Global Scientific JOURNALS

GSJ: Volume 7, Issue 11, November 2019, Online: ISSN 2320-9186
www.globalscientificjournal.com

# Productivity of Various Plants in Aquaponics Systems

Yuli Andriani, Zahidah, Ayi Yustiati, Junianto, Iskandar, Eka Harditama

Faculty of Fisheries and Marine Sciences, Universitas Padjadjaran
Jln. Raya Jatinangor km 21, Sumedang 45363, West Java, Indonesia

Correspondence author : yuli.andriani@unpad.ac.id

## ABSTRACT

Aquaponics is one of the cultivation systems that has multiple advantages, one of which is in the aspect of crop production. This study aims to determine the production of various plants (water spinach, lettuce and onion spring) integrated cultured with stripped catfish (*Pangasius hypophthalmus*) in the aquaponics system. The study was conducted at the Laboratory of Aquaculture, Ciparanje, Faculty of Fisheries and Marine Sciences, Universitas Padjadjaran from June to July 2017. The method used in this study was an experimental method using a Completely Randomized Design (CRD) with 3 treatments and was repeated 4 times. Treatment A: combination of stripped catfish and water spinach, Treatment B: combination of stripped catfish and lettuce, and Treatment C: combination of stripped catfish and onion spring. The parameters measured in this study were plant productivity (length and number of leaves) and water quality including dissolved oxygen (DO), pH and temperature. The results showed that water spinach productivity was higher compared to lettuce and onion spring. While water quality parameters indicate that the use of the three types of plants produce water quality that still meets the requirements for fish farming.

Keywords : Aquaponics, Stripped catfish, Water quality, Plant growth

## INTRODUCTION

Aquaponics is a combination of aquaculture and hydroponics that aims to culture fish and plants in integrated system. The interaction between fish and plants produces an ideal environment for the plants to grow, which is more productive than conventional methods. When compared to conventional land-based cultivation, there are several aquaponic advantages, including not requiring fertilizers and pesticides, very efficient use of water, can be done on non-agricultural land, producing two products at once namely plants and fish, products produced in organic and free categories chemical and biological cypress, efficient workforce and can be carried out by everyone at various ages (Somerville et al., 2014). According to Rakocy et al., (1997) aquatic plants can effectively utilize nutrients so that they have several benefits from the efficient use of water and the reduction of pollution from sewage into public waters.

According to Somerville et al, (2014) there are more than 150 different vegetables that can grow on the aquaponic system. There are two general categories of aquaponic plants based on nutritional demand, including plants that require low nutrients (such as lettuce, basil, mint, pak choi and watercress) and plants that require high nutrition (this includes botanical fruits, such as tomato, eggplant, cucumber, zucchini, and strawberry). Vegetable plants that are often used in the aquaponic system are including water spinach, lettuce, and onion spring. The purpose of this research is to determine the productivity of various plants integrated with catfish (*Pangasius hypophthalmus*) in the aquaponic system.

## MATERIALS AND METHOD

### Time and Place

Research was conducted from June to July 2017 at Ciparanje Green House, Faculty of Fisheries and Marine Sciences, Universitas Padjadjaran, Jatinangor.

### Research Materials

Striped catfish fries used are 7-8 cm in size from catfish broodstock originating from Cijengkol-Subang BPBAT. There are 3000 fish used with a density of 200 fish per day. Vegetables used are water spinach, lettuce, and onion spring aged 1 to 2 weeks from seeding. Husk charcoal is used as a growing medium for plants during seeding and cultivation. The feed given is commercial feed (pellets).

### Research Tools

Fiber tub measuring 70 cm x 70 cm x 70 cm as many as 12 tubs. Pump for drawing water from the cultivation container to the 4" PVC pipe. 12 pumps with the size of 90 watts (4 meters) and 25 watts (2 meters)were used. 12 heaters were installed to stabilize the temperature of the water. 4" and ½" PVC pipe to drain water or collect water for the plants. 4 mechanical filters for filtering water in the fiber control tub. 76 plastic cups in each treatment that serves as a place to put plants. Kenko digital scales with the accuracy of 0.1 gram to measure fish weights. Iron rack measuring 3m x 1m x 2m for laying pipes.

### Method

The research method used was an experimental method using Completely Randomized Design (CRD) with 3 treatments and 4 repetitions. The treatment was consist :

Treatment A: combination of stripped catfish and water spinach
Treatment B: combination of stripped catfish and lettuce
Treatment C: combination of stripped catfish and onion spring.

## Research Procedure

### Aquaponics Installation

The containers used in this research were 12 fiber tubs with a dimension of 70 cm x 70 cm x 70 cm, which were filled with water 75% of the body volume, amounting to 257 L and 1 iron rack. A 4-inch PVC pipe with a length of 4 m was used as bio filter container. The 4-inch PVC pipe was perforated using a drill to form 19 holes with diameter of 6cm, with a distance of 15 cm from the mouth of the pipe and 20 cm for each hole. A small tub was put under the drain pipe to act as a water reservoir. The water in the reservoir was channeled back through the ½ -inch PVC pipe using a water pump, so that the water could go back up to the cultivation containers. The next process was activating the aquaponic system which had been assembled for one week, so that the water used had stable water quality.

### Fish Acclimatization

Fish acclimatization was carried out for one week. Acclimatization process was carried out so that the fish could adapt to the new environment and adjust themselves during the research process.



### Plant Seeding

The seeding process was carried out by planting the seeds in the husk charcoal for one to two weeks. After the roots had grow longer, the plants were sorted into plastic cups and implanted into the pipe holes.

### Research Implementation

The study was conducted for 30 days. Feeding in this study used commercial feed (pellets). The size of the pellet was in accordance with the size of the juvenile mouth. The amount of feed given was 3% of biomass with a frequency of 2 times a day. Plant growth plant and measurement of water quality parameters were done every 7. The parameters observed were the crop growth and water quality (Dissolved oxygen, pH and temperature), while the observation of crops was performed once a week by measuring the length of the crop stems and the addition of leaves.

## Observation Parameters

### Plant Growth

The length of crop stem measurement and calculation of the addition of leaves were performed regularly every 7 days, starting from the beginning of the study until the last day of observation.

**Water Quality**

Observation of water quality (Dissolved Oxygen, pH and temperature). Measuring water quality is an important part of the research, because good water quality can affect the growth and survival of fish.

**Data Analysis**

Data collected were analyzed descriptively through observational analysis using supporting data and related literatures.

## RESULT AND DISCUSSIONS

**Plant Growth**

Plants growth can be seen from the increase in stem height and number of leaves. In plants, growth is particularly important because both survival and reproduction depend on plant size and therefore on growth rate (Shipley, 2006). Based on the observation of the height of the plants, all plants (water spinach, lettuce and onion spring) grow well. The highest stem height growth was in water spinach, followed by onion spring and lettuce (Figure 1).

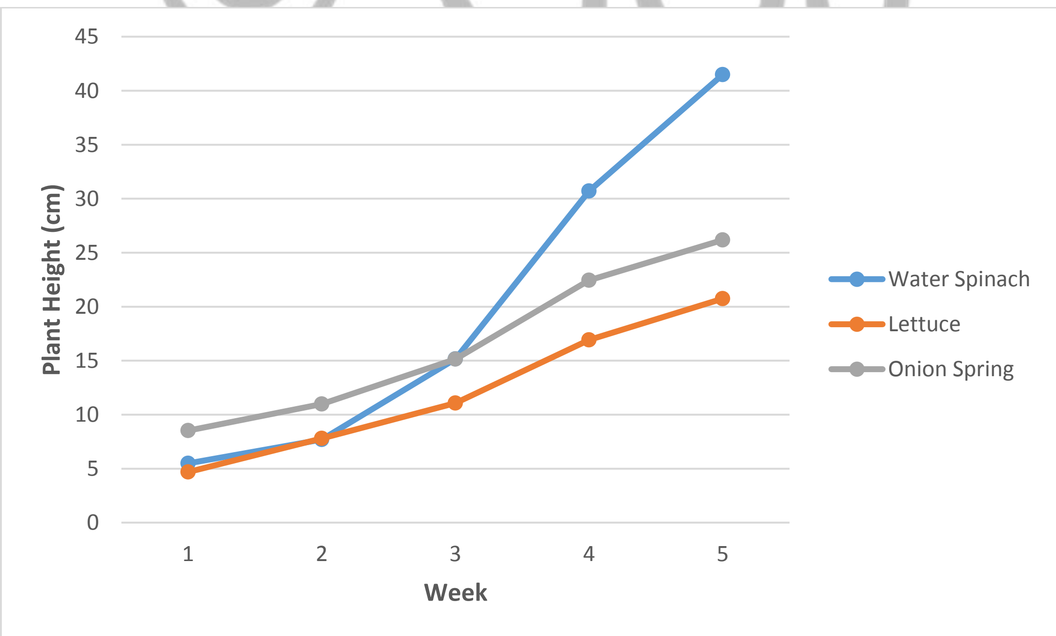


Figure 1. The Average of Plant Height

The difference in plant height is due to different types of plants used in the treatment. The results observed during the study, the best plant growth is in the pipe at the upper shelf level because it gets enough sunlight for the plants to carry out photosynthesis. While plants at the lower level of the shelf did not grow well, because the sun is obstructed by the plants that were placed on the upper shelf, so the plants underneath lacked sunlight. Therefore the plants underneath grow elongated, so the stems become thin. Sunlight is critical for plants, and as such, the plants need to receive the optimum amount of sunlight during the day. Most of the common plants for aquaponics grow well in full sun conditions. It is vital to locate an aquaponic unit in a place where each plant will have access to sunlight. This ensures adequate energy for photosynthesis (Somerville et al., 2014).

Observations of the number of leaves can be seen in Figure 2. From the results of observations during the study, the highest increase in the number of leaves was found in water spinach, followed by lettuce and onion spring.

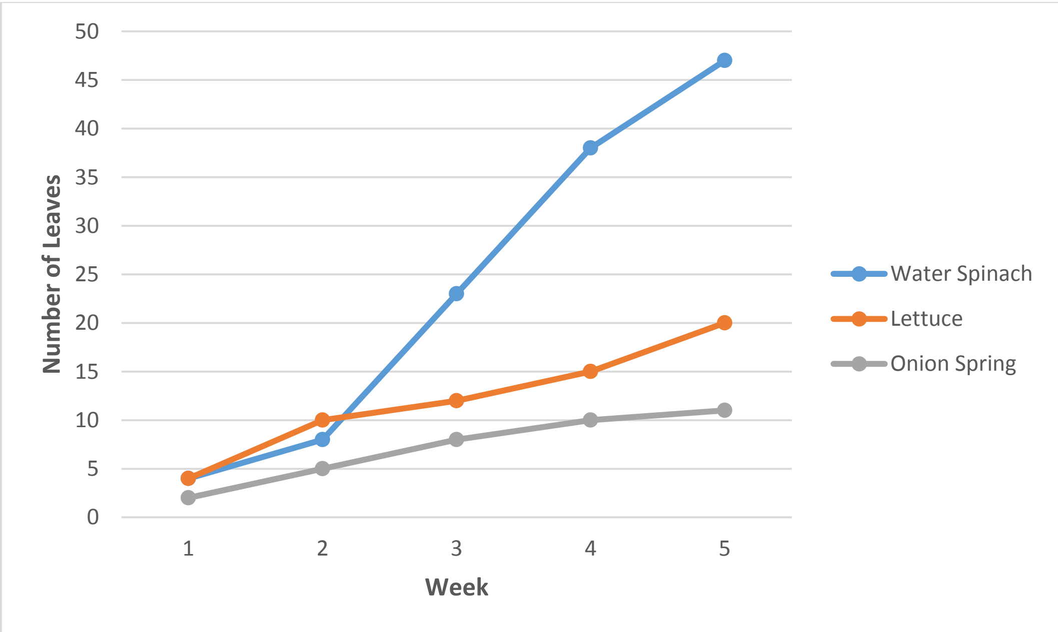


Figure 2. The Average of Number of Leaves

Based on the observation, height increase and the number of leaves are directly proportional to time. According to Somerville et al. (2014), most of the food in a plant is produced in the leaves. Leaves are designed to capture sunlight, which the plant then uses to make food through a process called photosynthesis. Leaves are also important for the transpiration of water. In water spinach, the higher the stalk the more the number of young leaves that grow, while in the lettuce plants, over time the the new leaves grow wider while the height increase of the stems is slowing. New leaf buds and width of leaves increases can also be observed over time in the onion plants. Seen from the picture above, harvesting time of plants can be done faster, at the 3rd week (27 days after planting) for water spinach. Lettuce is similar, at the 4th week (34 days after planting) harvesting can be done, while the onion spring can not be harvested because the diameter of the leaf is still small, the growth is very slow and the harvest time is quite long.

**Water Quality**

Optimal water quality is one of the requirements in fish cultivation. Water quality in the cultivation container must be controlled so that it can produce optimal growth of striped catfish fry. In fish farming activities, water quality is one of the factors that determine the success of an aquaculture business. The chemical composition of aquaponics nutrient solutions is complex due to the large number of dissolved ions and organic substances resulting from the release of excretory compounds as a product of fish metabolism and feed digestion (Cerozi and Fitzsimmons, 2016). Water quality parameters observed in this study were including dissolved oxygen, pH and water temperature which are the basic parameters that are often applied by farmers in general. The results of water quality observation in the aquaponic system can be seen in Table 1.

Table 1. Water Quality Parameter During Research

| Parameter | Treatment | | |
|---|---|---|---|
| | A | B | C |
| DO (mg/L) | 3.4 – 5.8 | 3.5 – 5,3 | 2.9 – 6.0 |
| pH | 7.0 – 8.1 | 6.9 – 8.0 | 6.7 – 7.8 |
| Temperature (°C) | 23.6 – 27.9 | 23.6 – 27.8 | 23.4 – 27.5 |



Oxygen is essential for all three organisms involved in aquaponics; plants, fish and nitrifying bacteria all need oxygen to live. The DO level describes the amount of molecular oxygen within the water, and it is measured in milligrams per litre. It is the water quality parameter that has the most immediate and drastic effect on aquaponics. The best dissolved oxygen level is in treatment D (control) in the range of 5–6.8 mg/L. This is because pumps supplying oxygen were installed in the controlled container. Whereas in other treatments, the oxygen content fluctuates and experiences a decrease every week, because the roots of the plants which inhibits the release of water from the growing media (water spinach plants in particular), which causes the water flow into the tank is small. According to Boyd (1982) the optimal dissolved oxygen for fish growth must be more than 5 mg/L. According to (Pangkey, 2008), oxygen solubility below 3 mg/L can cause fish to experience stress, while oxygen levels below 2 mg/L cause death in fish. But the striped catfish are still able to survive, because it has arboresen as a respiratory aid. Optimum levels of dissolved oxygen for nitrification are 4–8 mg/litre. Nitrification will decrease if dissolved oxygen concentrations drop below 2.0 mg/ litre (Somerville et al., 2014).

pH is the concentration of hydrogen ions ($H^+$) in water. In any aquatic system, pH is a main factor that controls fish metabolism, microbial activities and affects the availability of nitrogen to plants (Wongkiew et al., 2017). The results of pH measurements during the study were 6.7-8.17. Fish have specific tolerance ranges for pH as well, but most fish used in aquaponics have a pH tolerance range of 6.0–8.5 (FAO, 2014). The optimal pH for nitrification is 7.5–8.0 (Zou et al., 2016). According to FAO (2014) the optimal pH for Nitrosomonas sp. is 7.2–7.8 and for Nitrobacter sp. 7.2–8.2. Optimal pH for aquaponic systems is maintained at a range of 5.5–7.2 for optimal availability and uptake by plants (Cerozi and Fitzsimmons, 2016). Therefore the nitrate and phosphate content in the container and inlet are high because the nutrient absorption process is less than optimal, but the nitrification process runs optimally because the pH is appropriate. The nitrification process slowed when the pH drops below 7.0 and when the pH is less than 6.0 the nitrification process slowly stops. For plants, the pH controls the plants access to micro and macronutrients. At a pH of 6.0–6.5, all of the nutrients are readily available but outside of this range the nutrients become difficult for plants to access (FAO, 2014). pH also influences the solubility of other nutrients such as calcium, phosphorus, potassium, magnesium, etc., which affects their bioavailability for plant uptake (Wongkiew et al., 2017).

The temperature of the experimental media during the study was around 23.3–27.9 °C. The optimum temperature suitable for fish is 25–32 °C. The temperature fluctuation is quite large at 4.6 ° C, its change gradually. According to Somerville et al., (2014) Temperature has an effect on DO as well as on the toxicity (ionization) of ammonia; high temperatures have less DO and more unionized (toxic) ammonia. Nitrifying bacteria thrive in higher water temperatures of 22–29 °C, contrarily, common vegetables grow better in cooler temperatures of 18–26 °C. The ideal temperature range for bacteria growth and productivity is 17–34 °C. If the water temperature drops below 17 °C, bacteria productivity will decrease. Low temperatures have major impacts on unit management during winter (Somerville et al., 2014).

## CONCLUSION

The results showed that water spinach productivity was higher compared to lettuce and onion spring. While water quality parameters indicate that the use of the three types of plants produce water quality that still meets the requirements for fish farming.

## ACKNOWLEDGEMENT

Acknowledgments were conveyed to The Ministry of Research, Technology, and Higher Education for the PDUPT 2017 and 2018 Research Grant for this study.

**REFERENCES**

Boyd, C. E. And F. Lichtkoppler, (1982), Water Quality Management in Pond Fish Culture, Auburn University, Auburn.

Cerozi, B.D.S. and Fitzsimmons, K. (2016). The effect of pH on phosphorus availability and speciation in an aquaponics nutrient solution. Bioresource Technology, 219, 778-781.

FAO (2014). Small-scale aquaponic food production, integrated fish and plant farming, FAO Fisheries and Aquaculture Technical paper, Food and Agricultural Organization of the United Nations.

Pangkey, H. 2008. Aquaculture Development on The Islands of Tidore City. *Jurnal Perikanan dan Kelautan*, IV (2): 27-34.

Somerville, C., Cohen, M., Pantanella, E., Stankus, A. & Lovatelli, A. 2014. Small-scale aquaponic food production. Integrated fish and plant farming. FAO Fisheries and Aquaculture Technical Paper No.589. Rome, FAO. 262 pp.

Shipley, B. 2006. Net assimilation rate, specific leaf area and leaf mass ratio: which is most closely correlated with relative growth rate? A meta-analysis. Functional Ecology, British Ecological Society.

Rakocy, J. E. 1997. *Tilapia Aquaculture in the Americas*. World Aquaculture Society, Baton Rouge, LA. 258 hlm.

Wongkiew, S., Hu, Z., Chandran, K., Lee, J.W. and Khanal, S.K. (2017). Nitrogen transformations in aquaponic systems: A review. Aquacultural Engineering, 76, 9-19.

Zou, Y., Hu, Z., Zhang, J., Xie, H., Guimbaud, C. and Fang, Y. (2016). Effects of pH on nitrogen transformations in media-based aquaponics. Bioresource Technology, 210, 81-87.