DEPIK
Jurnal Ilmu-Ilmu Perairan, Pesisir dan Perikanan
Journal homepage: www.jurnal.unsyiah.ac.id/depik

The growth performance of common carp (*Cyprinus carpio*) co-cultured with different vegetable plants in aquaponics system

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ARTICLE INFO

Keywords:
Aquaponics
Common Carp
Vegetable Plants

DOI: 10.13170/depik.10.1.19467

ABSTRACT

A 28-days trial was conducted in an aquaponics culture system to determine the effect of the different vegetable plants application on the growth performance and survival rate of common carp *(Cyprinus carpio)*. Common carp seeds were obtained from local fish farmers in Aceh Besar District. A total of 360 common carp fingerlings (size 3-5 cm) were used and placed in 12 containers with the capacity of 80 L each. The study used four treatments, namely A (control), *B Kale (Ipomoea aquatica), C Lettuce (Lactuca sativa), and D Pakcoy (Brassica rapa subsp. chinensis)*, with three replications for each treatment. The result showed that different vegetable plants' applications significantly affected ($P < 0.05$) the absolute weight gain, absolute length gain, and survival rate of common carp fingerlings. The highest value obtained was in treatment *B (Ipomoea aquatic)* with an absolute weight gain of 3.93 ± 0.28 g, absolute length gain of 3.81 ± 0.21 cm, and survival rate of $100 \pm 0.0\%$, while the lowest was in treatment A (control) with an absolute weight gain of 1.21 ± 0.76 g, absolute length gain of 1.70 ± 0.10 cm and survival rate of $91 \pm 0.86\%$. Water quality was also collected in this study and the parameters during rearing were still within the tolerance limits of common carp rearing. Therefore, it can be concluded that the Kale plant, *Ipomoea aquatica* is the most recommended vegetable plant to be co-cultured with common carp in the aquaponics system.

Introduction

Common carp (*Cyprinus carpio*) is originating from China, Taiwan, and Europe and began to be maintained in Indonesia around 1920. Until now, Common carp have been widespread in Indonesia and also known has economic value. A report by Pratama and Awalludin (2013) stated that common carp contains 16.05 g of protein, 2.51 g of fat and 20 mg of calcium; thus, it also has high nutritional value and affordable prices.

Raising fish in container with cultivating plants in water in a symbiotic environment whereby the water contains of rich nutrient from fish leftover is fed to hydroponic grown plant, involving nitrifying bacteria for converting ammonia into nitrates; this is commonly called the aquaponics system. The use of beneficial bacteria in fish and fish rearing has also been carried out in previous studies (Muhammadar *et al.*, 2018; Dachi *et al.*, 2019). This application functions to maintain the balance of water quality, maintain temperature stability, assist oxygen distribution and can reduce ammonia levels due to leftover feed and carp feces which will be used by vegetable plants themselves as nutrients. The aquaponics system as a phytoremediation application can be used for an efficient cultivation process. Phytoremediation itself is the use of plants to reduce, extract, or remove organic and inorganic compounds from waste in water (Hadiyanto and Christwardana, 2012). This system can reduce ammonia compounds in water by absorbing wastewater using vegetable plants (Effendi *et al.*, 2015). The aquaponics system is known that has more advantageous than other filtration systems, because it maintains natural water quality and the farmer gets more benefits from the fish and vegetable crops (Paz- Alberto and Sigua, 2013).

Water quality is one of important factor that can support the growth rate of common carp. The most common problem faced by carp farmer is the increase of water pH and high ammonia levels caused by the accumulation of leftover feed and

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Received 25 January 2021; Received in revised from 19 March 2021; Accepted 2 April 2021
Available online 24 April 2021
p-ISSN 2089-7790; e-ISSN 2502-6194

feces with the result that affect the water quality. This issue may inhibit the growth rate of common carp and even cause disease in carp itself.

Ammonia absorption varies from plant to plant, therefore in this study, we used Kale (*Ipomoea aquatica*), Lettuce (*Lactuca sativa*), and Pakcoy (*Brassica rapa subsp. chinensis*) plants to investigate the effectiveness among plants to absorb excess nutrients from the fish culture medium. Based on previous information, these kinds of plants can filter out the buildup of organic substances such as leftover feed. Therefore, in order to provide optimal growth performance in the rearing of common carp fingerling, it is necessary to conduct research regarding to the effectiveness of different plants co-cultured with common carp fingerling.

Materials and Methods

Experimental design

The research was conducted for 28 days in September - October 2019 in Cot Mesjid Village, Lueng Bata District, Banda Aceh City. A completely randomized design (CRD) was applied with 4 treatments triplication. The treatment applied was the different types of plants, namely:

A. P1: Control, without using plants
B. P2: Using kale *(Ipomoea aquatica)* plants
C. P3: Using lettuce (*Lactuca sativa*) plants
D.P4: Using pakcoy *(Brassica rapa subsp. chinensis)* plants.

Procedures

Several containers with an aquaponics system were used with each bucket each treatment and repeat label. PVC pipe was prepared as a plant medium with a predetermined size and shape. Each container was equipped with a water pump and a different plant as a filter for dirt or a filter in the fish culture container. The container used was an 80 L bucket, cleaned first and filled with 60 L of water. Common carp fingerling (3-5 cm size) was distributed carefully in order to avoid stress. The, the fish was acclimatized for 15 minutes and spread with a stocking density of 30 ind/bucket (SNI, 1999).

The data taken during the study were absolute weight gain, absolute length gain and survival rate. Absolute length gain data were measured with a ruler, absolute weight gain was measured by digital scales and the survival rate was calculated for fish that died during the study. The research was started by measuring the initial length, weight and stocking density to determine the growth and survival rate of the sample fish. Parameters measurement was carried out every 7 days 28 days. Water quality data were measured on the first day of the study and the last day of the study.

Research parameters

Absolute weight gain

The growth of the tested fish biomass can be calculated using a formula (Effendie 1997; Putra *et al.*, 2019), namely:

W = Wt - Wo

Where:

W = Increase in fish biomass (g).

Wt = Average weight of test fish at the end of the study (g). Wo = average weight of test fish at the start of the study (g).

Absolute length gain

Absolute length gain is the increase in length (difference end length and start length) during the rearing period. Absolute length gain can be calculated (Safriani *et al.*, 2019a; Putra *et al.*, 2020a):

Pm = Lt - Lo

Where:

Pm = absolute length gain (cm)
Lt = average length of fish at the end of maintenance (cm)
Lo = average length of fish at the beginning of rearing (cm)

Survival rate (SR)

The survival rate of fish is the percentage of the number of fish that live on the end of treatment compared with the number of fish at the beginning of the treatment. Survival rate can be calculated (Putra *et al.,* 2016; Putra *et al.*, 2019a):

SR = x 100%

Where:

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

Water quality

Observation of water quality parameters includes temperature, DO, pH and ammonia referring to previous study (Evendi *et al.*, 2017; Putra *et al.*, 2020b). These parameters were measured at the start and end of the study.

Data analysis

The data obtained in the study were analysed using ANOVA (Analysis of Variance) at a 95% confidence interval to test whether there is an effect between treatments. The data analysed using ANOVA (Analysis of Variance) were data on absolute length gain, absolute weight gain, and survival rate, while water quality data was displayed in tabular form and described descriptively. Then the data is presented in tabular form.

Results

ANOVA (Analysis of Variance) test results showed that different plants co-cultured in aquaponics system had a significant effect (P <0.05) on the absolute weight gain, absolute length gain and survival of common carp fingerling. Based on Table 1, the results of Duncan's continued test showed that there were significant differences between treatments on the parameters of absolute weight growth, absolute length growth and survival. Treatment B (kale), C (lettuce) and D (pakcoy) were significantly different from treatment A (control).

Water quality parameters for 28 days of rearing period obtained temperature data in the range of 26-27ºC, DO ranges from 4.0 - 5.2 mg/L, pH remains 7-7 and ammonia ranges from 0.15-0.30 mg/L. It expressed that the water quality parameter data was still within a reasonable range for the growth and survival of common carp. Water quality data during the 28-day study can be seen in Table 2 below.

Table 1. Data on the growth and survival of carp fry.

Treatment	Absolute weight gain (g)	Absolute length gain (cm)	Survival Rate (%)
Control no plant (A)	1.21±0.76[a]	1.70±0.10[a]	91±0.86[a]
Kale (B)	3.93±0.28[b]	3.81±0.21[d]	100±0.0[b]
Lettuce (C)	3.40±0.07[b]	3.37±0.22[c]	99±0.86[b]
Pakcoy (D)	3.29±0.17[b]	2.92±0.08[b]	99±0.86[b]

Note: different superscript letters in the same column show significantly different (P <0.05).

Table 2. Data on the measurement of water quality in the research container.

Treatment	Range				
	Temperature (ºC)	DO (mg/l)	pH	Ammoniac (mg/l)	
				H0	H28
Control no plant (A)	26-27	4.0 – 4.4	7	0.15	0.30
Kale (B)	26-27	4.0 – 5.2	7	0.15	0.10
Lettuce (C)	26-27	4.0 – 4.6	7	0.15	0.25
Pakcoy (D)	26-27	4.0 – 4.6	7	0.15	0.25

Discussion

The absolute weight gain parameter indicates the fish consumption on the given diet (Putra *et al.*, 2019b). The stable water quality in aquaponics system also support the fish growth performance. According to Monalisa and Infa (2010) the optimum water quality can increase fish appetite. This study showed that treatment B (kale) got the highest weight gain 3,93±0,28[b] g, while the lowest value was in treatment A (control) with a value of 1.21±0.76[a] g (Table 1). Result also showed that different vegetable plants have different effect on fish growth performance. In treatment B (kale), the absolute weight gain was higher than in treatment C (lettuce), D (pakcoy) and A (control). This in accordance with Setijaningsih and Suryanigrum (2015) mentioned that kale plant is more effective in utilizing nutrients and water that has undergone biofiltration in aquaponics system.

The results showed that the fish reared with the aquaponics system (treatments B, C and D) could provide higher absolute length gain compared to fish reared without the aquaponics system (control). To the best of our knowledge, this is due to the influence by the aquaponics system which can maintain water quality so that fish growth is not disturbed by poor water quality. According to Abdan *et al.* (2017) there are several factors that influence fish growth like feed quality, fish health and water quality. Based on research data for 28 days using different vegetable plants, the absolute length gain average was obtained.

Survival is the ability of fish to survive in a certain period (Putra *et al.*, 2018). Current study expressed that the aquaponicss system was able to successfully improve the survival of common carp fry. This is expected to be influenced by the suitable DO (Dissolved Oxygen) value. The presence of Dissolved Oxygen (DO) is very necessary for every organism (Ulfah *et al.*, 2019). Low ammonia in the aquaponics system can maintain and increase dissolved oxygen, this is in accordance with the opinion of Adewolu *et al.* (2008) mentioned that the survival of fish is influenced by several factors, including water quality including dissolved oxygen, ammonia, temperature, pH, then feed, age of fish, environment and fish health condition.

Based on research data for 28 days using different aquaponics plants, the survival rate was obtained. Based on Table 1 the best survival rate (%) found in treatment B with 100% of survival rate then with treatment C and D with a survival rate of 99%, and finally in treatment A with a survival rate of 91%. The difference in absolute length gain in common carp is due to differences in plant types in each treatment. The highest increase in absolute length was obtained in the treatment of kale compared to the treatment of lettuce, pakcoy, and control. This is because the growth of kale plants is better than other plants so that water absorption is better than other plants so that the water quality parameters in the maintenance media are better. According to Hartami *et al.* (2015), if the aquaponics plants grow well, the ammonia and turbidity in the waters will decrease and it will not interfere with fish life.

Water quality parameters are very important because they can affect the life and growth of fish (Mulyadi and Yani, 2014; Dachi *et al.,* 2019). Water quality parameters measured in this study including water temperature, dissolved oxygen (DO), degree of acidity (pH) and ammonia. Result showed that the temperature during rearing priod of the study was still within the normal range for carp growth. The temperature during common carp rearing ranged from 26-27 °C and it was still within a tolerate range for carp rearing (Putra *et al.,* 2019b). This is consistent with the research of Effendi *et al.* (2015) which states that the optimum temperature for fish growth is 25-32 ºC.

The results of measurements of total dissolved oxygen in water during the study ranged from 4.0 - 5.2 mg / L this was within tolerance line for raising carp. This is in accordance with the opinion of Brotowijoyo (1995) that the optimal water DO range for freshwater fish farming is in the range of 5-8 mg /L. Based on the measurement, the pH was 7, it was also include the optimum pH common carp survival. According to Boyd (1991) that water that is good for fish farming is 7 (neutral), this is in line with the opinion expressed by Soeseno (1978) who explained that the best pH for fish rearing is neutral (7), slightly alkaline with a pH of 7.0 - 8.0. The ammonia levels in aquaponics system during the study ranged from 0.15 - 0.30 mg / L. The highest average levels of ammonia occurred in fish rearing treatments without using plant or control (A) types and the lowest ammonia levels were found in kale (B) treatment. Rini *et al.* (2018) stated that in the aquaponics system, the roots of kale are thought to absorb fish culture waste so that the water absorbed by kale roots is clean and the water quality is quite maintained. Moreover the kale plants continue to live fertile because they have fertilizer to live and fast growth. This is also supported by the research of Setijaningsih and Suryanigrum (2015) mentioned that kale is more effective in utilizing nutrients, then water that has undergone biofiltration in catfish rearing. This is also in accordance with the results of Dauhan *et al.* (2014) stated that the treatment of kale plants is also in good condition, which means that the absorption of ammonia is optimally utilized by kale plants for growth. The low levels of ammonia using kale are thought to be due to the roots of the kale plant being more stringy and longer than lettuce and pakcoy. When viewed in terms of the roots of kale plants, it is more optimal to absorb ammonia.

The use of pakcoy plants and lettuce plants in this study can also affect ammonia levels from feed residue and fish feces. This is because plants use ammonia in water as nutrients for growth. This is in accordance with Mulqan *et al.* (2017) reported that several factors that affect the growth of aquaponics plants, namely light intensity, temperature in the root area and water quality. Aquaponics plants can also utilize leftover feed and metabolic products as a source of nutrition for growth (Oladimeji *et al.*, 2020). Pakcoy and lettuce plants used in this study can grow and the levels of ammonia used are not much different. This is presumably because the photosynthetic abilities of pakcoy and lettuce are not much different so that the growth of pakcoy and lettuce plants is almost the same (Gumelar *et al.*, 2017).

Conclusion

The rearing of fish using the aquaculture system co-cultured with vegetable plants like kale, lettuce and pakcoy had a significant effect on absolute length and weight gain and common carp survival rate ($P < 0.05$). The use of kale plants was more effectively recommender in the aquaponics system co-cultured with common carp (*Cyprinus carpio*) fingerling.

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How to cite this paper:
Rahimi, S.A.E., M.M. Razeky, A.W. Perdana, D.F. Putra. 2021. The growth performance of common carp (*Cyprinus carpio*) co-cultured with different vegetable plants in aquaponics system. Depik Jurnal Ilmu-Ilmu Perairan, Pesisir dan Perikanan, 10(1): 30-34.