Journal of Agroscience Indonesia
Volume 1 Number 2 November 2023 page 53 - 60
Journal homepage: https://ojs.unm.ac.id/journalagroscience

Cultivation of Tilapia (*Oreochromis Niloticus*) In Aquaponic System With Different Plants Species

Diana Rifka Simanullang [1,*], Patang[2], Indrayani[3]

[1] *Alumni of Agricultural Technology Education, Faculty of Engineering, Universitas Negeri Makassar, Makassar 90224, South Sulawesi, Indonesia;*
[2,3] *Study Program of Agricultural Technology Education, Faculty of Engineering, University Negeri Makassar, Makassar 90224, South Sulawesi, Indonesia;*
**e-mail of corresponding author: dianarifkasimanullang65@gmail.com*

ARTICLE INFO

Article History:
Available online 1 November 2023

Keywords:
Tilapia, Aquaponics, Kale, Lettuce, Pakcoy, Water Quality

ABSTRACT

This study aims to analyze the effect of using different plant species on the growth and survival of tilapia in the aquaponic system and to identify the most effective plant species in maintaining water quality in tilapia rearing with aquaponic systems. This study is an experimental study with a completely randomized design (CRD) with four treatments (the use of kale, lettuce, pakcoy and control without plants) with three replications. The variables observed were the growth and survival of fish during maintenance. The data collected was then analyzed by the ANOVA test. The results showed that there was no significant effect ($p>0.05$) between the use of different types of plants on the growth of tilapia but the treatment using water spinach gave the highest weight gain for tilapia reaching 2.21g with an absolute length increase of 1.14 cm, and the specific growth rate reached 7.36% per day. The use of different plant species had no significant effect ($p<0.05$) on the survival of tilapia in the aquaponics system and kale was the most effective plant species in maintaining the water quality performance of tilapia during maintenance.

INTRODUCTION

The rapid development of development every year causes a decrease in environmental quality, one of which is the reduction of water as a medium for growing cultured fish (Siregar et al., 2013). Another impact arising from the pace of development is the reduction in the area of fish farming, so intensive maintenance is carried out by increasing the density of seed stocking but this can reduce water quality (Putra et al., 2013). This causes agriculture and fisheries to be considered a difficult business because the availability of areas and water sources is eroded by the development of industrialization and settlements. The increasing rate of development causes land to become narrow and the amount of water is limited, especially during the dry season. Environmental pollution factors and declining water quality are increasing along with the increasing pace of development in various sectors, which can ultimately threaten the continuity of food supply.

One way to overcome the problem of limited land and water resources is by implementing an aquaponic system. Aquaponics is a combination of aquaculture and hydroponic technology. By applying this technology, fish and plants grow in a system that is interconnected and mutually beneficial to each other. By applying aquaponic technology, harvesting of plants and fish can be done

https://doi.org/10.26858/jai.v1i2.56151

simultaneously. This technology is an applied technology that saves water and land in fish farming so that it can be used as a fishery model, especially in urban areas (Nugroho and Sutrisno, 2008).

Tilapia *(Oreochromis niloticus)* is a species of freshwater fish that is favored by domestic and international communities (Yanti et al., 2013; Fadri et al., 2016). that is favored by domestic and foreign communities (Yanti et al., 2013; Fadri et al., 2016). Tilapia (*Oreochromis niloticus*) is a type of freshwater fish that attracts the attention of the government so that it is expected to increase production, and attract the attention of many people, which focuses on improving nutrition (Khairuman & Amri, 2005).

The process of substance exchange that occurs in the body of fish that plays an important role in productivity and survival is influenced by various physical factors of water quality (Dauhan et al., 2014). Maintenance water quality can decrease due to sediment and fish waste. Inedible pellets will settle to the bottom of the pond and make the pond water quality decrease, which can affect the growth and survival of fish. Poor maintenance water recirculation can cause poisoning and decreased oxygen for cultured fish. Tilapia can be cultivated traditionally or intensively in ponds, rivers, lakes and aquaponics. Aquaponics is thought to be used in raising tilapia. So far, many people have cultivated fish using aquaponic systems with various types of plants.

Several previous studies have been conducted with kale, lettuce, and pakcoy plants using goldfish, with the aim of the study being to determine the real effect of aquaponic systems with different plant types on absolute weight growth daily growth rate (SGR) and FCR (Prahesti, 2019). Research with plant species of kale, mustard greens and lettuce with tilapia fish, with the aim of seeing the effect of different plant species on the growth and survival of tilapia seeds. Different plant species on the growth and survival of agile tilapia (*O. niloticus*) in an aquaponic system, and to see the growth and survival of (Mulqan, 2017). Research with pakcoy, water kangkong and caisim plants, in tilapia rearing which aims to determine the effect of using different types of plants and determine the type of plant that is good for tilapia.
of different plants and determine the most effective plant species for maintaining water quality performance, growth and maintain water quality performance, growth and survival of tilapia. However, research on aquaponics using kale, pakcoy and lettuce in tilapia rearing has not been conducted.

Based on the description above, it is necessary to conduct research to analyze the effect of using different plant species and identify the most effective plant species in maintaining water quality, growth and survival of tilapia.

MATERIALS AND METHODS

This research is a type of descriptive quantitative research, including experimental research with an experimental design using a Completely Randomized Design (CRD) with four treatments and three replications, namely kale plants, pakcoy plants, lettuce plants and no plants. This study used tilapia seeds with a stocking density of 1 tail/liter (SNI, 1999).

Time and Place

This research was conducted from April to May 2021 at the Laboratory of the UPTD Bantimurung Freshwater Fish Seed Center, Maros Regency, South Sulawesi Province.

Tools and Materials

The tools used in this study are sample bottles, thermometer, ph meter, DO meter, spectrophotometer, filter paper (*Whattman* no. 42), erlenmeyer, funnel, hyacinth pipette, scale pipette, drip pipette *cool box*, stationery and books, scales, containers, aquariums, aerators, sterofoam, seser, duct tape, *net pot* and camera. The materials used in this study were water samples, *EDTA* solution, *nitroprusite* solution, standard solution (ammonia), *acetone*, *tissue, extran* solution, distilled water, fish, kale, pakcoy and lettuce seeds.

Research Procedure

The procedures carried out in this study are:

1. Prepare an aquarium with a size of 50 cm wide, 75 cm long, 51 cm high and filled with 20 liters of water equipped with an aerator.
2. Prepare kale, pakcoy and lettuce seeds. Plant seeds that will be used are 14 HST (Days After Planting).
3. Seed stocking. Fry with a size of 3-5 cm were reared at a stocking density of 20 fish per aquarium. Before stocking, 15% of the

population was sampled for weight and length as initial stocking size.

4. Aquaponic preparation. After stocking the tilapia fry, the hydroponic plants are then introduced. In one tilapia rearing aquarium, 6 *nett pots* will be used. Each aquarium is filled with one type of plant that has reached the age of 14 HST. The aquaponic system used in this study is a floating raft system.

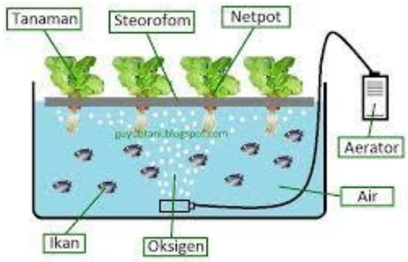

Figure 1. Research design

5. Feeding. Fish fry will be fed with artificial feed brand MS Prima Feed PF500 with a frequency of 2 times in the morning and evening and a dose of 5% of the seed weight (Melianawati and Suwirya, 2010).
6. Water quality management. During the study, no water changes were made in the fish ponds. The aim was to see the effect of plant species on tilapia water quality. Water quality observations were made including temperature (morning-evening), pH (morning-evening), DO (morning) and ammonia and phosphate content (once a week).
7. Measuring research parameters which include:
   a. Absolute weight gain was measured weekly (Muchlisin et al., 2016):
   $$Wm = Wt\text{-}Wo$$
   Wm = Absolute weight growth q (grams),
   Wt = Weight of biomass at the end research (grams),
   Wo = Weight of biomass at the beginning research (grams).
   b. Length gain was measured weekly (Muchlisin et al., 2016):
   $$Pm = Lt - Lo$$
   Pm = Absolute length gain (cm),
   Lt = Final average length (cm),
   Lo = Initial average length (cm)
   c. Specific growth rate (SGR) (Zenneveld et al., 1991):
   $$SGR = \frac{(InWt-InWo)}{T} x100$$
   SGR = Specific growth rate (%/day),
   Wo = Average weight of seeds at the beginning of the study (grams),
   Wt = Average weight of seeds on day t (grams),
   T = Length of rearing (days).
   d. Survival rate (Muchlisin et al., 2016):
   $$SR = \frac{(Nt)}{No} x\ 100$$
   SR = Survival (%)
   Nt = Number of fish at the end of the study (tail)
   No = Number of fish at the beginning of the study (tail)

Data Analysis

The data collected were then described in the form of figures and tables and then analyzed by the ANOVA analysis of variance method and if significantly different followed by the Duncan test.

RESULTS AND DISCUSSION

Absolute Weight Gain of Tilapia (*Orechromis niloticus*)

The results showed that all treatments experienced an increase in weight gain, but the treatment with the highest gain was produced in treatment A which reached 2.21 g, followed by treatment B which reached 2.12 g, treatment C which was 2.08 g and control treatment which was 1.74 g. The highest weight gain occurred in treatment A was thought to be due to the superior quality of rearing water compared to other treatments, so that the growth of fish in treatment A was faster than other treatments. The highest weight gain that occurred in treatment A was thought to be due to the superior quality of rearing water compared to other treatments, so that fish growth in treatment A was faster than other treatments. Growth is the process of increasing weight and length that occurs in a living thing with changes in weight and length caused by changes in tissue structure (Effendi, 1997).

The results of the observation of absolute weight gain of tilapia can be seen in Figure 2.

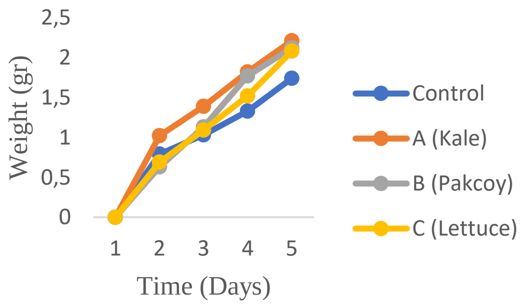

Figure 2. Graph of Absolute Weight Gain of Tilapia (*Oreochromis niloticus*) During the Study

The highest weight gain of tilapia was obtained from the treatment using kale plants. Kale plants experience faster growth than pakcoy and lettuce plants, so they have the ability to maintain superior water quality. Research conducted by Mulqan (2017), resulted in absolute weight gain of tilapia reaching 7.16 g on kale plants. The above research supports the results of this study that kale plants provide absolute weight gain in tilapia.

Kale plants are better at utilizing the remaining results of fish farming as a source of nutrients needed by kale plants from the remaining feed and feces of cultivated fish (Musa et al., 2007). The utilization of fish farming waste has a good effect on the growth of cultured fish. However, the weight gain in all treatments did not have a significant difference. This can be caused by the ability of each treatment to maintain water quality is almost the same, so that tilapia water quality during maintenance remains in good condition by providing feed according to fish needs. Two factors that affect growth are internal factors, namely heredity, immunity and the ability to utilize food, while external factors include physical, chemical and biological properties of waters (Hidayat et al, 2013).

Absolute Length Gain of Tilapia (*Oreochromis niloticus*)

The results showed that all treatments had an increase in length but there was no significant difference between treatments. The treatment with the highest length gain was produced in treatment B which reached 1.57 cm, followed by treatment C which reached 1.33 cm, control treatment which was 1.28 cm and treatment A which was 1.14 cm. The highest tilapia weight growth occurred in the kale treatment, but the highest length gain occurred in the pakcoy treatment.

The results of the observation of absolute weight gain of tilapia can be seen in Figure 3.

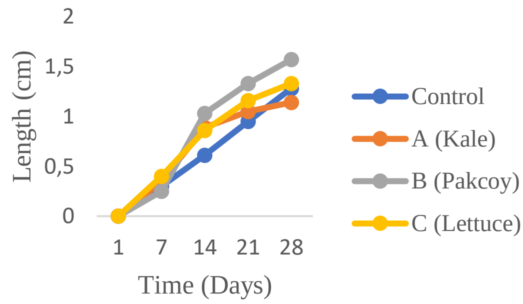

Figure 3. Graph of Absolute Length Gain of Tilapia (*Oreochromis niloticus*) During the Study

Research conducted by Prahesti (2019) resulted in weight gain in the control treatment and the highest fish length gain in the pakcoy treatment. The results of this study support this study that pakcoy plants provide the highest absolute length gain in tilapia. Factors that affect growth are divided into internal factors, namely genetics, reproductive system, gender and age. External factors are dosage and available food, habitat conditions, competition and water quality (Effendie, 2002). Fish growth is influenced by digestibility and intestinal physiology (Zonneveld et al, 1991).

Specific Growth Rate

The specific growth rate of tilapia (*Oreochromis niloticus*) can be seen in Table 1 below:

Table 1. Specific Growth Rate (SGR)

Specific Growth Rate (% per day)	Treatment			
	K	A	B	C
	5.8	7.36	7.06	6.93

The results showed that there was no significant difference between treatments on the specific growth rate of tilapia (ANOVA, P>0.05). The treatment that experienced the highest increase was produced in treatment A which reached 7.36% per day, followed by treatment B which reached 7.06% per day, treatment C 6.93% per day and the control treatment which was 5.8% per day. The highest specific growth rate was obtained from treatment A due to the better ability of kale plants to maintain water quality. This is shown in the dissolved oxygen content which reached 5.56 mg/l, with the lowest ammonia content of 0.17 mg/l and phosphate content of 1.99 mg/l. A decrease in water quality can affect fish appetite, when appetite is reduced, growth is also reduced, due to reduced feed intake into the fish body. Other factors related to this factor are the conditions of the rearing environment such as water quality, space, quality and number of fish cultivated. Fish growth is also influenced by internal factors that are generally difficult to control, namely metabolism, genetics, sex, age, parasites and disease. Feed availability and temperature are the main external factors that affect fish growth (Effendie, 2002).

Survival (SR)

The results showed that all treatments had 100% tilapia survival. In this study, fish were reared on a laboratory and controlled scale. Fish survival is highly dependent on the environmental conditions of the fish rearing media, if the fish rearing environment is favorable then fish survival will be high. High fish survival is supported by good water quality, such as the availability of dissolved oxygen that meets the needs of fish and the existence of a recirculation system so that the stability of the water quality of fish rearing media can be maintained and become suitable for cultured fish. Biotic and abiotic factors such as competitors, stocking density, age and adaptability, also affect the high and low survival rate of fish.

Aquaponic Plant Growth

Weight and length gain of kale, pakcoy and lettuce plants during the study can be seen in Table 2.

Table 2: Growth of aquaponic plants

Plant Type	Plant Weight Gain (g)	Plant Length Increase (cm)
Kale	64	27
Pakcoy	65	5,16
Lettuce	39	4,1

The weight gain of kale plants is 64 g with a length gain of 27 cm, the weight gain of pakcoy plants is 65 g with a length gain of 5.16 cm and the weight gain of lettuce plants is 39 g with a length gain of 4.1 cm.

The difference in growth that occurs in each type of plant is thought to be related to plant morphology such as the ability of roots to utilize nutrients contained in the growing medium. Some factors that greatly affect plant growth are root area temperature, ambient temperature, pH, light intensity, nutrient content and the type of growing media used (Fitriani et al, 2015).

Roots are the most important part of the plant. Roots are the part of the plant that functions to absorb nutrients in the soil that are translocated to all parts of the plant. Kale, pakcoy and lettuce plants have a taproot system with many roots on the side. If the availability of nutrients is sufficient, the roots form a shallow root system, but if nutrients are insufficient, the roots tend to expand the roots (Laksono, 2014).

Plant growth is influenced by light intensity, light intensity being the main factor in vegetative growth. Light intensity has an important role in the process of photosynthesis and transpiration which affects stem elongation and leaf expansion.

The results showed that kale plants experienced faster growth than lettuce and pakcoy plants, so that the growth of lettuce and pakcoy looked stunted. Stunted pakcoy and lettuce plants are caused by cultivation temperatures that are not suitable for plant growth and nitrogen deficiency which affects plant growth. The environment that is suitable for optimal pakcoy growth is in the range of air temperature 15.6^o C-21.1^o C with the optimal level of relative humidity required by pakcoy plants, which is 80%-90% (Tim Penebar Swadaya, 1995). Lettuce plants can grow optimally in an environment with a temperature of 15-25^o C (Setyaningrum & Saparinto, 2011) with optimal humidity of 80%-90% (Krisna et al, 2017). The maintenance temperature of kale plants is the optimal temperature for kale growth, which is 25-30^o C, thus supporting the growth of kale (Fikri M. Syihabul, 2015). Nutrients N, P and K are needed for the growth of stem length and diameter. N compounds play a role in the synthesis of amino acids and proteins optimally, which are then used for plant growth and development. Lack of N element causes plants to become stunted.

Nitrogen waste from cultured fish is utilized by plants in the process of plant growth which can reduce ammonia content in waters (Merlina & Rakhmawati, 2016). *Nitrobacter* will oxidize nitrite into nitrate. Nitrate is the result of the nitrogen cycle which is relatively harmless to fish, and is needed by plants and phytoplankton. Plants play a role in the biofiltration process by absorbing ammonium.

Nitrobacter and *Nitrosomonas* bacteria that will optimize the nitrification process with a pH of 7.0-7.3 play a role in reducing ammonia concentrations through the nitrification process. (Rijin, 1996). Plants can utilize ammonium and nitrate directly through the photoremediation process (Buzby & Lin, 2014). The process of ammonia nitrification by bacteria through oxidation and converting ammonia into nitrate causes an increase in the concentration of nitrate needed by plants (Tyson et al, 2011).

Water Quality Parameters

Water quality parameters of tilapia (*Oreochromis niloticus*) during the study can be seen in Table. 3 below

Table 3. Average Values of Water Quality Parameters During the Study

Parameters	Treatment			
	K	A	B	C
Morning Temperature (° C)	25,84	26,35	26,31	26,24
Afternoon Temperature (° C)	28,02	28,57	27,87	28,33
pH (Morning)	7,79	8,65	7,70	7,77
pH (Afternoon)	7,86	7,84	8,49	7,84
DO (mg/l)	5,48	5,64	5,48	5,53
Ammonia (mg/l)	0,66	0,17	0,20	0,23
Phosphate (mg/l)	2,89	1,99	2,77	2,66

Temperature is very influential on the growth and survival of fish. Increasing temperature affects the speed of metabolism in cultivation cultivars which can cause an increase in carbon monoxide and ammonia in the maintenance media. Based on the research that has been done, the temperature in the fish rearing media during maintenance is 25-28 ° C, this temperature is a decent temperature for tilapia. The water temperature of 25° C in the control treatment is thought to be due to the absence of a recirculation process in the tilapia rearing pond, so that the temperature in the control treatment is lower than the water temperature using plants. In the control treatment, the pond water interacts directly with the air, this happens because in the control treatment there is no barrier between the pond water and the air in the form of plants so that if the ambient temperature is cold, the pond water will follow the ambient temperature. A temperature range of 25-32°C is recommended in fish farming (National Standardization Agency, 2009). Temperatures that are too low and high from the optimum temperature significantly affect the growth, survival and feed utilization of tilapia. This occurs due to the response of the fish body to changes in temperature.

The pH value of tilapia rearing pond water is in the range of 7.79-8.65 which is included in the tolerance range for tilapia rearing. pH in the range of 7-8 is the recommended pH range for fish farming (Samsundari and Wirawan, 2013). Very significant changes in pH can interfere with metabolism, growth and can cause fish to become stressed (Meilinda Pramleonita *et al*, 2018). pH that is too low and too high can interfere with fish growth, fish can live well in the pH range of 5-9 (Effendie, 2003).

Based on the results of the research that has been done, the dissolved oxygen value of pond water during tilapia rearing is in the range of 5.48-5.64 mg/l. The oxygen content is sufficient for the oxygen needs in tilapia rearing. Fish can grow optimally with a dissolved oxygen content of at least 3 mg/L (Kordi, 2010). The dissolved oxygen content during tilapia rearing is in the optimum range presumably due to the aeration system in the cultivation media, which is able to meet the dissolved oxygen needs of cultured fish. In raising fish, dissolved oxygen is needed in the process of respiration and metabolic processes that take place in the fish body and the survival of the fish being raised. If the dissolved oxygen content does not meet the needs, it can interfere with the performance of the fish brain caused by the lack of oxygen intake to the fish brain which can cause death in fish (Dahril et al, 2017).

Based on the results of the research conducted, the ammonia value of pond water during the study was in the range of 0.17-0.66 mg/l. The lowest ammonia content was found in the kale treatment. It is suspected that this happens because plants utilize ammonia directly in the cultivation media. Plant roots can utilize ammonia and nitrate through a photoremediation process (Buzby and Lian, 2014). The number of roots in kale plants which is more than pakcoy and Tuesday plants is thought to affect the level of ammonia absorption (Irfan Zidni et al, 2019).

The remaining feed and feces in the culture medium are the source of the presence of organic and inorganic materials in the culture medium. The accumulation of organic matter creates toxic compounds for farmed fish. Nitrifying bacteria will break down organic and inorganic materials by breaking down the remaining protein from fish into ammonia. Rapid changes in ammonia content can endanger fish life. Waters that have high ammonia content can cause stress in fish, weakness, decreased immune system, and decreased appetite which causes slow growth and even death. Ammonia content that is too high can disrupt fish life and even cause death (Yudha, 2009).

Based on the research conducted, the phosphate content of tilapia pond water ranged from 1.99 - 2.89 mg/l. The high concentration of phosphate in a rearing pond comes from the metabolic process of fish, namely feces, resulting in precipitation in the cultivation media. Phosphate in feed is used by fish according to the needs of the fish body, and unused phosphate is disposed of in the form of feces (Hughes et al, 1998). Increased phosphate content in rearing ponds can cause a decrease in water quality. Good fish farming has a phosphate content in the range of 0.2-1 mg/l (Ebeling, 2006 in Irfan Zidni et al. 2019). Very high phosphate concentrations cause environmental pollution. The results showed that the phosphate content reached 2.89 mg/l indicating *hypereutroph*. *Hypereutroph* is a water condition with a very high nutrient content, which causes algae and odor (Oktaviani et al.2020). Phosphate in waters does not have a direct effect on humans and animals, but if consumed for a long time it can cause digestive disorders (Isail, 2011).

The control treatment of phosphate content reached 2.89 mg/l, this is thought to be due to the absence of utilization of phosphate content in pond water. The lowest phosphate value was produced by kale plants at 1.99 mg/l, this is thought to be due to the ability of kale plant roots to absorb nitrogen more effectively than pakcoy and lettuce plants. Roots are the part of the plant that absorbs the most nutrients with the help of rhizobacteria so that it can absorb phosphate into the plant body (Oktaviani et al, 2020). Phosphate absorbed through the roots is utilized in the process of photosynthesis, respiration, spread and enlargement of cells in the plant body.

CONCLUSION

There was no significant effect between the use of different plant species on tilapia growth in the aquaponic system, but the kale plant species gave the highest growth in tilapia. The treatment with kale plants gave the highest weight gain in tilapia reaching 2.21 g with an absolute length gain of 1.14 cm and a specific growth rate of 7.36% per day. There was no significant effect between the use of different plant species on tilapia survival in the aquaponic system.

Kale was the most effective plant species in maintaining the performance of tilapia water quality in the aquaponic system during the study. The treatment using kale plants has the best water quality with dissolved oxygen reaching 5.64 mg/l, the lowest ammonia content of 0.17 mg/l and phosphate content of 1.99 mg/l.

REFERENCES

Badan Standarisasi Nasional. 2009 *Produksi Ikan Nila (*Oreochromis niloticus *Bleeker) Kelas Pembesaran diKolam Air Tenang, 2. SNI 7550, 2009 (68605).*

Buzby, K. M., & Lin, L. S. 2014. Scaling Aquaponic System: Balancing Plant Uptake with Fish Output. *Aquacultural Engineering*. 63:39-44.

Dahril. I., Tang.U.M., & Putra.I, 2017.Pengaruh Salinitas Berbeda terhadap Pertumbuhan dan Kelulusan hidupan Benih Ikan Nila Merah (*Oreochromis* Sp.). *Jurnal Berkala Perikanan Terubuk, Volume 45, No.3*,ISSN.0126-4265.

Dauhan Res., Efendi E., & Suparmono. 2014.Efektifitas Sistem Akuaponik dalamMereduksi Konsentrasi Amonia pada SistemBudidaya Ikan. *E-Jurnal Rekayasa danTeknologi Budidaya Perairan*, 2(1): 297-302.

Effendi, H. 2003. *Telaah Kualitas Air*. Kanisius: Yogyakarta.

Effendie, I. M. 2002. *Biologi Perikanan*. Yayasan Pustaka Nusantara: Bogor. 163.

Effendie, M.I. 1997. *Biologi perikanan*. Yayasan Pustaka Nusatama: Yogyakarta.

Fikri M. Syihabul *et al.* 2015. Pengaruh Kompos Limbah Media Tanam Jamur pada Pertumbuhan dan Hasi Kangkung Darat. Vegetalika Vol. 4, No. 2.

Fitriani H., Iskandar M.P., & Ramal Y. 2015. Respon Pertumbuhan Tanaman Sawi (*Brassicajuncea* L.) secara Hidroponik Terhadap Komposisi Media Tanam danKonsentrasiPupuk Organik Cair. *e-Jurnal Agrotekbis, Vol, 3, N0, 3, Hal: 290-296.*

Hidayat, D., Sasanti, A. D., & Yulisman, Y. (2013). Kelangsungan hidup, pertumbuhan dan efisiensi pakan ikan gabus (channa striata) yang diberi pakan berbahan baku tepung keong mas (pomacea sp). *Jurnal akuakultur rawa indonesia*, *1*(2), 161-172.

Hughes, K. P. (1998). Efficacy of phytase on phosphorus utilization in practical diets fed to striped bass Morone axatilis. *Aquaculture Nutrition*, *4*(2), 133-140.

Ismail, Z. (2011). Monitoring trends of nitrate, chloride and phosphate levels in an urban river. *International Journal of Water Resources and Environmental Engineering*, *3*(7), 132-138.

Khairuman, A., & Amri, K. (2005). *Budi Daya Ikan Nila Secara Intensif*. AgroMedia.

Kordi, K.M.G.H., (2010). *Budidaya Ikan Nila di Kolam Terpal*. LilyPublisher: Yogyakarta.

Krisna, B., Putra, E. E. T. S., Rogomulyo, R., & Kastono, D. (2017). pengaruh pengayaan oksigen dan kalsium terhadap pertumbuhan akar dan hasil selada keriting (Lactuca sativa L.) pada hidroponik rakit apung. *Vegetalika*, *6*(4), 14-27.

Laksono, R. A. (2014). Pertumbuhan dan hasil tanaman kubis bunga kultivar orient F1 akibat jenis mulsa dan dosis bokashi. *Jurnal Agrotek Indonesia*, *1*(2), 81-89.

Merlina, E., & Rakhmawati. (2016). Kajian Kandungan Amonia pada Budidaya Ikan Nila (*Oreochromis niloticus*) Menggunakan Teknologi Akuaponik Tanaman Tomat (*Solanum lycopersicum*). Prosiding Seminar Nasional Tahun Ke-V Hasil-hasil Penelitian Perikanan dan Kelautan. 1818-187.

Mulqan M., Sayyid A. E. R., & Irma D. (2017). Pertumbuhan dan Kelangsungan Hidup Benih Ikan Nila Gesit(Oreochromis Niloticus) pada Sistem Akuaponik dengan JenisTanaman yang Berbeda. *Jurnal Ilmiah Mahasiswa Kelautan dan Perikanan Unsyiah.* 2(1): 183-193..

Musa, Y., & Nasaruddin, K. M. (2007). Evaluasi produktivitas jagung melalui pengelolaan populasi tanaman, pengolahan tanah dan dosis pemupukan. *Agrisistem*, *3*(1), 21-33.

Zonneveld, N., Huisman, E. A., & Boon, J. H. (1991). *Prinsip-prinsip budidaya ikan*. PT Gramedia Pustaka Utama.

Nugroho, E. (2008). *Budidaya Ikan dan Sayuran dengan Sistem Akuaponik.* Penebar Swadaya. Depok.

Oktaviani, E., Lunggani, A. T., & Ferniah, R. S. (2020). Karakterisasi Rhizobakteri Pelarut Fosfat Potensial dari Rhizosfer Tumbuhan Mangrove Teluk Awur Kabupaten Jepara secara Mikrobiologi. *Jurnal Ilmu Lingkungan*, *18*(1), 58-66.

Prahesti, J., Jumadi, R., & Rahim, A. (2019). Penggunaan Sistem Akuaponik Dengan Jenis Tanaman Yang Berbeda Terhadap Pertumbuhan Dan Kelangsungan Hidup Ikan Mas (Cyprinus Carpio). *Jurnal Perikanan Pantura (JPP)*, *2*(2), 68-77. doi:10.30587/jpp.v2i2.994.

Pramleonita, M., Yuliani, N., Arizal, R., & Wardoyo, S. E. (2018). Parameter fisika dan kimia air kolam ikan nila hitam (Oreochromis niloticus). *Jurnal Sains Natural*, *8*(1), 24-34.

Putra, I., Pamukas, N. A., & Rusliadi, R. (2013). Peningkatan kapasitas produksi akuakultur pada pemeliharaan ikan selais (Ompok sp) sistem aquaponik. *Jurnal perikanan dan kelautan*, *18*(1), 1-10.

Van Rijn, J. (1996). The potential for integrated biological treatment systems in recirculating fish culture—a review. *Aquaculture*, *139*(3-4), 181-201.

Samsundari, S., & Wirawan, G. A. (2013). Analisis penerapan biofilter dalam sistem resirkulasi terhadap mutu kualitas air budidaya ikan sidat (Anguilla bicolor). *Jurnal gamma*, *8*(2).

Setyaningrum, H. D., & Saparinto, C. (2012). *Panen sayur secara rutin di lahan sempit*. Penebar Swadaya Grup.

Siregar, H. R., Sumono, S. B., & Daulay, E. S. (2013). Efisiensi Saluran Pembawa Air dan Kualitas Penyaringan Air dengan Tanaman Mentimun dan Kangkung pada Budidaya Ikan Gurami Berbasis Teknologi Akuaponik. *Jurnal Rekayasa Pangan dan Pertanian*, *3*(3), 60-66.

Indonesia, S. N. (1999). Produksi benih ikan nila hitam (Oreochromis niloticus Bleeker) kelas benih sebar. *Badan Standarisasi Nasional*.

Tim Penebar Swadaya. 1995. *Budidaya dan sarang wallet.* Penebar Swadaya: Jakarta.

Tyson, R. V., Treadwell, D. D., & Simonne, E. H. (2011). Opportunities and Challenges to Sustainability in Aquaponic Systems, HortTechnology hortte, 21 (1), 6-13. Retrieved Mar 13, 2019.

Tyson, R. V., Treadwell, D. D., & Simonne, E. H. (2011). Opportunities and Challenges to Sustinibility in Aquaponic System (Reviews). *Hort Technology*. 21 (1): 6-13.

Yanti, Z., Z. Muchlisin, & Sugito. 2013. Pertumbuhan dan Kelangsungan HidupBenih Ikan Nila (*Oreochromis Niloticus*) pada Beberapa Konsentrasi TepungDaun Jaloh (*Salix Tetrasperma*) Dalam Pakan. *Depik, 2(1): 16-19.*

Yudha, P. A. (2009). Efektifitas penambahanzeolit terhadap kinerja filter air dalamsistem resirkulasi pada pemeliharanikan arwana *Sceleropages formosus* diakuarium. *Skripsi*. Fakultas Perikanandan Ilmu Kelautan. Institut PertanianBogor.

Zidni, I., Iskandar, R. A., Andriani, Y., & Ramadan, R. (2019). Efektivitas sistem akuaponik dengan jenis tanaman yang berbeda terhadap kualitas air media budidaya ikan. *Jurnal Perikanan dan Kelautan*, *9*(1), 81-94.