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# Productivity of Tilapia (*Oreochromis niloticus*) and Koi (*Cyprinus carpio*) with Various Plants Combination in Aquaponic System

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KeyWords
Aquaponic, tilapia, koi, growth, survival, crop production

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ABSTRACT

This research aims to analyze the productivity of tilapia and koi with varoius plant combination in the aquaponic system. Research was conducted at the Ciparanje Greenhouse and Fisheries Aquaculture Laboratory, Faculty of Fisheries and Marine Sciences, Padjadjaran University from February to April 2018. This research used experimental method with Completely Randomized Design consisting of four treatments and four replications. Treatment A: a combination of water spinach and tilapia; treatment B: combination of lettuce and tilapia; treatment C: combination of water spinach and koi fish; treatment D: combination of lettuce and koi fish. The parameters measured in this research were fish growth, fish survival, and crop production. The research data were analysed descriptively. The results showed that the growth of koi fish was higher than that of tilapia in both combination of lettuce and water spinach, while survival in both treatment groups reached 100%. Water spinach productivity was higher than lettuce, this is related to the structure and the length of the roots of the plants.

## Background

The aquaponics system is a combination of aquaculture technology with hydroponic technology in one system to optimize the function of water and space as cultivation medium (Nugroho et al .2012). The combination of aquaculture technology and hydroponics is seen as a simple agricultural technique, but capable of producing multiple products; fishery commodities and crops simultaneously (Kurniawan, 2013). The aquaponics system can be used in all types of fresh water fish, both consumption and ornamental fish such as tilapia and koi fish.

The availability supply of tilapia and koi fish so far are fulfilled by means of fish cultivation in farms. However, in a closed, sustainable fish farming system, metabolic wastes will be produced and accumulated, and reached a level where it becomes toxic for the fish (Wicaksana *et al*. 2015). Plants in the aquaponics system functionas *filters,* so the waste water can be reused (Anjani *et al*.2017).Plants used in the aquaponics system are only hydroponic plants, which are plants that can be planted in water as a medium to replace soil, such as vegetables, fruit and ornamental plants (Kurniawan 2013). The combination of aquaculture and hydroponics is a technology that can be used to improve the water quality of fish cultivation media by reducing ammonia levels through the nitrification process.

Productivity in the aquaponics system will be achieved if the interaction between fish, aquatic plants and nitrifying bacteria in the culture system goes well. Protein from feed is broken down in to simple compounds by bacteria such as *Nitrosomonas* bacteria which convert ammonia to nitrite and *Nitrobacter* convert nitrite to nitrate. This nitrate is further used by water spinach and lettuce plants as nutrients, so that there is a nitrogen balance in the aquaponic system. Sufficient water quality needs to be maintained to support fish growth through the effective use of feed (Hasan*eta.* 2017).

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## Methodology

### Time and Place of Research

Research was conducted in February- April 2018, at the *Greenhouse* Laboratory of Aquaculture Ciparanje Faculty of Fisheries and Marine Sciences, Universitas Padjadjaran and Laoratory Research and Development Center for Natural Resources and Environment (PPSDAL) Universitas Padjadjaran.

### Tools and Materials

The tools used for research were as follows: 4,718 litre tubs, Resun SP-2500 water pump of 220V-240V 18 watt, Amara branded aerator, Atman branded heater of 200 Watt, plastic glasses for growing crops, Lutron branded DO meter with accuracy of 0.1 mg / L, Lutron branded PH meter with accuracy of 0.01, Spectrophotometer, hermometers with an accuracy of 0.1˚C, water quality checker kit. Materials used were as follows: one week old water spinach and lettuce, charcoal husk, *Rockwool ,* tilapia fries with a size between 3-5 cm obtained from Ciparay Fisheries, koi fries with a size between 3-5 cm obtained from Ciparanje Laboratorium, floating feed with a minimum crude protein content of 35%, Siegnete solution, Nessler solution.

### Research Methods

There search method used was experimental method. The treatment consisted of four treatments with four replications. The experimental design used was a Completely Randomized Design (CRD). The treatments used were as follows:

A: combination of water spinach and tilapia;

B: combination of lettuce and tilapia;
C: combination of water spinach and koi fish,
D: combination of lettuce and koi fish.

## Procedure

The preparation stage was started by fixing water installations for the aquaponics system. The fish were acclimatized by placing them in a cultivation tank with are circulation system for two weeks before being integrated with the plants. The fish were placed in the cultivation container with carefully calculated density; tilapia with a density of 133 fish/container (SNI No 01-6139-1999) and 118 koi fish/container (SNI No 01-6133-1999). Then, plants with *rockwool* media were planted in plastic cups with a density of one stem per glasses, placed according totreatment and with the distance between each glasses of 20 cm. The fishes were cultivated for 30 days. If there were fish that died, they were immediately replaced with fish from the stock. Fish are fed 3% of the biomass at 08.00 WIB and 16.00 WIB. The fishes were weighed every single week and the number of fish alive were counted at the beginning and end of the study. Besides, plant productivity was calculated by measuring its length and weight once a week. Water quality parameters observed were pH, temperature, ammonia dissolved oxygen; and carried out at the beginning, middle and end of the study.

## Observation Parameters

1. Daily Growth Rate
   Daily growth rate was calculated using Zonneveld *et al*.(1991) formula:

$$LPH = \frac{\ln Wt - \ln Wo}{t} \times 100\%$$

Information:
LPH = Daily growth rata (%)
Wt = Average weight at time t (grams)
Wo = Average weight at the beginning of the study (grams)
t = Length of research (days)

2. Survival Rate
   The survival rate of tilapia and koi fish was obtained using Effendie formula (2003), as follows:

$$SR = \frac{Nt}{No.} \times 100\%$$

Information:
SR = survival of fish (%)
Nt = Number of fish at the end of the research (per fish)
No = Number of fish at the beginning of the research (per fish)

3. Productivity of Water Spinach and Lettuce Plants Plant growth was calculated using the formula:
   Growth Increase (grams/day) =

$$\frac{\text{Final weight - initial weight}}{\text{Interval}}$$

## Data analysis

Data were analysed descriptively and compared with the standards set for the associated parameters.

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# RESULTS AND DISCUSSION

## Daily Growth Rate

The daily growth rates of tilapia and koi on different plant combinations have different values (Figure 1).

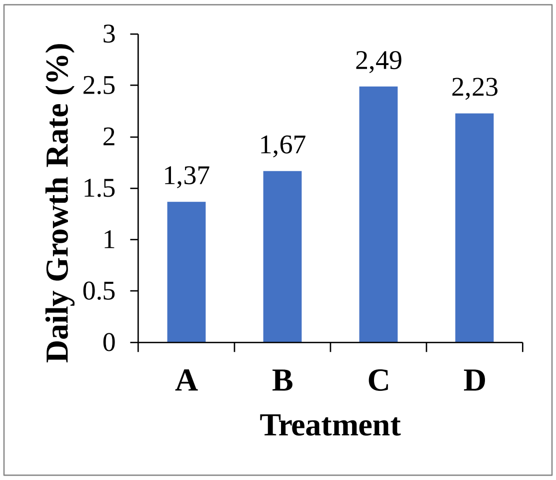


Figure 1. Fish daily growth rate

The daily growth rate of koi fish was greater (2.49%) compared to tilapia (1.37%). This shows that the feed given can increase body weight. The feed used contains 40% protein. Affandi et al. (2002) stated that maximum protein retention was obtained in foods containing 35% protein and in almost all cases that the presence of energy retention and new tissue formation resulted in an increase in fish body weight. The increase in body weight in fish fries is an indicator of nutritional adequacy. This is in accordance with the statement of Hidayat (2013), the fish will grow faster and the fish will be larger if the nutritional content of the food provided meets their daily needs.

The daily growth rate of koi fish is greater than tilapia, which can be influenced by the structure of the digestive system to digest feed. According to Putri et al. (2016), fish digestion consists of the digestive tract and digestive glands. Not all fish have a stomach and in exchange there are modifications to suit their life habits. One of the fishes that has a stomach is tilapia, while fish that does not have a stomach is koi fish. Fishes with a stomach have a more complete digestive organs than non-stomach fish.

Stomach in fish functions at the beginning of the digestion process by breaking down feed ingredients with the help of HCl. This process can make it easier for the feed ingredients to be processed further in the intestine which will then be absorbed and circulated through the bloodstream as energy sources. In non-stomach fish, it does not have a place to store incoming feed and does not produce HCl so that the feed will be slowly broken down in the enlarged front *intestine* (*Intestinal bulb*) as the initial entry point for feed (Megawati et al. 2012).

Not only because of differences in the physiological status of fish, differences in digestibility of crude fiber are also influenced by the presence of bacteria in the intestine (Evans and Claiborne 2006). The ability of fish to digest crude fiber is limited by the ability of the microflora in the intestine to secrete cellulose. Fish without stomach has more microflora in the gut than fishes with a stomach. This fact is confirmed by research conducted by Megawati et al. (2012), fish with a stomach consumes less feed compared to non-stomach fish, and have an average value of lower crude fiber digestibility, which is around 38.68%, so that the nutrients contained in feed such as protein and fat can be absorbed properly.

The results of the growth rate in this research were not much different. According to Mardhiana et al. (2017), the growth rate is not much different because the energy contained in feed is first used by the fish to meet the energy needs of maintaining the body and if there is any remaining energy it will be used for growth. This means that if the energy in feed is limited, the energy is only used for metabolism and not for growth (Buwono 2000).

The value of the growth rate which is almost the same is assumed because the feed used the same amount of iso protein, causing the level of feed consumption to be not much different. The feed given to tilapia and koi fish is the same feed so that the protein content is the same and the growth rate value obtained is not significantly different. This is in accordance with the statement of Puspasari et al. (2015) which stated that the use of isoprotein feed will cause the same growth rate value because the protein content obtained is the same.

Growth happen if there is excess energy from the feed net of energy for metabolism and energy contained in the feces (Putri et al., 2012). The energy contained in feces contains ammonia. A low ammonia level indicates feces excreted by fish is low, so that the excess energy from the feed used for fish growth will be even greater. The aquaponics system can also reduce the ammonia concentration from fish feces in the cultivation medium. Ammonia is toxic to fish so that low levels of ammonia in the waters will be better for the fish because it reduces the cause of fish stress. If the fish is stressed, the fish appetite will decrease. Good water quality in the cultivation medium causes better fish growth.

The research results of Hasan et al. (2017) on the growth of different types of fish in the aquaponics system with water spinach plants showed that catfish grow with the highest rate, followed by tilapia, and the lowest is koi. This is in contrast with the results of this research, which showed that the growth of koi is greater than tilapia. The difference in the number of plant varieties used can be a contributing factor because in this research two plant varieties were used so that the water quality in the koi fish cultivation pond was also better.

## Survival Rate

Survival rate is the number of fish lived from the beginning until the end of cultivation (Effendi, 2003). Fish *survival rates* during the research are presented in Figure 2.

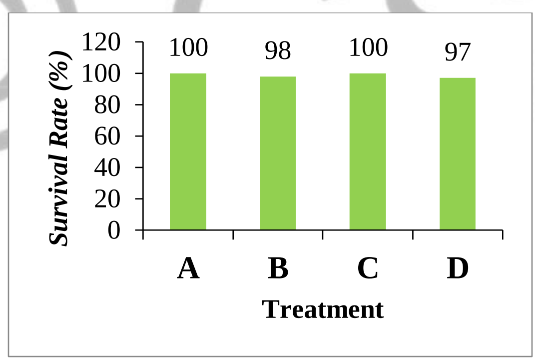


Figure 2. Fish *survival rate* during research

The survival rate of tilapia and koi fish in each treatment were 100%. This shows that the water quality in the fish culture medium is suitable for its survival. Water quality were determined by values of temperature, pH, DO and ammonia. The water quality in all of the treatments were sufficient for fish, because aquaponic system is helpful providing the conditions of water ecosystem that is ideal, in terms of the efficiency of absorption of feed, the process of nitrification, and optimal dissolved oxygen levels. Normal water quality will help in the nitrification process so that ammonia will turn into nitrate. This nitrate is not toxic to fish so that fish survival is high. If the water quality is poor, it will result in the formation of non-ionized ammonia, namely $NH^3$ which is toxic to fish so that it can cause death which resulted in low percentage of fish survival. This is different if the fish are stressed due to poor water quality, resulting in a reduced appetite for fish and the feed given is not used properly by the fish. The availability of oxygen also affects the fish respiration process. Fish that lack oxygen will experience stress, causing high mortality.

The high rate of survival of tilapia and koi fish during there search was also in fluenced by the appropriate stocking density because fish density could affect the culture environment and fish interactions. The appropriate stocking density will maintain the appropriate water quality, because the concentration of ammonia which is the result of cultural waste can still be tolerated and dissolved oxygen levels are still sufficient for respiration and nitrification processes. Adequate stocking density results in stableinteractions between fish because the living space is not too crowded for fish to move and there is no high competition between fish for feed. According to Muarif and Rosmawati (2010), high fish density causes water quality to decline. Higher density of fish causes ammonia level and $CO^2$ to increase, and decreases the solubility of oxygen. Higher density also causes living space to be more crowded, and increases fish interaction. For example, catfish is a cannibal fish, when fish interaction is high, then the chance for the fish to commit cannibalism is also higher, which causes rate of survival to be low.

Tilapia and koi fish are able to make good use of the feed so that their survival is high. Feed is the most important component in fish farming. Daily provision of feed with a complete nutrient, and ration composition tailored in accordance to the needs of the fish are important factors in effort to spur growth and increase rate of survival of fish. According to Asma et al. (2016) feed is one of the factors that greatly affect the growth of fish, as feed acts as an energy supplier to promote growth and maintain fish survival. The availability of feed is one of the absolute requirements for the success in fish farming. Feed is the source of protein, fat, carbohydrates, vitamins and minerals which are important for fish. Therefore, feeding with sufficient, high quality daily ration, is one of the factors that determine the success rate of fish cultivation.

Research conducted by Nugroho et al. (2012) showed that the average survival rate of tilapia in the aquaponics system planted with water spinach was 84%. Based on this, it can be concluded that by using water spinach and lettuce plants, this research yields better survival of fish, which is 100%, compared to the survival of tilapia in the aquaponics system which uses only one plant variety.

## Plant Growth

Plant height was measured once a week in situ during the research. The plant height measured from the beginning to the end of the study ranged from 4.92 to 58.09 cm. Water spinach plants has the highest height measurement of 58.09 cm and the lowest plant height is lettuce of 19.68 cm. Table 1 and Figure 3 show the results of research on plant height measurements.

Table 1. Plant Height during Research (cm)

| Treatment | Period (Week -) | | | | |
|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 |
| A | 15.16 | 20.25 | 29.92 | 40.41 | 58.09 |
| B | 5.65 | 10.23 | 13.70 | 18.35 | 23.25 |
| C | 5.21 | 10.04 | 19.65 | 28.88 | 37.15 |
| D | 4.92 | 7.17 | 10.37 | 16.23 | 19.68 |

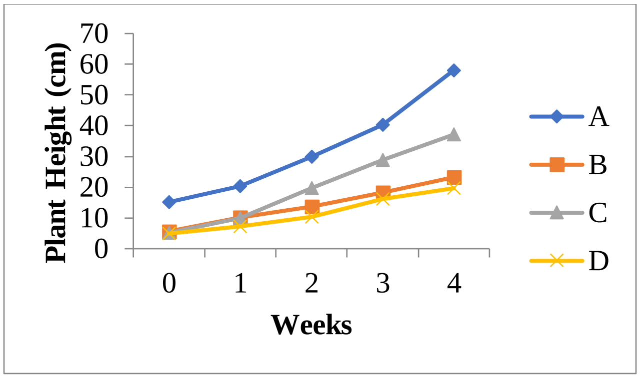


Figure 3. Change in plant height

Plant weights were also measured to see plant growth during the research. Weights were measured at the start and end of the study. The measurement results show that water spinach plants have greater final weight than lettuce. The results of the calculation of the increase in plants per day are shown in Figure 4.

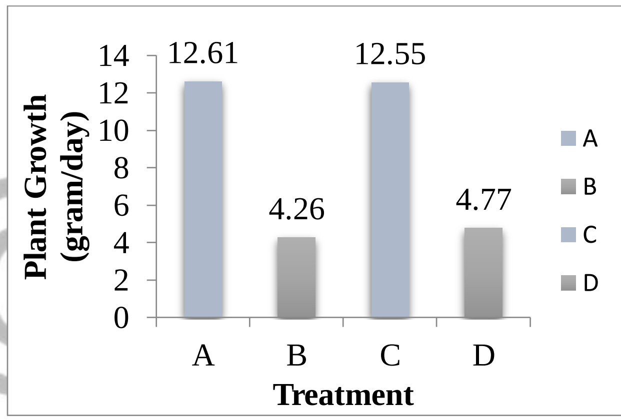


Figure 4. Plant growth

Plant growth is influenced by the amount of nutrients absorbed. Ammonia from feed and fish metabolism will be made into nitrogen which is used by plants as nutrients. Root growth will encourage the increase of amount of nutrients that can be absorbed by plants and used for metabolic processes. Adequate nutrient elements will support the growth of plant organs such as plant weight and height. Plant growth is in line with the reduction in ammonia levels in the water of the cultivation medium. This is in accordance with the statement of Firdaus et al. (2018), plants used in aquaponics system are able to have an effect on the total ammonia concentration in water. Plant based aquaponics is able to suppress ammonia levels in water than one without.

The highest plant weight gain was found in water spinach at 12.61 grams/day and the smallest weight was in lettuce at 4.26 grams/day. The weight of each plant at the beginning and end of the research showed different increases, this proved that each variety used had a different ability to absorb nutrients for growth. According to Firdaus et al. (2018), plants absorb nutrients in water for growth, one of which is weight gain.

Treatment A (water spinach plant with tilapia) has a higher weight increase because it is suspected that the remaining tilapia feed is more than koi fish. This is in line with Rahman's research (2015), a higher consumption of fish food will ultimately affect the amount of waste (a source of nutrition) produced. According to Padli et al. (2017) roots functions to absorb nutrients in plants. According to Hasan et al. (2017), roots are an important factor in determining plant productivity. The more extensive the root system, the higher the efficiency of nutrient and water absorption by plants. The more and larger the plants used in aquaponic cultivation, the more effective it is in reducing ammonia.

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The results of Hasan et al. (2017) regarding the growth of three types of fish and water spinach (*Ipomoea reptans Poir*) cultivated in an aquaponic system showed that the growth of water spinach plants, both the increase in stem length and the increase in number of leaf blade, and weight showed that the growth of water spinach in aquaponics was higher than the positive control (with compost media) and negative control (with soil media without compost). This is because the nutrients derived from feces and fish feed residue are easily broken down into inorganic nutrients in water and are more quickly absorbed by plants.

## Conclusion

Based on this research, it can be concluded that the combination of different fish and plants can improve water quality with temperatures ranging from 20.6 - 30.2 °C, pH between 6.54 - 8.57 and dissolved oxygen concentration of 4.5 - 8.8 mg / L during the study. The percentage reduction in ammonia concentration was the highest of all treatments at 87.79% in the combination of tilapia and water spinach with an increase in plant weight of 12.61 grams/day. The daily growth rate of koi fish was greater than tilapia by 2.49%

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