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2 Original Research Article
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4 **Growth of Lettuce and Water Spinach Plant**
5 **in Koi Fish (*Cyprinus carpio*) Culture in Aquaponics System**
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Comment [A1]: The title is not appropriate, Performance of lettuce and water spinach in Koi fish-based aquaponic system. If scientific name of Koi fish is to be retained, that of the two plants should also be mentioned.

7 **ABSTRACT**

8 This research aims to determine the growth of lettuce and water spinach plants used as
9 biofilter in koi fish (*Cyprinus carpio*) aquaponic system. Research was carried out at the
10 Laboratory of Fisheries, Ciparanje, Faculty of Fisheries and Marine Sciences, Universitas
11 Padjadjaran from March to April 2018. Research was carried out experimentally using
12 Randomized Block Design (RBD) with 2 treatments and 6 repetitions. The treatments were
13 used in the research is a combination of koi and land water spinach, and a combination of koi
14 and lettuce. The parameters observed were fish growth, fish survival, increase in length of
15 plant stems and increase in leaf strands. The research showeds that the use of land water
16 spinach plants as an aquaponic system biofilter is more effective than lettuce. The
17 combination of koi fish and land water spinach plants produced the highest productivity of
18 plants, with stem length of 39 cm and the addition of 15 leaflets. This combination also
19 produced the highest absolute growth of 3.93 grams / fish and survival rate of 100%.

Comment [A2]: Your research did not examine the efficiency of the plant as biofilter, it only examined the growth performance of the plants in aquaponics

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21 Keywords: Aquaponics, Biofilter, Water spinach, Koi, Lettuce
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23 **INTRODUCTION**

24 Cultivation activities produce solid waste and liquid waste from faeces and fish feed
25 residues. The accumulation of waste can cause a decrease in water quality which affects
26 physiological processes, behavior, growth, and mortality of fish. Therefore, management of
27 water quality is needed in fish culture's media (Gunardi and Hafsari, 2008).

28 Aquaponics is a combination of aquaculture and hydroponics that aims to maintain fish and
29 plants in a system that is interconnected. The interaction between fish and plants produces an
30 ideal environment for fish and plant to grow bigger, so it is more productive than conventional
31 methods (Fathulloh 2015). Aquaponics system reduces organic materials by absorbing
32 wastewater from cultivation processes using plant. Plants are grown in hydroponic systems
33 with roots submerged in water (Widyastuti 2008). The plants function as biofilter which will
34 break down toxic substances into substances that are not harmful to fish while supplying
35 oxygen to the water used for cultivating fish (Fathulloh, 2015).

36 Vegetable plants that are often used in aquaponic systems are including lettuce (*Lactuca*
37 *sativa L.*) and water spinach (*Ipomoea reptans P.*). According to Rokhmah (2014), lettuce is a
38 plant that is widely used in aquaponic systems, because it is short lived and is relatively less
39 problematic with pests compared to fruiting plants. Land water spinach is a fast-growing plant,

40 has lush roots and is not too strong, and its maintenance requires continuous water (Nugroho
41 and Sutrisno 2008).

42 The different types of plants will produce different uptake of organic matter, so that the
43 use of both types of plants in aquaponic systems can reduce organic materials. The koi fish is
44 used to see the growth response of the two types of plants. In addition, koi is a species of fish
45 that has economic value that encourages the community to increase production through
46 intensive cultivation. Koi carp is an economically important freshwater ornamental fish
47 cultured in Indonesia with annual production of cultured was 83,885 MT in 2012 (Kumar et al,
48 2015).

49 The purpose of this research is to determine the effectiveness of lettuce and land water
50 spinach plants as bio filter in koi fish culture in aquaponics system.

51 METHODS AND MATERIALS

52 Time and Place

53 Research was conducted in March to April 2018 at the Ciparanje Fisheries Cultivation
54 Laboratory, FPIK Unpad, while water quality tests were carried out at the Ecology Laboratory,
55 Center for Research and Development of Natural Resources and Environment (PPSDAL) of
56 Universitas Padjadjaran.

57 Research Materials

58 The vegetables used in this study were land lettuce and water spinach aged 1 to 2 weeks from
59 seeding. Rockwool served as the place for the roots of plants to stick, so the plants can be
60 stuck firmly in the pot. Koi fish used in this experiment were about 3-7 cm long.

61 Research Tools

62 Two pieces of fiber tub with a diameter of 30 cm and a depth of 100 cm were used as the
63 container for the fishes. Pump was used to draw water from the cultivation container to the 4"
64 PVC pipe. Two pieces of pumps with a size of 90 watts (4 meters) and 25 watts (2 meters), and
65 one heater for stabilizing water temperature were also used. 4" PVC pipe and ½" PVC pipe was
66 placed to drain water and retain water for the plants. As many as 228 pieces of Plastic cups
67 were used as a place to put the plants. Kenko brand digital scales with accuracy of 0.1 gram
68 was utilized to measure fish weight.

69 Research Methodology

70 The research methodology used in this study was the experimental method, by conducting
71 trials using lettuce and water spinach plants, and koi fish. The experimental design used was
72 Randomized Block Design (RBD) with 2 treatments repeated 6 times.

73 Research Procedure

74 Container Preparation

75 The container used in this research were two tubular fiber with a diameter of 30 cm and
76 with a depth of 100 cm.

Comment [A3]: This is insufficient about Koi, is it only grown in Indonesia, is it only reared as ornamental fish?

Comment [A4]: What the experient achieved differ from this. Effectiveness as a biofilter media can only be confirmed using water quality. The only thing achieved here is the comparative growth performance of spinach and lettece in aquaponic system for rearing of Koi fish.

Comment [A5]: Delete this and just write experimental design as the heading.

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81 **Fish Acclimatization**

82 Fish acclimatization was done so that the fish could adapt to the new environment and the
83 fingerlings could adjust when the research process took place. The newly purchased
84 fingerlings were stored in an acclimatization container (fiber tub) for 1 week so that the fish
85 did not get stressed and to reduce the high mortality value. Feeding was carried out on a
86 regular basis ad libitum 2 times a day (8:00 a.m. and 8:00 p.m.) so that the fingerlings continue
87 to get food intake during the adaptation process.

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89 **Preparation of Aquaponic Installation**

90 The recirculation aquaponics system was installed as such, where the fish and plants were
91 kept in separate container placed on a multilevel iron rack. Then, the water in the container
92 which the fish were kept was flowed into the plant containers using 4" PVC pipe. One end of 4"
93 PVC pipe on the top shelf was hollowed out and connected to the ½ " pipe PVC which has been
94 installed with a water pump as a tool to suck up water up to the plant maintenance container.
95 After that, under the drainage pipe there was a small tub acting as a water reservoir. The
96 water in the storage container were flowed back through the ½ " PVC pipe using a water
97 pump, so that the water could rise again to the fiber tub where the fish were kept.

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99 **Seeding**

100 The seeding process was done by planting lettuce seeds and water spinach on the net pot
101 using soil and rockwool. Lettuce and water spinach were sown for 2 weeks before planting in
102 the growing media on aquaponic media.

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104 **Research Implementation**

105 Research was carried out for 30 days. The density of koi fish was as much as 354 fishes.
106 Feeding was done twice a day at 07.00 and 15.00 WIB with feeding rate of 10% of total body
107 weight of fishes. After that, the number of fish that die was counted every day. The weight and
108 length of fish seeds were measured once a week to 30% of the total fish sample. Observation
109 of plants was carried out once a week by measuring the length of the plant stems and
110 increasing leaflets.

111 **Observation Parameters**

112 **Fish Growth**

113 The growth of the fish was measured by weighing the initial and final sample weight, then
114 measuring the total length of the fish. Absolute growth and growth rate were calculated using
115 the following formula (Ogunji et al 2008):

116 a. Absolute growth

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$$PM = W_t - W_o$$

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120 b. Growth rate

Comment [A6]: Describe the nutritional content of the feed used

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$$SGR = \frac{(\ln Wt - \ln Wo)}{T} \times 100\%$$

Comment [A7]: This should be division (/) sign or symbol

Keterangan :

- SGR = Specific Growth Rate (%)
- Wo = Initial weight of fish (g)
- Wt = Final weight of fish (g)
- T = Cultivation period (days)

Comment [A8]: %/day

Rate of survival

Fish survival was calculated using the following formula (Effendie 1979):

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

Comment [A9]: x100 and not x100%

Keterangan :

- SR = Survival of fish sample (100%).
- Nt = Number of test fish at the end of the study (fish)
- No = Number of test fish at the beginning of the study (fish)

Plant Observation

Measurement of the length of plant and counting the increase of leaflets were carried out regularly once every 7 days, starting from the beginning of the research until the last day of observation.

Data Analysis

The results of the data were analyzed descriptively through observational studies with supporting data and related literature. Furthermore, the data were analyzed using analysis of variance (F-test) with the confidence level of 95% to determine the effect of each treatment on the length of the plant stem and the addition of leaflets. If there are significant differences between treatments, then the data is analysed with Duncan's multiple distance test with α level of 5% (Gasperz 1991).

RESULTS AND DISCUSSIONS

Fish Growth

At the beginning of the experiment, the average weight of koi fish was 0.88 grams / fish and increased after 30 days of cultivation. The final weight of koi fish was 3.93 grams / fish (Fig 1).

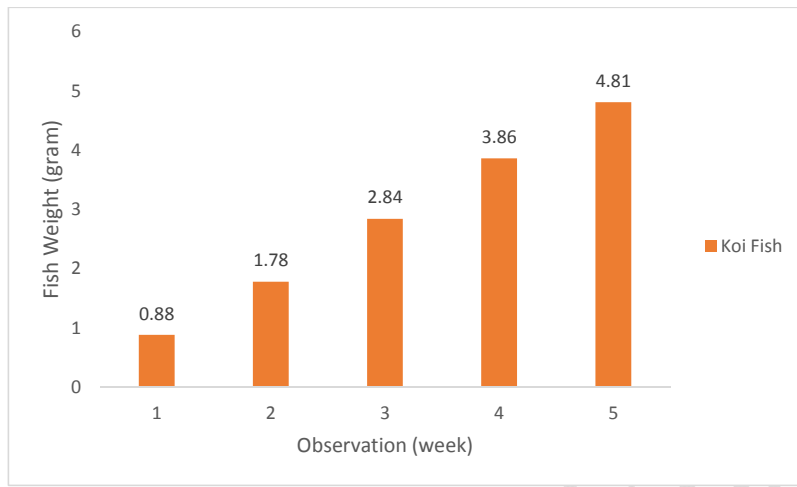


Figure 1. Average weight increase of koi fish

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The average growth rate in koi fish is 0.057%. Feeds with high protein content will support fish growth, especially the increase of biomass in fish. Feed protein nutrition for enlargement of koi fish ranges from 32% - 41%. The high protein requirements are mostly used to increase the colour brightness, so that the feed given with the protein content is still insufficient for the growth of koi fish (Ayu, 2013). Growth in koi fish is not optimal because when viewed from its physiology, koi fish do not have a stomach so that the digestibility runs longer and the feed that had been eaten will be decomposed slowly in the enlarged front intestine (Ratna Ayu 2012).

Rate of Survival of Fish

Survival is closely related to whether or not food is adequate, fish health, and whether cultivation environments is good or bad (Rika 2008). The protein content in feed can be used as a form of antibody that function against foreign substances that enter the body of the fish (Mudjiman, 2008). The environmental conditions of the research site are supported by the hygiene of the cultivation media. According to Sari (2014), materials that are not useful and even detrimental to fish will be sedimentated at the bottom of the cultivation container. Nitrogen cycle occurs in cultivation container due to the presence of decomposing bacteria and also inorganic materials (from food waste and fish metabolic waste). Aquaponics system reduces the waste by absorbing the wastewater using plant roots, so that the remaining absorbed feed undergoes an oxidation process with the help of oxygen and bacteria (Dauhan et al. 2014).

Based on 30 days of cultivation period, the survival rate of fish which cultivated in the aquaponics system showed an outstanding value, with 100% of survival rate of koi fish.

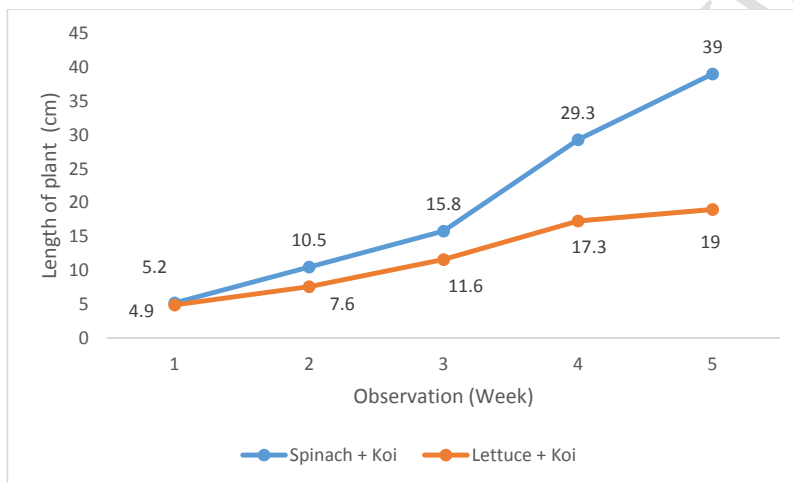
The Growth of Leaf and Length of the Plants

The average length of water spinach plants at the end of cultivation period ranged from 38.7 cm - 39.0 cm, while the lettuce plants were 19.0 cm - 20.7 cm (Figure 2). According to

Comment [A10]: The results should have shown the performance of Koi in the two treatments

Comment [A11]: This is not coherent.

183 Wasonowati (2013), plant growth is influenced by internal and external factors. Internal
184 factors that influence plant growth are related to physiological processes, while external
185 factors that affect plant growth including solar radiation, temperature, water, and nutrient
186 supply. There are 3 important things that affect stem growth, like the presence of light, growth
187 regulators and nutrients. The availability of water and nutrients affects the growth of
188 segments, especially by cell expansion. Plants that lack light will show symptoms of etiolation,
189 where plants will grow very fast in dark places but the condition of plants is weak and the
190 stems are not sturdy (Siswadi and Teguh, 2015). The increase of plant height and number of
191 leaves, is in line with increasing plant age (Edi, 2014).
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194 **Figure 2.** The growth of plant length
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196 The increase in the number of leaflets during the research ranged from 12-15 stands of
197 leaves in water spinach plants, whereas in lettuce plants there were 9-13 strands of leaves
198 (Figure 3). At the beginning of planting, the plants have an average of 4 leaves each. But after
199 the cultivation period, each treatment of plants had a different number of leaves. The highest
200 leaf growth was found in treatments with water spinach plants and koi fish, which had 19
201 leaves. The addition of leaf blade occurs because of the availability of sufficient nutrients to be
202 absorbed by plants.
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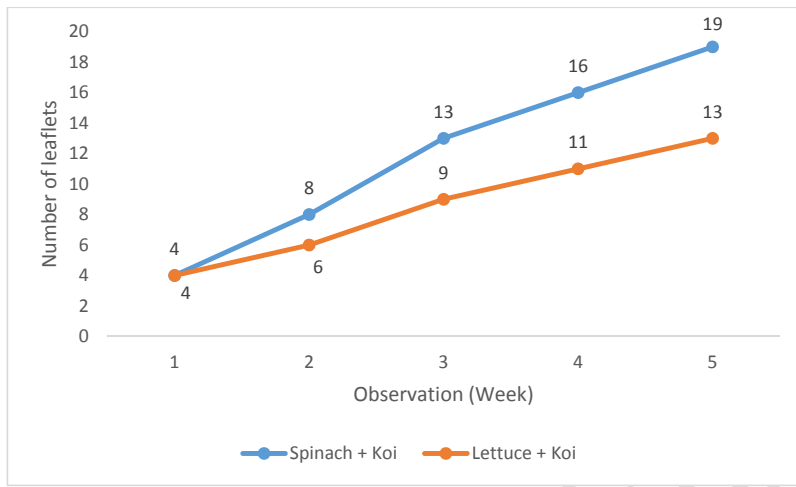


Figure 3. The number of leaves

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Leaves are vegetative organs of plants, their numbers greatly affect plant growth because the leaves are the organ where photosynthesis occurs. The more leaves there are in plants, the greater the production will be. In addition, the results of photosynthesis will affect plant growth and development (Mayani 2015). Plants that do not get additional nitrogen will grow stunted and the leaves formed will be smaller, thinner and the number will be lesser, while the plants that get enough nitrogen then the leaves formed will be larger and wider (Lakitan, 1996).

214 **CONCLUSION**

215 The result of this research showed that the use of water spinach plant as an aquaponic
216 system biofilter is more effective than lettuce. The combination of koi fish and water spinach
217 plant produced the highest productivity of plant, such as stem length of 39 cm and the
218 addition of 15 leaflets. The combination also produced the highest absolute growth of 3.93
219 grams / fish and survival rate of 100%.

Comment [A12]: There is no data to support this. Growth performance is different from effectiveness as biofilter media.

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UNDER PEER REVIEW