The physical growth of *Oreochromis niloticus* and three plant species on the aquaponic technology

A Mustikasari¹.²,*, P Marwoto² and R S Iswari²

¹Education Quality Assurance Institution for Central Java, Jl. Kyai Mojo, Semarang, Central Java, Indonesia
²Doctoral Program in Science Education of Postgraduate Studies, Universitas Negeri Semarang, Jl. Kelud Utara III, Semarang 50237, Central Java, Indonesia

*Corresponding author: ardianim@gmail.com

Abstract. The physical growth of *Oreochromis niloticus* fish and three types of plants consist of *Ipomoea Aquatica*, *Brassica rapa*, and *Capsicum annuum* on the aquaponic technology have been studied. The aquaponic technology system has been done with 200 fishes m⁻³, water pump with 15 watts solar energy panel, physical and biological filter, and deep flow technique (DFT). In this study, we have reported that the specific growth rate (SGR), survival (SR), Feed conversion ratio (FCR), and Wet weight (W) are used as the physical growth indicator of *Oreochromis niloticus* fish, while the length and the number of leaves of plants are used as the physical growth indicator of plants. The physical growth of *Oreochromis niloticus* fish showed that SGR is 5.56% day⁻¹, SR is 97.67%, FCR is 0.92g and the wet weight is 1220g. The physical growth of the plant in aquaponic technology systems has been compared with the hydroponic treatment systems as controls. Analysis with *t*-test shows that physical growth of *Ipomoea Aquatica* and *Brassica rapa* has no significant difference respectively, whereas *Capsicum annuum* has significant differences compared with controls. Also, *Brassica rapa* in the aquaponic technology system shows a more yellow leaf color than the control. Based on these results, we conclude that aquaponic technology system provides effective results for the physical growth of *Oreochromis niloticus* with *Ipomoea Aquatica*, while additional nutrients for the both *Brassica rapa* and *Capsicum annuum* are required.

1. Introduction

Population growth has resulted in faster industrial and housing developments. Various problems encountered are limited land, water quality decline, food contamination by chemicals and pesticides [1, 2].

Technology and innovation needed to overcome various problems. One of them through aquaponic technology. Aquaponic is integration between aquaculture and hydroponics. The aquaponic system is capable of reducing the ammonia waste which is a limiting factor in fish culture. Aquaculture-based technology is required to treat fish-borne disposal. Water is a fish culture medium used as a source of nutrients in plant maintenance, whereas the plant functions as a biofilter for water. Plant biological filtration will absorb nitrogen (NH3-N, NO2-N, and NO3-N) and carbon dioxide (CO2) produced from fish culture [1,2].

The use of aquaponic technology has several advantages. Plants become free of pesticides and chemical fertilizers, because the plants obtain nutrients from fish waste. While the fish cultivated in the aquaponic system gives results three times than conventional cultivation. The use of resources
becomes more efficient. Besides aquaponic cultivation has a high aesthetic value. Thus aquaponics is a technology development model for safety and sustainable food production [1,2,4,5,6,23].

The problems of this research are 1) how is the physical growth of tilapia (*Oreochromis niloticus*) on aquaponic technology?; 2) Are there any significant differences in the growth of kangkung (*Ipomoea aquatica*), mustard (*Brassica rapa*) and paprika (*Capsicum annuum*)? The purpose of this research is to know the physical growth of tilapia fish (*Oreochromis niloticus*) and any significant differences in the growth of three types of plants, consist of *Ipomoea aquatica*, *Brassica rapa*, and *Capsicum annuum* on aquaponic technology.

2. Methods

2.1 Preparation of aquaponic

2.1.1 Aquaponic system

Figure 1 shows the aquaponic system. The system of aquaponic is performed on three ponds. The measure of the pond is 1m X 1m X 0.5m. The number of fishes in each pond is 200 fishes/m3. Water pumps have been used with 15 watts solar energy panels. The pond is equipped with physical and biological filters. The irrigation system of plants through DFT. The number of spots on each pond is 36 [1,21].

![Aquaponics System Diagram](image_url)

**Figure 1. Aquaponics System**

2.1.2 Aquaculture system

Preparation of aquaculture system was done by letting the pond without fish, but the water and air pump were running for two weeks. The process of fishless cycling was used to supply oxygen and bacteria [7].

---

*Note: The diagram image should be replaced with a proper image if available.*
2.1.3 Plant seeding
The seeding of the plant should be done before they were transferred to the aquaponic system. Seeding was using rockwood media for two weeks [8].

2.1.4 Tilapia fish (Oreochromis niloticus)
Fish seeding using healthy tilapia with size 5-6 cm. The culture of fish using commercial pellets of food as much as 6% of the total body weight given twice daily [9].

2.2 Physical Growth
This study measured specific growth rate (SGR), survival (SR), feed conversion ratio (FCR) and wet weight (W) was used as an indicator of the physical growth of Oreochromis niloticus fish. The length and number of plant leaves were used as an indicator of physical plant growth [10].

2.2.1 Specific growth rate (SGR)
Specific growth rate (% day⁻¹) determined by the ln mean final weight difference with the ln mean initial weight, compared to culture days.

2.2.2 Survival (SR)
Survival (%) determined by the number of fish that live up to the end with the number of fish at the start of culture.

2.2.3 Feed conversion ratio (FCR)
Food conversion ratio (g) determined by the dry weight of fish feed given during culture with the wet weight of fish.

2.2.4 Wet weight (W)
Fish Wet weight (g) is determined by the total weight of the fish at the end plus the weight of dead fish minus the total weight of the fish at the beginning of the culture.

2.2.5 The height of plants
The plant height (cm) is measured from the base of the stem until the longest leaves using a ruler after a certain time.

2.2.6 The number of leaves
The number of leaves (sheets) is calculated according to the number of leaves present in each plant after a certain period.

2.2.7 Data analysis
Analyze data with ANOVA to know whether there is a real difference in aquaponic system plant with hydroponics.

3. Result and Discussion
Technology aquaponics is done using water pumps with 15 watts of. The use of solar panels in aquaponics technology makes higher efficiency in the use of energy. The pond is equipped with physical and biological filters. The effect of the physical filter is reducing suspended solids. The biological filter reduces ammonia with two species. Nitrosomonas convert ammonia to nitrite while nitrosobacteria convert nitrite to nitrate [11,22,24]. Plants used nitrogen in nitrate as minerals. The irrigation system of plants through deep flow technique. DFT is a system with water availability of more than 5 cm and continues to circulate, while plants float on water. The roots are fed by the substrate continuously, to provide optimal nutrition. The development of the Deep Flow system is more useful for aquaponic systems than hydroponics [12].

Tilapia (Oreochromis niloticus) and three types of plants, consist of Ipomoea aquatica, Brassica rapa, dan Capsicum annuum have been studied. Tilapia is the fish species that have high survival and economic value so that tilapia is usually cultivated in aquaponics system [13]. The physical growth of tilapia (Oreochromis niloticus) in aquaponic technology is shown in Table 1.
Table 1. Physical growth of Tilapia Fish (*Oreochromis niloticus*).

| Parameter       | Measurement results |
|-----------------|---------------------|
| SGR (%day⁻¹)    | 5.56                |
| SR (%)          | 97.67               |
| FCR (g)         | 0.92                |
| Wet weight (g/replicate) | 1220             |

The physical growth of *Oreochromis niloticus* shows that SGR is 5.56% day⁻¹, SR is 97.67%, FCR 0.92 and the wet weight is 1220g. The *Oreochromis niloticus* fish at aquaponics technology has to experience good physical growth. The SGR, SR, FCR and wet weight are at an ideal value. SGR (% day⁻¹) determined by the ln mean final weight difference with the ln mean initial weight, compared to culture days (SGR = (lnWt – lnWo)/t X 100%). SR (%) determined by the number of fish that live up to the end with the number of fish at the start of culture (SR = (Nt/No) X 100%). FCR (gr) determined by the dry weight of fish feed given during culture with the wet weight of fish (FCR = dry feed given/wet weight gain). W (g) determined by The total weight of the fish at the end plus the weight of dead fish minus the total weight of the fish at the beginning of the culture (W = (Wt + Wd) – Wo). SGR, SR, and wet weight are better than another study. The effectiveness of the aquaponic system. FCR of 0.92 is not far above FCR value 0.85 reported as the study of the culture of African catfish and better than the range 1.0–1.7 reported as many studies [1,3,10,14,16,18,28]. It shows the success of the process of *fishless cycling* which is useful for supplying oxygen and bacteria in the fish pond to be used [7,28].

Figure 2. The Height of plants

Figure 3. The Number of leaves

Figure 2 and Figure 3 show the physical growth of plants, the height of plants and number of leaves in aquaponic technology systems has been compared with the hydroponic treatment systems as controls on three types of plants consisting of *Ipomoea aquatica*, *Brassica rapa*, and *Capsicum annuum*. Data analysis to know there is a real difference between control plants (hydroponics) and aquaponics is done with one-way analysis of variance (ANOVA). The test result of *Ipomoea Aquatica* and *Brassica rapa* on aquaponic technology did not have significant differences with control, while *Capsicum annuum* on aquaponic technology had significant differences with control.
Figure 4. Plant control and aquaponics (1) Control (2) Aquaponics

Figure 4 Demonstrate the physical differences of plants *Ipomoea Aquatica*, *Brassica rapa*, and *Capsicum annuum* in aquaponic technology systems. The *Brassica rapa* plant shows more yellow leaf color than the controls. The soluble nutrients measured as total dissolved solids (TDS) is 120 ppm. In the control solution (hydroponics) the TDS value is 1,135 ppm. A much lower TDS level in aquaponics will produce good results because the nutrients are produced continuously. The availability of macro nutrients and micro nutrients such as phosphate, nitrate, sulfate, potassium, calcium, magnesium, iron, zinc in aquaponic is lower than hydroponics [3,25]. Lack of macronutrients and micronutrients causes *Brassica rapa* leaves to become yellowish. Nutrients such as N, Mg, and Fe are chlorophyll constituents. Nutrient deficient plants show chlorosis symptoms in the leaves, which leads to low photosynthesis. One of the apparent symptoms is the yellowish color of the leaves [3,15,19,20]. High nitrate concentrations and lack of nutrients cause *Capsicum annuum* in aquaponic technology systems don't promote fruit development. Physical growth plant in the aquaponic system needs additional nutrients for the both *Brassica rapa* and *Capsicum annuum* [3,27].

Plant growth is also influenced by physical factors such as light, temperature, and pH. The aquaponics system gets excellent sunlight, temperature 26 – 27°C, pH 6.8 – 7.4. The light intensity is required by the plant for the process of photosynthesis. The optimum temperature for vegetable growing between 20 - 260C. Levels of pH affect the ability of plants to absorb nutrients. Environmental conditions such as nutrients result in a non-uniform pH value [1,8,17,26].

4. Conclusion
Technology aquaponics is done using water pumps with 15 watts of solar energy panels, physical and biological filters, and DFT. Technology aquaponics provides effective results for the physical growth of *Oreochromis niloticus* with *Ipomoea Aquatica*, while additional nutrients for both *Brassica rapa* and *Capsicum annuum* are required. The physical growth of *Oreochromis niloticus* shows that SGR is 5,56% day⁻¹, SR is 97.67%, FCR 0,92 and the wet weight is 1220g. Physical growth of *Ipomoea Aquatica* and *Brassica rapa* has no significant difference respectively, whereas *Capsicum annuum* has significant differences compared with controls. *Brassica rapa* shows a more yellow leaf color than the control. Aquaponic technology system provides effective results for the physical growth of *Oreochromis niloticus* with *Ipomoea Aquatica*, while additional nutrients for the both *Brassica rapa* and *Capsicum annuum* are required.

References
[1] Love D C, Fry J P, Li X, Hill E S, Genello L, Semmens K and Thompson R E 2015 *Aquaculture* 435 67
[2] Love D C, Uhl M S and Genello L 2015 *Aquacultural Engineering* 68 19
[3] Bittsanszky A, Uzinger N, Gyulai G, Mathis A, Villarroel M, Kotzen B and Komives T 2016 *Ecocycles: Scientific journal of the European Ecocycles Society* 2 17
[4] Kloas W, Grob R, Baganz D, Graupner J, Monses H, Schmidt U, Staaks G, Suhi J, Tschirner M, Wittstock B, Wuertz A and Rennert B 2015 *Aquatcul Environ Interact.* 7 179
[5] Goddek S, Delaide B, Mankasingh U, Ragnarsdottir K V, Jijakli H and Thorarinsdottir R 2015 *Sustainability* 7 4199
[6] Fox B K, Tamaru C S, Hollyer J, Castro L F, Fonseca J M, Jay-Russell M, and Low T 2012
Food Safety and Technology 5 1

[7] Trang A T D, Konnerup D, and Brix H 2017 Aquacultural Engineering D 10 1016
[8] Sace C F and Fitzsimmons K M 2013 Academy Journal of Agricultural Research 1 236
[9] Mamat N Z, Shaari M I and Wahab N A A A 2016 Fisheries and Aquaculture Journal 7 1
[10] Ridha M T and Cruz E M 2001 Aquacultural Engineering 24 57
[11] Vermeulen T and Kamstra A 2012 International Symposium on Soilless Cultivation 1004 71
[12] Hu Z, Lee J W, Chandran K, Kim S, Broatto A C, and Khanal S K 2015 Bioresource Technology journal 10 1016
[13] Palm H W, Bissa K and Knaus U 2014 AACL Bioflux 7 162
[14] Simeonidou M, Paschos I, Gouva E, Kolygas M and Perdikaris C 2012 Aquaculture, Aquarium, Conservation & Legislation-International Journal of the Bioflux Society (AACL Bioflux) 5
[15] Roosta H R and Mohsenian Y 2012 Scientia horticulturae 146 182
[16] Mungkung R, Aubin J, Prihadi T H, Slembrouck J, Van der Werf H M and Legendre M 2013 Journal of Cleaner Production 57 249
[17] Knaus U and Palm H W 2017 Aquaculture journal D 10.1016
[18] Naslund J and Johnsson J I 2014 Fish and Fisheries D 10.1111
[19] Nuwansi K K T, Verma A K, Prakash C, Tiwari C K, Candrakant M H, Shete A P, and Prabhath GPWA 2015 Aquacult int D 10.1007
[20] Piyush P, Sandip K, Swapnil K and Dipali S 2016 International Journal of Scientific and Technical Advancements 2 69
[21] Dediu L, Cristea V, & Xiaoshuan Z 2012 African Journal of Biotechnology 11 2349
[22] Hu Z, Lee J W, Chandran K, Kim S, Broatto A C and Khanal S K 2015 Bioresource technology 188 92
[23] Tokunaga K, Tamaru C, Ako H and Leung P 2015 Journal of the World Aquaculture Society 46 20
[24] Enduta A, Jusoh A, Ali N A and Wan Nik W B 2011 Desalination and water treatment 32 422
[25] Roosta H R 2014 Journal of plant nutrition 37 1782
[26] Zou Y, Hu Z, Zhang J, Xie H, Guimbaud C and Fang Y 2016 Bioresource technology 210 81
[27] Okemwa E 2015 International Journal of Scientific Research and Innovative Technology 2 54
[28] Kawser A R, Hossain M A and Sarker S A 2016 International Journal of Fisheries and Aquatic Studies 4 329
[29] Bosma R H, Lacambra L, Landstra Y, Perini C, Poulie J, Schwaner M J and Yin Y 2017 Aquacultural Engineering 78 146