THE COMPARISON OF WATER SPINACH (*Ipomoea aquatica*) DENSITY USING AQUAPONIC SYSTEM TO DECREASE THE CONCENTRATION OF AMMONIA (NH_3), NITRITE (NO_2), NITRATE (NO_3) AND ITS EFFECT ON FEED CONVERSION RATIO AND FEED EFFICIENCY TO INCREASE THE SURVIVAL RATE AND SPECIFIC GROWTH RATE OF AFRICAN CATFISH (*Clarias* sp.) IN INTENSIVE AQUACULTURE

Ayu Oktaviani Putri[1], Okta Yuan Tegar Pamula[1], Yasinta Fakhriah[1], Prayogo[2*], Sudarno[2], Abdul Manan[2], Luthfiana Aprilianita Sari[2] and Nina Nurmalia Dewi[2]
[1]Aquaculture Study Program, Faculty of Fisheries and Marine, Universitas Airlangga
[2]Department of Fish Health Management and Aquaculture, Faculty of Fisheries and Marine, Universitas Airlangga
*prayogo.unair@yahoo.co.id

Abstract

In intensive aquaculture farming activities will generate solid waste and liquid waste that comes from feces and leftover fish feed. The waste accumulation can lead to deterioration of water quality that affects the physiological processes, behavior, growth, and mortality of fish. Technological innovation is needed for the management of water quality and increase productivity as a result of shrinkage of aquaculture land. One of the technological innovations that can be applied is the incorporation of fish farming with crops through the aquaponics system. This study aims to determine the effects of water spinach optimum density to absorb waste ammonia (NH_3), nitrate (NO_3) and nitrite (NO_2) optimally to increase the survival rate and growth rate of African catfish (*Clarias* sp.) in intensive aquaculture as well as to see its effect on conversion rates and feed efficiency with aquaponics system. The method used is the experimental method. The experimental research is used to determine the effect of certain variable towards a group under controlled conditions. The results of measurements of ammonia levels during P0 showed that the treatment significantly different ($p < 0.05$) with treatment P1; P2; and P3. P3 treatment with water spinach number 40 stems provides maximum results in lowering the concentration of ammonia compared with treatment P0 (without spinach), P1 (20 water spinach), and P2 (30 water spinach). The measurement results nitrite levels during the observation showed that all treatments there were no significant differences ($p > 0.05$). The measurement results also showed that the nitrate content whole of observation results showed that all treatments there were no significant differences ($p > 0.05$). The best feed conversion ratio was found in P3 treatment of 1.08. The best feed efficiency was found in P3 treatment of 92,25%. The highest survival rate was found in P3 treatment (88.69%) and lowest survival rate was in P0 treatment (26,71%). The highest specific growth rate was found in P3 treatment (1.15%), while the lowest specific growth rate was in treatment P0 (0.79%). Results of water quality measurement supporting all treatments decreased and increased. The supporting water quality is temperature, pH, and dissolved oxygen. The decrease and increase in support water quality are caused by environmental factors such as weather. Other parameters were observed in addition to supporting the water quality is water spinach plant growth. Value growth water spinach is best found in treatment P3. In the treatment P3, water spinach growth rose 5.14 cm with an initial size of 10.92 into 16.06.

Keywords: Water Spinach, Aquaponic System, Survival Rate, Growth Rate

INTRODUCTION

Catfish is one of the freshwater fish species that contain the source of animal protein and economic value. The need for an animal protein source, especially fishery commodity keeps increasing every year so that there is a need for innovation, so that fishery production keeps increasing. Production of dumbo catfish (*Clarias* sp.) in Indonesia showed a fairly high increase in 2010 amounted to 270,600 tons, 366,000 tons in 2011, 495,000 tons in 2012, and 2013 at 670,000 tons (Directorate General of Aquaculture, 2014).

Aquaculture activities especially intensive cultivation, of course, will generate solid waste and liquid waste that comes from feces and leftover fish feed. The accumulation of such waste can lead to a decrease in water quality that affects physiological processes, behavior, growth, and fish mortality. Fish farming wastes are

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the result of metabolic activities that contain lots of ammonia (Effendi, 2003). Fish emit 80-90% ammonia (inorganic N) through osmoregulation process, whereas from feces and urine, about 10-20% of total nitrogen (Boyd, 1982). The accumulation of ammonia in aquaculture media is one of the causes of water quality degradation, which can fail fish farming production. Therefore, it is necessary to manage water quality on fish maintenance media.

Technological innovation is needed for water quality management and improves productivity due to a decline in cultivated land. One of the technological innovations that can be applied is the combination of fish farming with plants through the system of aquaponics. Aquaponics is a bio-integration that combines aquaculture with vegetables or hydroponic plants with principled recirculation (Diver, 2006). Ionic technology is capable of producing fish optimally on narrow land with limited water sources and can be applied in urban areas.

The selection of commodities for the ionic system plays an important role in planning and getting results following what is desired. According to Pramono (2009), the types of freshwater fish that can be cultivated on the system of taponilla include tilapia, carp, koi, catfish, and prawn. One of the popular fishery commodity in the community is dumbo catfish (*Clarias* sp.). Dumbo catfish key traits among them is the fast growth rate and adaptability to an extreme environment (Khairuman and Amri, 2002). As for plants, the commonly used is water spinach. Water spinach planted in polluted areas will absorb toxic substances contained in the surrounding environment (Nazaruddin, 1999).

The use of water spinach in the aquaponic system can reduce fish nitrogen wastes up to 58% (Setijaningsih, 2009). Under that matter hence researched to know the effect of density of aquaponic system in decreasing ammonia level (NH_3), nitrite (NO_2), and nitrate (NO_3) and its effect on feed conversion ratio and feed efficiency optimally to improve survival rate and intense dumbo catfish growth rate (*Clarias* sp.).

METHODOLOGY

Place and Time

This research was conducted on February 19th - March 19th, 2017. This research was conducted in Wet Laboratory and Dry Laboratory Faculty of Fishery and Marine University Airlangga Surabaya and Laboratory of Indonesian Center for Industry and Trade Research Center (Baristand).

Research Materials

The tools used in the study include 16 aquariums, 12 tray tubs, 16 pumps, 12 hoses, digital scales, nets, rulers, pH meters, thermometers, and DO meters. Materials used to support this research were catfish dumbo with size 4-6 cm as much as 672 fish. Spinach seeds used are seedlings sown first for 2 weeks. Planting media for water spinach was in the form of rock wool and Styrofoam.

Research Design

The experimental design used was completely randomized design. This study used four treatments; each treatment received four replications. The treatment used in this research is the difference of the number of water spinach tested that is P1 = 20 stems, P2 = 30 stems, P3 = 40 stems and for control (P0) not given the treatment of water spinach. Each treatment used 42 Dumbo catfish. The calculation of stocking density is calculated according to Suprapto and Samtafsir (2013) i.e. 400 fish/m^3 to 2400 fish/m^3.

Work Procedures

The aquaponic system is designed by placing a container on a fish pond. The container plants use a tray tub equipped with inlet and outlet channels. The inlet channel directly connects to the pump that pumps the pond water into the plant

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maintenance container. The outlet channel drains water from the plant maintenance container to the aquarium. Water that flows using the principle of recirculation, so that water from the process of cultivation of dumbo catfish that go into the container of plant maintenance will be used as a source of water in the cultivation process.

The research parameters observed during the study were the effect of density of water spinach for decreasing of ammonia; nitrites; and nitrate optimally to improve the survival rate and growth rate of dumbo catfish, as well as supporting water quality (temperature, pH and DO), initial length and the final length of water spinach. Observation of temperature; pH; and DO is performed daily at 4 pm, for ammonia levels; nitrites; nitrate; is done every seven days.

Ammonia measurement used the reference SNI 06-6989. 30-2005. Nitrite measurement used the reference SNI 06-6989. 9-2004, and nitrates used SNI 06-2480-1991.

Data Analysis

The main parameter data obtained were analyzed using SPSS 16.0, which included ANOVA (Analysis of Variance) test, if it is significant, will be tested further using the Tuckey test (Kusriningrum, 2012). Once the results are obtained, the main and supporting parameters data will be presented in graph and tables using Microsoft Excel programs.

RESULTS AND DISCUSSION

Ammonia (NH_3) Level

Ammonia is the result of protein catabolism and decomposition of organic materials such as the remains of feed, feces, and plankton that are killed by bacteria decomposers (Wijaya *et al.,* 2014). Free ammonia (NH_3) is not ionized and is toxic to aquatic biota, whereas NH_4^+ can be used directly by plants as a source of nutrients (EPA, 2013). The result of ammonia measurements during the study is presented in Figure 1.

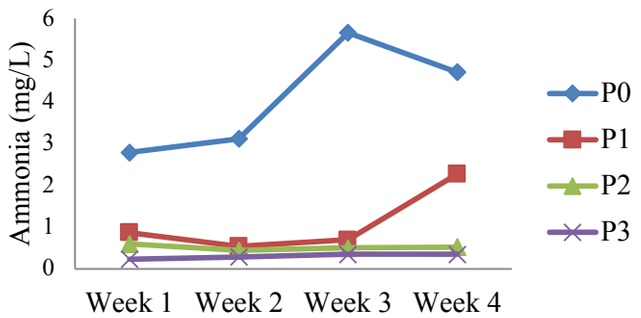

Figure 1. Ammonia concentration.

Measurements of ammonia concentrations during the study showed that P3 treatment with 40 stems of water spinach gave maximum yield in reducing ammonia concentration. In the first week; second; third; and the fourth ammonia at treatment P3 0.23275; 0.29200; 0.34925; And 0.35375 mg/l. The highest ammonia concentration occurred in the last sampling for treatment P1; P2; And P3. This is because the longer the maintenance time, the higher the accumulated concentration of ammonia entrenched.

The ability of water spinach in absorbing ammonia can decrease along with the increase of pests that attack the water spinach and the higher concentration of ammonia (Effendi, 2003). According to Bhatnagar and Devi (2013), the optimum

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ammonia concentration for catfish growth is <0.025 mg/L.

Nitrite (NO_2) Level

Nitrite is the result of the ammonia oxidation process through a nitrification process that takes place under aerobic conditions (Rijn *et al.,* 2006). Nitrite ions can act as a source of nitrogen for plants. Nitrites can be toxic to fish and shrimp because it can oxidize Fe^{2+} in hemoglobin, so the ability of the blood to bind oxygen is feeble (Effendi, 2003). The result of the measurement of the nitrite level is presented in Figure 2.

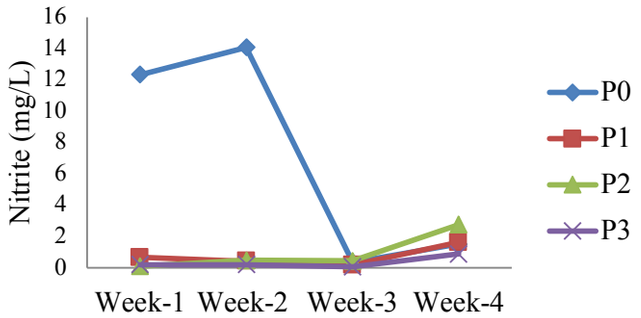

Figure 2. Nitrite concentration.

The measurement of nitrite concentration during the study showed that the treatment of P3 with the number of 40 stems water spinach gave the maximum result. Nitrite concentration in treatment P3 has the lowest value when compared with treatment P0; P1; And P2. In the first week; second; third; and the fourth nitrite level at treatment P3 equal to 0.20400; 0.20675; 0.06450; And 0.889150 mg/l.

Nitrite levels obtained during the study showed that the nitrite present in the aquaculture pond is not yet feasible for the life of some aquatic organisms that cannot tolerate adverse environmental conditions. According to Effendi (2003), nitrite content in waters should be no more than 0.05 mg/L, and if nitrate levels exceed 0.05 mg/L, it would be toxic to some aquatic organisms. The accumulation of nitrite in waters occurs due to high feeding and inefficient biological filters (Hookins *et al.,* 1994).

Nitrate (NO_3) Level

Nitrate is the main form of nitrogen compounds in the waters and is a nutrient for the growth of plants and algae in water (Effendi, 2003). The nitrification process by nitrifying bacteria converts about 93-96% of ammonia to nitrate under optimal conditions in the biofiltration unit (Tyson, 2007). The result of the measurement of nitrate level is presented in Figure 3.

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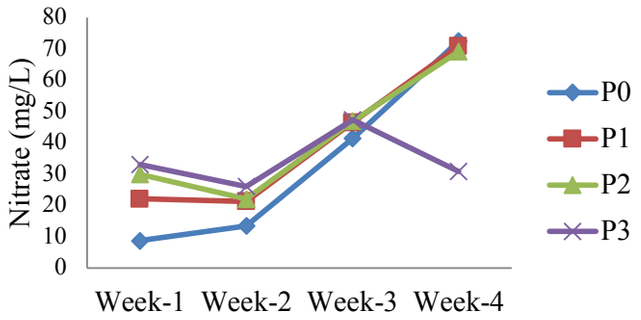

Figure 3. Nitrate concentration.

Measurement of nitrate content during the study showed that P3 treatment tended to experience a fluctuating change. In the first, second, third, and fourth week the nitrate level at treatment P3 equal to 33.06950; 26.03725; 47.3325; And 30.898 mg/l. The value of nitrate content during observation is still said to be optimum because the nitrate content does not exceed the threshold. This follows Pillay (2004) statement that the recommended nitrate concentration should be less than 100 mg/L.

Feed Conversion Ratio

Feed is a major factor affecting the growth of dumbo catfish. The amount of feed consumed will change the feed conversion ratio. The value of feed conversion ratio at treatment P0 was 3.43, at treatment P1 was 1.135, at treatment P2 was 1.175, and at treatment P3 was 1.08. The lowest feed conversion ratio on P3 treatment. The lower feed conversion ratio is better the quality of feed and more efficient in using the feed consumed for growth (Mudjiman, 2002). The result of feed conversion ratio is presented in Figure 4.

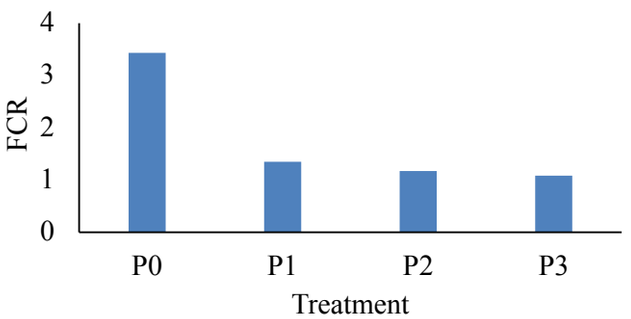

Figure 4. Feed conversion ratio.

Feed Efficiency

The value of feed efficiency at treatment P0 is 30%, at treatment P1 is 74%, at treatment P2 is 85.25%, and at treatment, P3 is 92.25%. Highest feed efficiency value in P3 treatment. Feed efficiency result is presented in Figure 5.

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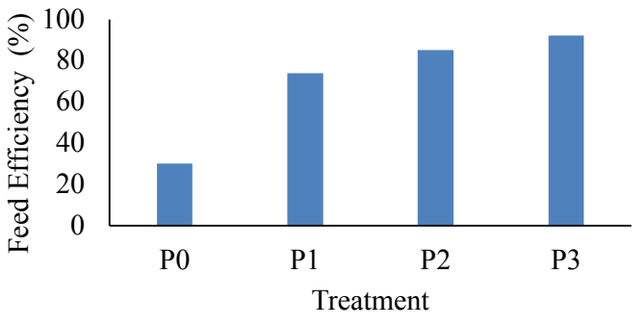

Figure 5. Feed efficiency.

Survival Rate

The survival rate is one of the parameters that can support the success of cultivation that is influenced by various factors, one of which is water quality. The results of fish survival rate can be seen in Table 1.

Table 1. Survival rate of dumbo catfish.

Treatment	Survival Rate ± SD
P0	26.71±17.19[a]
P1	75.59±10.71[b]
P2	80.95±8.47[b]
P3	88.69±3.57[b]

Note :Different letters in one column showed a significant difference among treatments ($p<0.05$)

The Analysis of Variance (ANOVA) calculation showed that the density of different water spinach in the aquaponic system significantly affects the survival rate of catfish ($p <0.05$). The Duncan Multiple Range Test showed significantly different results between treatment P0 and P1, P2, and P3. The highest survival rate was found in P3 treatment (88.69%) in maintenance media, and the lowest survival rate was in P0 (26.71%) without water spinach (control).

Specific Growth Rate

Specific growth rates serve to calculate the weight percentage of fish each day (Aggraeni and Abdulgani, 2013). The results of fish survival rate can be seen in Table 2.

Table 2. Specific growth rate of dumbo catfish.

Treatment	Specific Growth Rate ± SD
P0	0.79 ±0.28[a]
P1	1.00 ± 0.12[ab]
P2	1.12 ± 0.10[b]
P3	1.15 ± 0.05[b]

Note :Different letters in one column showed significant difference among treatments ($p<0.05$)

In Table 2, it can be seen that the specific growth rate of dumbo catfish showed significantly different value ($p <0,05$) between treatment P2 and P3 compared to P0 (control). The highest specific growth rate was found in P3 (1.15%), while the lowest specific growth rate was in P0 (0.79%).

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Water Spinach (*Ipomoea aquatica*) Growth

Measurement of water spinach was done by measuring from the base of the stem to the end of the leaf by using a ruler. The result of water spinach measurement is presented in Figure 6.

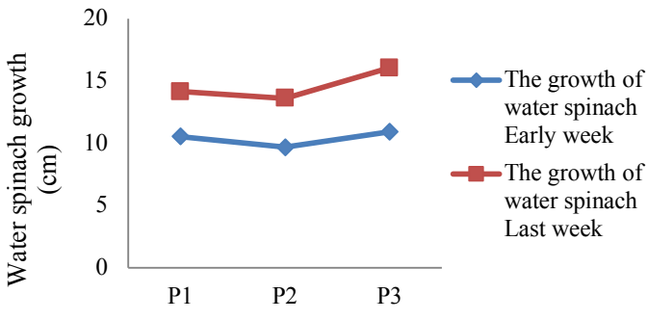

Figure 6. Water spinach growth.

During the observation, the growth of water spinach has increased significantly. The best growth value of water spinach is found in P3 treatment. Based on the results of water spinach measurement at the beginning and end of the study showed to be optimal. The process of absorption of organic matter by plants takes place through the roots. Plant roots require enough oxygen for respiration so that the absorption of nutrients can be optimum (Ginting and Rakia, 2008). Nitrate in plants serves as the main fertilizer or nutrient for plant growth to be converted into protein (Saptarini, 2010).

Temperature

Temperature is a factor that affects the growth of fish and plants and the process of decomposition of organic matter. Water temperature measurement result is presented in Figure 7.

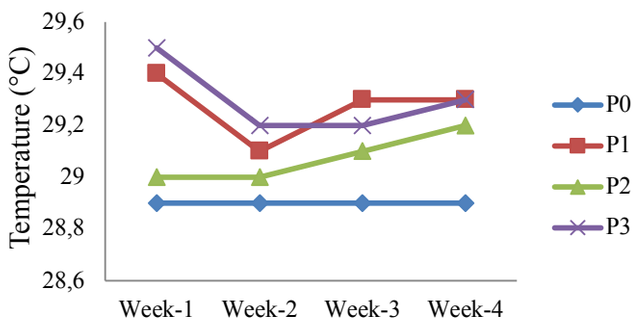

Figure 7. Water temperature measurement.

The observed water temperature at P3 treatment during observation showed a constant value. Observed temperature values during the study can be said optimum for the growth of dumbo catfish. This is following the statement of Boyd and Licht-koppler (1979) which explains that the optimum temperature for the growth of catfish is 25-32 °C. Temperature obtained during the observation is also the optimum temperature for the growth of water spinach. This is in accordance with the statement of Indah *et al.* (2014) which explains that the optimum temperature for water spinach growth ranges from 25-30 °C.

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Degree of acidity/pH

The pH value describes the number of hydrogen ions in water. The degree of acidity/pH may affect the toxicity of a chemical compound, the ionizable ammonium compound found in waters having a low pH. The result of the measurement of pH is shown in Figure 8.

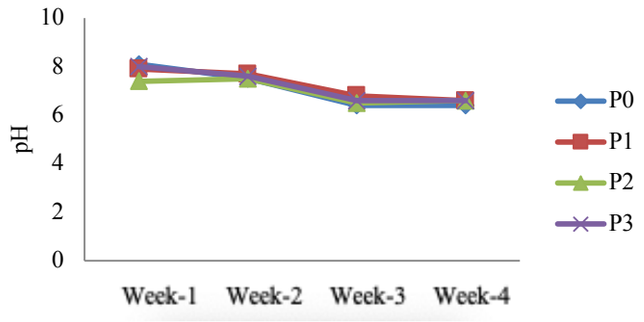

Figure 8. pH measurement.

The pH measurement results obtained during the observations showed that the pH value of each week decreased in all treatments. Decreased pH per week occurs along with ammonia and environmental temperatures (Boyd, 1991). When high pH is more found ammonia that is not ionized and toxic (Widyastuti, 2008). The pH value during observation showed that the pH was still at optimum level. This follows Kordi and Tancung (2007) revelation that the good pH value for fish culture was 6,5-9,0.

Dissolved Oxygen

Dissolved oxygen is a crucial factor in the ecosystem because it is needed for the process of respiration for aquatic organisms (Effendi, 2003). The results of the dissolved oxygen measurement is presented in Figure 9.

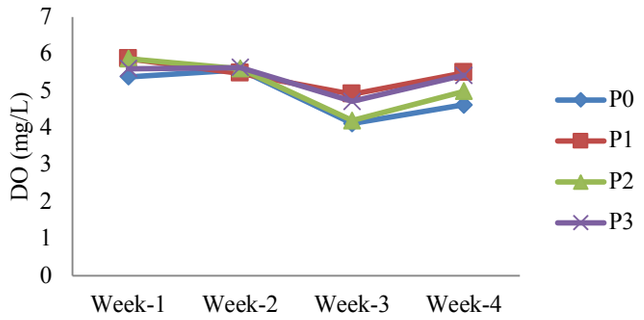

Figure 9. pH measurement.

The results of the observation of dissolved oxygen during the study showed fluctuating results. Based on observations of dissolved oxygen levels for plants, it is in a healthy level.

CONCLUSION

Based on the results of the above research, it can be concluded that the density of water spinach affects the optimal decrease of ammonia, nitrite, and nitrate con-centration to improve survival rate, growth rate, and feed conversion ratio of dumbo catfish (*Clarias* sp.).

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