Asian Journal of Fisheries and Aquatic Research

7(2): 10-19, 2020; Article no.AJFAR.57290
ISSN: 2582-3760

The Potential Effect of Using Fine Bubbles on the Growth Rate of Striped Catfish (*Pangasianodon hypopthalmus*) Fingerlings with Different Stocking Densities in Aquaponic Systems

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Authors' contributions

This work was carried out in collaboration among all authors. Author DAP designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors ZH, HH and US managed the analyses of the study. Author AAA managed the literature searches. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AJFAR/2020/v7i230112
Editor(s):
(1) Dr. Rakpong Petkam, Khon Kaen University, Thailand.
Reviewers:
(1) Dacley Hertes Neu, Universidade Federal da Grande Dourados, Brazil.
(2) Heba Salah Hamed, Ain Shams University, Egypt.
(3) Dediu Lorena, University Dunarea de Jos Galati, Romania.
Complete Peer review History: http://www.sdiarticle4.com/review-history/57290

Original Research Article

Received 10 April 2020
Accepted 16 June 2020
Published 30 June 2020

ABSTRACT

Aquaponic is a combination of aquaculture and hydroponic systems. To increase fish production, aquaponic system can be used as an option because it can increase fish production with high density in limited land and water. The problem that often occurs in fish farming with high or intensive stocking densities is a decrease in dissolved oxygen concentration due to high oxygen consumption requirements. Handling that can be done to maintain the availability of dissolved oxygen concentration is by adding aeration by using Fine Bubbles (FBs). This research was conducted in October - December 2019 at the Green House Ciparanje Land Aquaculture Area, Faculty of Fisheries and Marine Sciences, UNPAD. The purpose of this research is to increase the growth of striped catfish with optimal density using the application of Fine Bubbles (FBs) and to improve the water quality of rearing media and plant productivity in aquaponic system. The

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research method used is an experimental method with randomized block design (RBD) consisting of four treatments and three repetitions. The treatment in this study is the spread of 375 striped catfish/150L, 450 striped catfish/150L, 525 striped catfish/150L and 600 striped catfish/150L. The parameters observed included specific growth rate (SGR), feed conversion ratio (FCR), fish survival (SR), water quality and plant growth. During the research, two harvests of water spinach were harvested in one cycle of fish rearing. The results show that the use of aquaponic systems and the addition of aerated FBs can increase the stocking density of striped catfish fingerlings to 600 striped catfish/150 L, with a high fish survival rate of 98% at a specific growth rate of 4.41 g and a feed conversion ratio of 1.00 g. The results of water quality observations for pH and DO parameters still meet the requirements but for temperature and ammonia, it has exceeded the safe threshold based on SNI (2000). The result of observation of water spinach plants, that the highest productivity in both harvests was in treatment C (525 striped catfish/ 150 L) up to 197.44 g, final plant height 44.54-47.10 cm and for the number of final leaves ranging from 9-10 leaves.

Keywords: Aquaculture; hydroponics; intensive; inorganic nitrogen; aquatic plants.

1. INTRODUCTION

Striped catfish (*Pangasius hypophthalmus*) is a freshwater fish that has some economic interests namely fast, can be easily cultivated and maintained with low oxygen reserves [1]. The catfish commodity has been domesticated and cultivated semi-intensively and intensively with high stocking density and minimal water use [2].

To increase fish production, the aquaponic system is one of the systems that can be used as an intensive cultivation system. Aquaponics is a combination of aquaculture system and hydroponic plant cultivation. In this system, fish and plants grow in one integrated system, and create a symbiotic relationship between the two [3]. The principle of aquaponics is to make continuous use of water from the rearing of fish to plants and vice versa from plants to fish ponds. Aquaponic systems use high-density aquaculture techniques in confined spaces, as well as controlled environmental conditions to increase fish production in limited land and water [4].

The success rate of intensive cultivation is greatly influenced by the ability of farmers to cope with water quality, one of which is the decrease in dissolved oxygen [5]. Dissolved oxygen is a major limiting factor in intensive cultivation system. Lack of oxygen can harm aquatic animals because it can cause stress, vulnerability to diseases, inhibit growth and even cause death [6]. Handling done to maintain the concentration of dissolved oxygen is the addition of aeration.

Aeration serves to dissolve oxygen into water to increase the concentration of dissolved oxygen (DO) to reduce gas saturation and heavy metal concentrations [7]. Aeration that is suitable for use in fish culture media with high stocking densities include Fine Bubble (FBs). Fine Bubble (FBs) is a technology that can produce small bubbles that are nano and micro sized with a diameter of 200 nanometers to 100 micrometers in water [8]. The application of Fine Bubbles (FBs) has some positive effects on aquaculture activities such as fish grow much faster, fish are not susceptible to disease and maintain good water quality even though in a closed pond system as the principle of continuously circulated water is applied [9].

This research aims to increase the growth of striped catfish with optimal density using the application of Fine Bubbles (FBs) as well as improving the water quality of media rearing and productivity of plants in the aquaponic system.

2. MATERIALS AND METHODS

2.1 Research Location

This research was conducted in October to December 2019 at the Green House Ciparanje Faculty of Fisheries and Marine Sciences, Padjadjaran University, Jatinangor while water quality testing was conducted at the Laboratory of Aquatic Resources Management at the Faculty of Fisheries and Marine Sciences, Padjadjaran University.

2.2 Equipment and Material

The equipment used during this research are 3 Fine Bubbles Generators (FBs). The pressure used is 5.5 atm and the flow rate is 0.3 L/min. Fiber container used is 16 units with a size of 70 cm x 70 cm x 30 cm. Pumps used are 16 units.

4-inch PVC pipe is used as a place of plants rearing and water as a source of plant nutrients. Four inches, ¾ inches, ½ inches PVC pipes, ½ L pipes, s½ inches shokdrat pipe and 4 inches DOV are used. As many as 228 pieces of plastic cups are used. Digital scales with 0.01 gram accuracy, thermometer, pH meter, filter paper, funnel, 500 ml erlenmeyer tube, 25 ml measuring cup, spectrophotometer, stationery are used.

The material used is nursery size II (PII) striped catfish which is 1-2 inches as many as 6450 fishes and the fish feed used is the Prima Feed (PF) 1000 with a size of 1.3-1.7 mm, with nutritional value, namely min protein 39-41%, min fat 5%, crude fiber max 6%, ash max 16%, and water content 10%. Aquatic plants used are land spinach as many as 228 stems and plant growth media used is husk charcoal. Test solutions used were $MnSO_4$, siegnet, nesler, O_2-reagent, sulfuric acid, sodium thiosulfate and distilled water.

This study uses an experimental method with randomized group design with four treatments and three repetitions (Fig. 1). The treatment used is different stocking densities of fish with each treatment, namely:

1. Treatment A: FBs with stocking density of 375 fish / 150 L
2. Treatment B (Control): without FBs with 450 fish / 150L stocking density
3. Treatment C: FBs with 525 fish / 150 L stocking density
4. Treatment D: FBs with 600 fish / 150 L stocking density

2.3 Fish and Plant Rearing

The rearing of fish during the study is carried out for 35 days. Fish are fed twice a day using 1000 Commercial Prima Feed (PF). Feeding is carried out in the morning at 09.00 and in the afternoon at 15.00 WIB. Feeding is done by counting 10% of the number of fish each time and being given 5% feed by these weights. Rearing of plants is done by diverting the flow of water into the plant growing media. Harvesting of plants is done twice during the study for one fish harvest.

2.4 Sampling and Observation

Water samples are taken every seven days during the research. Water sampling for testing ammonia and dissolved oxygen (DO) is done by putting 300 mL of water into a bottle. Water samples tested were water in fish rearing tanks. Water samples were taken to the FPIK Unpad Aquatic Resources Management laboratory. Measurement of temperature and pH is done in situ by dipping the tip of the tool on the surface of the water. Measurements were made three times at different points.

The observation of fish growth is done by sampling that is done every seven days. The number of fish taken randomly is 10% of the total fish population. The fish is weighed and then measured in length. The observation of plant growth is done by sampling which is done every seven days. The number of plants observed was seven plants in each treatment. Plants were measured in height and weight then counted the number of leaves.

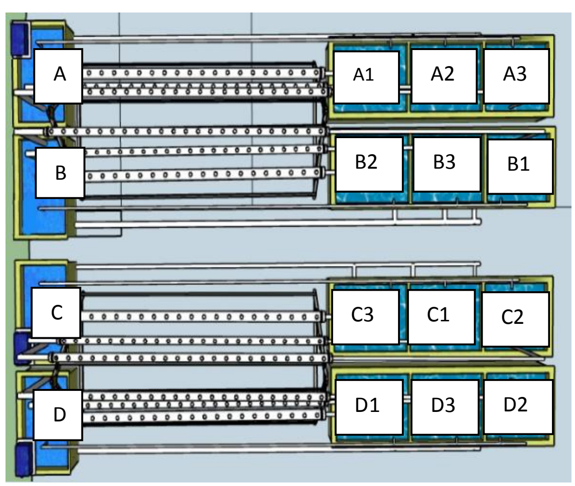

Fig. 1. Layout of FBs experiment in aquaponics

2.5 Research Parameter

The parameters observed in this study include fish growth, feed conversion ratio, survival rates, water quality and plant growth.

2.5.1 Specific Growth Rate (SGR)

The observation of growth can be calculated using the calculation method [10] as follows:

$$SGR = \frac{(\ln Wt - \ln Wo)}{t} x100\%$$

Information:

SGR = Specific growth rate (%/fish)
Wt = Average fish weight of the final test of the study (g/fish)
Wo = Average initial fish test weight (g/fish)
t = length of fish rearing (days)

2.5.2 Feed Conversion Ratio (FCR)

The observation of feed conversion ratio or food convertion ratio (FCR) is calculated based on the formula [11] as follows:

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

Information:

FCR = Feed conversion ratio.
F = Amount of feed consumed (grams)
Wt =Weight of fish at the end of the study (gram)
Wo = initial fish weight (gram)
D = Weight of dead fish (grams)

2.5.3 Survival rate

The observation of fish survival can be calculated using the formula [12] as follows:

$$SR = \frac{Nt}{No} X100\%$$

Information:

SR = Survival rate (%)
Nt = Number of individuals at the end of the study (fish)
No = Number of individuals at the beginning of the study (fish).

2.5.4 Water quality

The measurement of water physics-chemical factors is done to determine water quality as a rearing medium during the study. The physics-chemical parameters of water are observed once a week which include measurements of temperature, pH, DO, and ammonia. The measurement of dissolved oxygen concentration (DO) is carried out using the titration method. The degree of acidity of the pH is measured using a pH-meter. Temperature is measured using a thermometer, and ammonia is measured using a spectrophotometer. The analyzed water samples are taken from fish rearing containers.

2.5.5 Plants growth

Plant growth is measured by measuring the height using a ruler, measuring the weight of the plant using the scales and counting the number of leaves manually by counting the leaves one by one. The measurement of plant height and number of leaves is measured once a week while the measurement of weight gain is measured at the beginning of the study and the end of the study.

2.6 Data Analysis

Specific growth rate data, feed conversion ratio and catfish fingerlings survival were analyzed by variance test (ANOVA) with a reliability level of 95%. If the results of the analysis of variance obtained significantly different effect ($P < 0.05$), then proceed with Duncan's multiple distance analysis with a reliability level of 95%. Water quality parameter data (physical and chemical) were analyzed using the comparative descriptive method with SNI 01-6483.3-2000 about the water quality of striped catfish fingerlings culture media while plant observation data were analyzed by the descriptive method by describing the condition of the plants during the study.

3. RESULTS AND DISCUSSION

3.1 Fish Growth

3.1.1 Specific growth rate (SGR)

The data of the average of striped catfish fingerlings specific growth rate can be seen in Table 1.

Table 1. Specific Growth Rate (SGR) of striped catfish

Repetition	Treatment (Fish/150L)			
	A (375)	**B (450)**	**C (525)**	**D (600)**
1	3,95	3,61	3,47	4,10
2	3,66	4,16	3,57	4,37
3	4,53	3,63	4,59	4,75
Average ± DS	4,05 ± 0,44	3,80 ± 0,31	3,88 ± 0,62	4,41 ± 0,33

**DS: Deviation Standard*

The value of the specific growth rate of fish during the study ranges from 3.80-4.41%. The results of the analysis of variance showed no significant difference (P> 0.05). The effect of different stocking densities on striped catfish fingerlings is specific growth rate values that are not significantly different among the treatments because of the good carrying capacity of the environment. This is in line with Effendi's statement [11], fish growth is influenced by two factors namely internal and external factors. Common factors are heredity including sex and age. External factors include water quality (pH, DO, temperature, ammonia, and salinity) as well as parasites and diseases. So, it can be concluded that the best stocking treatment for fish growth is treatment A to D using fish stocking densities of 375 - 600 fish/150 L because there is no significant difference.

3.1.2 Feed conversion ratio (FCR)

The data of the average of striped catfish fingerlings feed conversion ratio can be seen in Table 2.

The value of the conversion ratio of fish feed during research ranges from 1.00 to 1.23 g. The results of the analysis of variance show no significant difference (P> 0.05). The use of aquaponic system and coupled with the use of fine bubbles (FBs) applications can support the oxygen demand of fish with high density thereby increasing appetite in fish. This is due to good environmental conditions in each treatment so that the feed conversion ratio tends to be the same. In addition, the value of the ratio of feed conversion that tends to be the same is caused by the striped catfish fingerlings used. The fingerlings originate from one parent and an adequate level of feeding. So, it can be concluded that the best stocking density treatment for fish feed conversion ratio is A to D treatment using 375-600 fish/150 L. stocking density.

3.1.3 Survival rate (SR)

The data of the average of striped catfish fingerlings survival rate can be seen in Table 3.

Table 2. Feed conversion ratio (FCR) of striped catfish

Repetition	Treatment (Fish/150 L)			
	A (375)	**B (450)**	**C (525)**	**D (600)**
1	1,10	1,20	1,30	1,10
2	1,30	1,10	1,30	1,00
3	1,00	1,40	0,90	0,90
Average ± DS	1,13 ± 0,15	1,23 ± 0,15	1,17 ± 0,23	1,00 ± 0,10

**DS : Deviation Standard*

Table 3. Fish survival rate (SR) of Striped catfish

Repetition	Treatments (Fish/150 L)			
	A (375)	**B (450)**	**C (525)**	**D (600)**
1	98,93	97,56	99,05	99,17
2	99,47	98,89	98,67	96,50
3	96,53	99,56	99,43	98,33
Average ± DS	98,31 ± 1,56	98,67 ± 1,02	99,05 ± 0,38	98,00 ± 1,37

**DS : Deviation Standard*

The survival value of fish during the research ranges from 98.00% - 99.05%. The results of analysis of variance show no significant difference (P> 0.05). The effect of different stocking densities on striped catfish fingerlings results in survival values that are not significantly different among the treatments because during fish rearing, an aquaponic system is used and added with fine bubbles (FBs) applications that can support fish life and produce high survival values. This is in line with the statement of Kordi and Tanjung [6], the carrying capacity or the quality of the environment have a significant effect on the lives of aquatic biota which is manifested in health, growth, and survival. The dense conditions in the pond caused by high stocking densities, significantly affect the growth, survival and health of biota. So it can be concluded that the best stocking solid treatment for fish survival is treatment A to D which uses a stocking density of 375-600 fish / 150 L.

3.2 Water Quality

Water quality parameters observed include physical and chemical parameters. Physical parameter is temperature while chemical parameters include pH, dissolved oxygen (DO), and ammonia. Data on temperature, pH, DO and ammonia measurements during the research can be seen in Table 4.

Based on measurements in situ, the temperature obtained during the research ranges from 23°C-28.5°C. The ideal temperature range for the rearing of Siamese catfish seedlings in accordance with SNI 01-6483.3 (2000) is between 25°C-30°C. The temperature range during the research fluctuates and has already exceeded the safe threshold for maintaining ideal striped catfish fingerlings. This happens because when the research takes place, there is a rainy season. The phenomenon of increasing and decreasing water temperature during this research is in accordance with Gusrina's statement [13], that water temperature at waters temperature can be affected by seasonality, latitude, altitude, time of day, cloud cover, flow and water depth.

The pH value in the fish rearing tank range between 6.84-7.34. The pH value in fish rearing tanks is good for the survival of Striped catfish fingerlings. This is in accordance with SNI [14] that the ideal pH range for growth of striped catfish fingerlings is 5.5-8.5. The pH value will affect the value of inorganic nitrogen such as free ammonia measured during base pH studies which will increase toxicity in waters [15]. The ability of plants to absorb ammonium ions helps reduce the value of free ammonia that occurs in water so that the pH value is stable and optimal for fish farming activities [16].

The concentration of dissolved oxygen during the research fluctuates, ranging from 5.73-7.06 mg/L. This condition is still within normal limit for growth of striped catfish fingerlings. The minimum concentration of dissolved oxygen in the rearing of striped catfish fingerlings is > 4 mg/L [14]. The difference in dissolved oxygen concentration that occurrs during the study is influenced by the density of dispersion in each treatment. Differences in stocking densities in each treatment cause differences in dissolved oxygen demand and competitiveness by fish. This is in line with the statement of Kordi and Tanjung [6], stocking density has a significant effect on the decrease in water quality because in addition to the large amount of residual metabolism, also the accumulation of leftover feed at the bottom of the pond and the amount of oxygen decreases in line with consumption needs due to the density of the biota in the pond.

Ammonia concentrations in fish rearing tanks fluctuate during research. The results of measurements of ammonia concentrations during the study range from 0.001 to 0.0027 mg/L. The ammonia concentration shows a value that has exceeded the safe threshold based on SNI [14], that for the range of ammonia concentration in Striped catfish fingerlings is less than 0.02 mg/L. High and low concentrations of ammonia in fish rearing ponds is influenced by the results of fish metabolism and the process of nitrification by bacteria. This is in line with Effendi's statement [17], that the increased need for feed by fish can cause metabolite discharges to increase then a buildup of feces, then supported by Affandi's statement [18] through the process of nitritification, ammonia will be oxidized by bacteria into nitrites and nitrates.

3.3 Plants Growth

3.3.1 Plants height

In observing plant height during research, there are two harvests of water spinach. Growth in plant height during research can be seen in Table 5.

Table 4. Water Quality parameters in the fish rearing units

Treatment (Fish/150L)	Temperature (SNI 2000 25-30°C)	pH(SNI 2000 5,5-8,5)	DO(SNI 2000 >4 mg/L)	Amonia(SNI 2000 <0,02 mg/L)
A (375)	23,5-26,83	6,99-7,33	6,17-7,06	0,001-0,017
B (450)	23-26,5	6,92-7,34	5,73-6,17	0,004-0,021
C (525)	24-28,5	6,89-7,30	5,84-6,93	0,003-0,025
D (600)	24-28,17	6,84-7,30	5,73-7,03	0,004-0,027

Table 5. Water spinach height in harvest during research

Treatment (Fish/150L)	Week					
	0		1		2	
	Harvest 1 (cm)	Harvest 2 (cm)	Harvest 1 (cm)	Harvest 2 (cm)	Harvest 1 (cm)	Harvest 2 (cm)
A (375)	23,55	15,8	26,38	26,5	48,67	50,07
B (450)	21,64	16,96	26	25,05	46,41	45,95
C (525)	21,62	13,99	26,12	25,71	47,10	44,54
D (600)	17,06	19,5	24,86	26,49	42,33	48,25

Based on the results of analysis of variance for both harvests, the first harvest show no significant difference (P> 0.05) while for the second harvest showed a significant difference in height of spinach plants on fish stocking densities in each treatment (P <0.05).

In the first harvest, water spinach plants have initial plant height ranging from 17.06 to 23.55 cm. After two weeks of rearing, the final height of the plants ranges from 42.33-48.67 cm. The use of treatments with different stocking densities give no significant effect on the height of water spinach plants in each treatment in the first harvest. So, it can be concluded that the best stocking density treatment for height increase of water spinach plants is treatment A to D that use a fish stocking density of 375 - 600 fish/150 L.

In the second harvest, the water spinach plant has an initial height ranging from 13.99 - 16.96 cm. After two weeks of rearing the plant's height is 44.54 - 50.07 cm. The use of treatment with different stocking densities gives a real influence on the height increase of water spinach plants. Based on this, further tests are conducted with Duncan's multiple range test. The results of the Duncan water spinach plant height test show that treatment D is significantly different from treatment A but not significantly different from treatment B and C. Treatment B is significantly different from treatment A but not significantly different from treatment D and C. Treatment C is not significantly different from treatment D, B and A. Treatment A is significantly different from treatment D and B but it is not significantly different from treatment C. So, it can be concluded that the best stocking density treatment for increasing height of water spinach plants is treatment A and C that use fish stocking densities 375 and 525 fish/150 L. This is thought to occur due to the process of nitrification by bacteria that runs optimally in the treatment so that the nutrient intake in plants is well fulfilled for the growth process. This is in line with the statement of Siswadi and Teguh [19], who stated that there are 3 important things that affect stem growth, namely the presence of light, growth regulators and nutrients.

3.3.2 Plants weight

In observing the weight of water spinach, there are two harvests. Water spinach plant weight is used to determine the productivity of water spinach during research. Plant weight gain during research can be seen in Table 6.

Table 6. Water spinach weight in harvest during research

Treatment (Fish/150 L)	Harvest 1 (g)	Harvest 2(g)	Total(g)
A (375)	84,59	49,31	133,90
B (450)	130,90	31,26	162,16
C (525)	130,33	67,10	197,44
D (600)	60,96	80,04	141,00

The results of the analysis of variance for the two harvests show that there are significant differences in the weight of water spinach plants on fish stocking densities in each treatment (P <0.05).

In the first harvest, the use of different stocking densities gives a significant effect on the weight gain of spinach plants. Based on this, further tests are conducted with Duncan's multiple range test. The results of the Duncan water spinach plant weight test show that treatment D is significantly different from treatments C and B but not significantly different from treatment A. Treatment A is significantly different from treatment C and B but not significantly different from treatment D. Treatment C is significantly different from treatment D and A but not significantly different from treatment B. Treatment B is significantly different from treatment D and A but it is not significantly different from treatment C. So, it can be concluded that the best stocking density treatment for water spinach plant weight is treatment B and C that use solid stocking of 450 and 525 fish/150 L.

In the second harvest, the use of treatments with different stocking densities has a significant effect on the weight gain of spinach plants. Based on this, further tests are conducted with Duncan's multiple range test. The results of the Duncan water spinach plant weight test show that treatment B is significantly different from treatments C and D but not significantly different from treatment A. Treatment A is significantly different from treatment D but not significantly different from treatment B and C. Treatment C is significantly different from treatment B but not significantly different from treatment A and D. Treatment D is significantly different from treatment B and A but not significantly different from treatment C. So, it can be concluded that the best stocking density treatment for water spinach plant weight is treatment C and D which use stocking density 525 fish and 600 fish/150 L.

The productivity of water spinach plants for the first harvest ranges from 60.96 g - 130.90 g and in the second harvest, it ranges from 49.31 g - 80.04 g. Water spinach plant productivity in general has decreased, this can be seen from the comparison of the first harvest and second harvest. In the first harvest the highest productivity of spinach plants is in treatment B with a weight of 130.90 g and C with a weight of 130.33 g, while the lowest productivity of water spinach plants is in treatment D with a weight of 60.96 g. In the second harvest, the highest productivity of spinach plants is in treatment D with a weight of 80.04 g and C with a weight of 67.10 g, while the lowest productivity of water spinach plants is in treatment B with a weight of 31.26 g. The difference in productivity in the first and second harvests during the research is due to the season, in the rearing for the second harvest, rain often occurs at the research location which causes less optimal sunlight to enter the plants so that the photosynthesis process does not work well for growth.

The highest productivity of water spinach during research seen from the accumulation of the first and second harvests is in treatment C, namely 197.44 g with the first harvest of 130.33 g and the second harvest of 67.10 g. The high amount of water spinach plant productivity in treatment C is due to the good nutrient absorption from fish metabolism with a density of 525 tails/150 L. Besides, the spinach plants in treatment C is the best plant to survive until harvest time compared to water spinach plants in other treatments so that it has a higher average productivity.

3.3.3 The number of leaves

In observing the number of leaves during the research, there are two harvests of water spinach. The number of leaves increased during the research can be seen in Table 7.

Table 7. The Number of water spinach in harvest during research

Treatment (Fish/150L)	Week					
	0		1		2	
	Harves 1 (Leaf)	Harvest 2 (Leaf)	Harvest 1 (Leaf)	Harvest 2 (Leaf)	Harvest 1 (Leaf)	Harvest 2 (Leaf)
A (375)	4	2	6	6	8	8
B (450)	4	2	6	6	9	9
C (525)	4	2	6	6	10	9
D (600)	4	2	6	6	8	10

Based on the results of the analysis of variance for the two harvests, the first harvest shows a significant difference ($P < 0.05$) while for the second harvest there is no significant difference ($P > 0.05$).

In the first harvest, water spinach plants have an initial number of 4 leaves. At the end of the observation the number of water spinach leaves range from 8 to 10 leaves. The use of different stocking densities has a significant effect on increasing the number of leaves of water spinach plants. Based on this, further tests are conducted with Duncan's multiple range test. The results of Duncan test number of leaves of water spinach plant show that treatment D is significantly different from treatments B and C but not significantly different from treatment A. Treatment A is significantly different from treatment B and C but not significantly different from treatment D. Treatment B is significantly different from treatment D and A but not significantly different from treatment C. Treatment C is significantly different from treatment D and A but not significantly different from treatment B. So, it can be concluded that the best stocking solid treatment for increasing the number of leaves of water spinach plants namely treatment B and C that use stocking densities of 450 and 525 fish/150 L.

In the second harvest, water spinach plants have an initial number of 2 leaves. At the end of the observation, the number of water spinach leaves ranges from 8 to 10 leaves. The use of treatment with different stocking densities gives no significant effect on increasing the number of leaves of water spinach in each treatment. So, it can be concluded that the best stocking treatment for increasing the number of water spinach leaves is A to D using fish stocking densities 375 - 600 fish / 150 L.

4. CONCLUSION

Based on the research that has been conducted, it can be concluded that the use of aquaponic systems and the use of aeration of Fine Bubbles (FBs) can increase the stocking density of Striped catfish fingerlings to 600 fish/150 L, with a high fish survival of 98%, a specific growth rate of 4.41 g and a feed conversion ratio of 1.00%. The results of water quality observations for pH and DO parameters still meet the requirement but for temperature and ammonia, it has exceeded the safe threshold based on SNI (2000), with temperature parameters ranging from 23-28.5°C, pH 6.84-7.34, DO 5, 73-7.06 mg/L and ammonia 0.001-0.027 mg/L. The result of observation of water spinach plants, the highest productivity in both harvests is in treatment C (525 fish/150 L) up to 197.44 g, final plant height 44.54-47.10 cm and for the number of final leaves ranging from 9-10 leaves.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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