants work on water quality control. Aquaculture activities with a system without changing water, bacteria have an important role in removing ammonia particles through the nitrification process (Rully, 2011). Kale plant (*Ipomoea aquatica*) also includes plants with roots that are not too strong which is one of the requirements to be maintained in an aquaponic system using a simple filter system, the number of clumps used is also made different (Nugroho, 2008). The picture of the aquaponics framework is presented in Figure 1.

Maintenance of tilapia

Rearing of tilapia was carried out for 30 days by observing several parameters such as water quality, growth in length and absolute weight and survival of tilapia during rearing. The fish used came from the Deju Farm Hatchery Unit which were still in the seed phase with a size of 5-7 cm. The stocking density in each rearing container was 1 fish per L. Tilapia were fed based on a feeding rate of 5% of the total weight. The frequency of feeding the fish is done 3 times a day at 08.00, 12.00, 16.00 WIB. Measurement of test parameters such as water quality, growth in absolute weight and length of tilapia and survival of tilapia tested was carried out once every ten days.

Test Parameters

Water quality

Good water quality can support optimal tilapia growth and survival. This is related to fish stress factors due to changes in water quality in rearing ponds. Some of the water quality parameters observed were temperature, dissolved oxygen, ammonia, salinity, and pH. Temperature and pH measurements were carried out once every 3 days at 08.00, 12.00, 18.00 WIB and dissolved oxygen, ammonia, salinity were measured at the beginning, middle and end of maintenance. Measurement of temperature and pH is assisted by using a thermometer and pH meter by inserting the tool into the maintenance container. Meanwhile, measurements of ammonia, dissolved oxygen and salinity were measured at the Basic Fisheries Laboratory, Department of Fisheries, Sriwijaya University.

Absolute growth in length and weight

The absolute weight growth of tilapia can be calculated by the following formula.

$$W = W_t - W_o$$

Keterangan:

W = Growth in absolute weight of fish reared (g)

W_t = Weight of fish at the end of rearing (g)

W_0 = Weight of fish at the beginning of rearing (g)

The absolute length growth of tilapia can be calculated by the following formula.

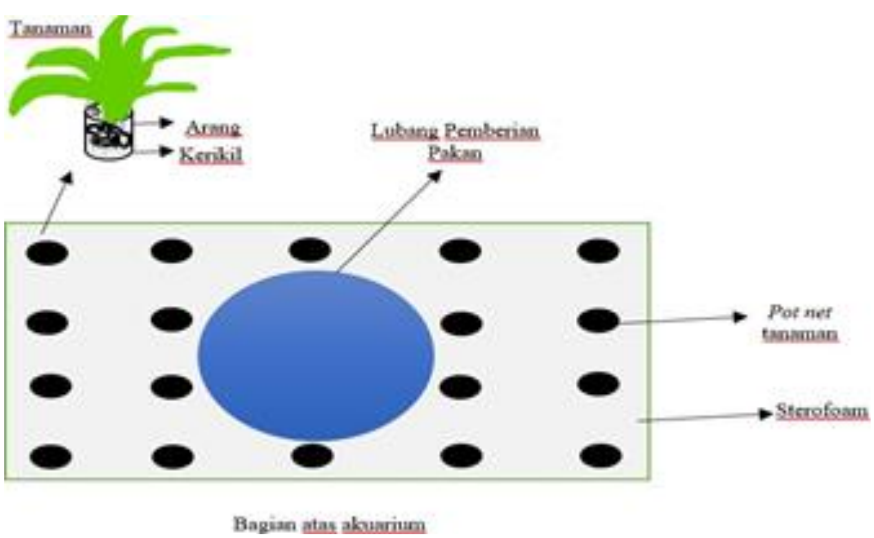

Figure 1. Aquaponic design

$$P = L_t - L_0$$

Keterangan:

P = Growth in absolute length of fish kept (cm)

L_t = Length of fish at the end of rearing (cm)

L_0 = Length of fish at the beginning of rearing (cm)

Survival Rate

The survival of tilapia can be calculated by the following formula.

$$\text{Survival rate (\%)} = \frac{N_t}{N_0} \times 100\%$$

Information:

N_t = Number of fish at the end of rearing (heads)

N_0 = Number of fish at the start of rearing (heads)

Aquaponic Plant Growth

The growth rate of aquaponic plants will be measured using a ruler every three days, then it will be compared using a graphic table for each plant. The content of ammonia that settles in pond water is able to support the needs of plants as liquid fertilizer produced by decomposing bacteria. This liquid fertilizer can boost the growth rate of plants from the fertility of the water (Wenny *et al.*, 2020).

The growth rate of the number of leaves of aquaponic plants will be measured by counting the number of leaves that grow every three days, then it will be compared using a graphic table for each plant. Nitrates in pond water are able to support plant needs as nitrogen elements produced by decomposing bacteria. This nitrogen element can encourage the growth of plant organs such as leaves (Wenny *et al.*, 2020).

Result and Discussion

Water quality

The results of measuring water quality parameters in research activities can be seen in Table 1. below.

Water quality is said to be good if physically, chemically and biologically it meets the needs of the fish being kept (Scabra & Setyowati, 2019). Water quality data in all of these studies were still at optimal values with a temperature range of

Table 1. Water Quality Parameter Data

Treatment	Water Quality				
	Suhu (^{O}C)	pH	Dissolved oxygen (mg L^{-1})	Ammonia (mg L^{-1})	Salinity (ppt)
Kale plant	27-31	7-8	2-3	0,098-0,290	9-29
Spinach plant	27-31	7-8	2-3	0,097-0,280	9-31
Lettuce plant	27-32	7-9	1-3	0,098-0,390	9-36

Table 2. Growth and Survival of Tilapia

Treatment	Plant	Absolute length growth (cm)	Absolute weight growth (g)	Survival Rate (%)
P1	Kale	3,2	2,1	84
P2	Spinach	2,8	1,7	80
P3	Lettuce	2,5	1,3	82

27-32°C, pH 7-9, dissolved oxygen 1-3 mg L^{-1}, ammonia 0.098-0.390 mg L^{-1}, and salinity 9-36 ppt. Each treatment in the study has different results. The results of each of these treatments have their influence, the impact of each effect is produced by different plants, placement of the aquarium and water quality control. The water quality results obtained have a maximum range and drinking, according to National Development Planning Agency (2000) the tolerable pond temperature for tilapia maintenance is between 25-30°C. According to National Standardization Agency (2009), the pH value for tilapia production in still water ponds ranges from 6.5 to 8.5. However, according to Kordi (2009), the optimal water pH value for tilapia is 6-8.5 and the pH value that can still be tolerated by tilapia is 5-11. According to National Standardization Agency (2009) the value of dissolved oxygen for tilapia production in still water ponds is at least 3 mg L^{-1} and ammonia is at least 0.2 mg L^{-1}. Standard tilapia can live with high salinity so that the data on each of these treatments can still be tolerated by rearing tilapia. Tilapia is tolerant of brackish and sea water with a salinity of up to 20 mg L^{-1} (BPPT, 2011).

Water quality is an important aspect that affects fish growth, survival, and productivity (Fauzia & Suseno, 2020). Poor water quality can disrupt fish growth (Yanuar, 2017). Conversely, good water quality can make cultivation activities carried out produce high productivity (Nurhariati *et al*., 2021). The application of an aquaponic system can play a role in maintaining optimal water quality, especially the ammonia content in the waters. According to Niawati *et al*. (2022), plants in the aquaponics system are able to utilize nutrients as a source of nutrients thereby reducing the ammonia content in the waters.

Tilapia Growth and Survival

Data on growth and survival of tilapia reared for 30 days are presented in Table 2. Data on the growth and survival of tilapia in the study had optimum results with a range, P1 had a weight growth of 3.2 g with a length growth of 2.1 cm, with an SR of 84% P2 had a weight growth of 2.8 g with a weight of 1.7 cm, with an SR of 80% and P3 has a weight growth of 2.5 g with a growth of 1.3 cm, with an SR of 82%. The data in the table explains that fish growth at P1 has higher growth followed by P2 and P3. Fish growth occurs due to the availability of sufficient amount of feed, where the feed consumed is greater than the basic requirement for survival (Huet, 1986). The addition of fish body weight also shows that the energy content in the feed consumed by fish exceeds the energy requirements for maintenance and other body activities (Lovell, 1988). competitors, population density, age and the ability of organisms to adapt to the environment.

Sampling during the maintenance of tilapia was carried out every 10 days starting from the day of stocking the fish to the rearing container. Feeding for each week has increased because fish growth continues to increase every day. Maintenance time on days 14-18 fish experience decreased appetite due to absorption of aquaponic vegetable roots with water not being able to absorb water properly due to insufficient water level so additional water level is carried out on day 18 and can overcome water quality control as well as sluggishness vegetables by water uptake. According to Effendi (1979), the growth rate can be influenced by food, temperature, age of the fish and the content of nutrients in the waters. Furthermore Effendi (1971) stated that individual growth can occur when there is an excess of energy and protein derived from food, which has been used by the body for basic metabolism, movement, maintenance of body parts and replacing damaged cells. The results of the growth and survival of tilapia in the study had different results, these results were influenced by several factors, namely, differences in vegetables, different water quality results and influences. Fish health in each treatment. At P1 fish had good growth influenced by the vegetables used, namely kale with roots that can absorb nutrients optimally, different such as P2 and P3 which had lower yields than P1 because the uptake of root vegetables and health during the rearing period made growth and survival the

Table 3. Plant Growth Data

Treatment	Plant	Growth	Maintenance Time
P1	Kangkung	8,03	21 day
P2	Bayam	7,28	24 day
P3	Selada	3,38	27 day

tilapia is a little stunted.

Plant growth

The results of measuring vegetable growth in this study can be seen in Table 3 below. The growth of P1 has an average growth of 8.03 cm per 5 days, an average growth of 1.61 cm/day and has a total growth of 33.8 cm at harvest. The growth of P2 has an average growth of 7.28 cm/5 days, an average growth of 1.33 cm/day and has a total growth of 32.1 cm at harvest time. The growth of P3 has an average growth of 3.38 cm/5 days, an average growth of 0.64 cm/day and has a total growth of 18.2 cm at harvest. Observation of the weight and height of kale, mustard greens and lettuce experienced growth during the study with the final weight for kale plants being 28.40 g with a plant height of 45 cm, the final weight of mustard greens being 348.00 g with a height of 32 cm. The final weight of the lettuce plant was 212.10 g with a total height of 21 cm. The difference in growth for each vegetable was caused by several factors, namely, root uptake that was not optimal, lack of fertilizer application and differences in plant species. These plants have different harvest periods such as kale which has an ideal of 20-35 days, spinach 20-35 days and lettuce 25-45 days.

Growth in kale and spinach has growth results that are still standard and can be tolerated, while growth in lettuce is not standard or slow because the uptake of lettuce roots cannot optimally grow in wet waters because lettuce roots do not form fibers and bloom. In accordance with research conducted by Jampeetong (2012) the growth rate of kale is 0.025 grams per day. This shows that the growth rate of kale in the study was faster. Plant growth is influenced by various factors, namely the intensity of sunlight, temperature in the root area, ambient temperature, pH, nutrient concentrations, and plant species. This is in accordance with the statement of Nugroho *et al*. (2012), in an aquaponic system the effectiveness of the system is also indicated by the successful growth of aquatic plants.

Plant growth data on days 10-17 decreased because plant roots that settled on the potting media were not submerged to the fullest so that water absorption in vegetable roots was insufficient resulting in slow and wilted plant growth. Statement of Musa et al. (2007), that the density or size of the plant population is very important to obtain optimal results, but there can be competition in nutrients, water and growing space and reduces the development of height and into the roots of plants. The main concern in the recirculation system in aquaponics is the removal of organic and inorganic materials. of the pet fish metabolism. Organic and inorganic materials will enter the media which will be used for aquaponic plant growth as a source of plant nutrition (Putra *et al*., 2011).

Conclusion

From the results of the research that has been done, it was found that the cultivation of tilapia with the aquaponics system with different plants has an influence on the growth of tilapia. The best results were in treatment (P1) which produced temperatures ranging from 27-31°C, pH 7-8, dissolved oxygen 2.3 mg L^{-1}, ammonia 0.098-0.290 mg L^{-1}, and salinity 9.29 ppt, long growth absolute weight of 3.2 cm, absolute weight of 2.1 g, survival of 84%, and growth of kale plants of 8.3 cm.

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