

4 **Growth of Lettuce and Water Spinach Plant**
5 **in Koi Fish (*Cyprinus carpio*) Culture in Aquaponics System**
6

7 **ABSTRACT**

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

20
21 Keywords: Aquaponics, Biofilter, Water spinach, Koi, Lettuce
22

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 to grow so it is more productive than conventional methods (Fathulloh
31 2015). Aquaponics system reduces organic materials by absorbing wastewater from cultivation
32 processes using plant. Plants are grown in hydroponic systems with roots submerged in water
33 (Widyastuti 2008). The plants function as biofilter which will break down toxic substances into
34 substances that are not harmful to fish while supplying oxygen to the water used for
35 cultivating fish (Fathulloh, 2015).

36 Vegetable plants that are often used in aquaponic systems including lettuce (*Lactuca sativa*
37 *L.*) and land 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 type of fish
45 that has economic value that encourages the community to increase production through
46 intensive cultivation.

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

49 **METHODS AND MATERIALS**

50 **Time and Place**

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

55

56 **Research Materials**

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

60

61 **Research Tools**

62 Fiber tub with a diameter of 30 cm and a depth of 100 cm as many as 2 pieces is used as a
63 container for the fishes. Pump is 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
66 place to drain water and retain water for the plants. Plastic cups as many as 228 pieces as a
67 place to put plants. Kenko brand digital scales with accuracy of 0.1 gram to measure fish
68 weight.

69

70 **Research Methodology**

71 The research methodology used in this study is the experimental method, by conducting
72 trials using two types of plants and two different types of fish with the same treatment. The
73 experimental design used was Randomized Block Design (RBD) with 2 treatments repeated 6
74 times.

75 **Research Procedure**

76 **Container Preparation**

77 The container used in this research is two tubular fiber with a diameter of 30 cm with a
78 depth of 100 cm.

79

80 **Fish Acclimatization**

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

87

88 **Preparation of Aquaponic Installation**

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

97

98 **Seeding**

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

102

103 **Research Implementation**

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

109 **Observation Parameters**

110 **Fish Growth**

111 The weigh increase of fish is measured by weighing the sample weight, then measuring the
112 total length of the fish. Absolute growth and growth rate are calculated using the following
113 formula (Ogunji et al 2008):

114 a. Absolute growth

115

116
$$PM = Wt - Wo$$

117

118 b. Growth rate

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120
$$SGR = (\ln Wt - \ln Wo) : T \times 100\%$$

121

122 Keterangan :

123 SGR = Specific Growth Rate (%)

124 W_o = Initial weight of fish (g)

125 W_t = Final weight of fish (g)

126 T = Cultivation period (days)

127

128 **Rate of survival**

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

$$130 \quad \text{SR} = \frac{N_t}{N_o} \times 100\%$$

131 Keterangan :

132 SR = Survival of fish sample (100%).

133 N_t = Number of test fish at the end of the study (fish)

134 N_o = Number of test fish at the beginning of the study (fish)

135

136 **Plant Observation**

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

140 **Data Analysis**

141 The results of the data were analyzed descriptively through observational studies with
142 supporting data and related literature. Furthermore, the data were analyzed using analysis of
143 variance (F-test) with the confidence level of 95% to determine the effect of each treatment
144 on the length of the plant stem and the addition of leaflets. If there are significant differences
145 between treatments, then the data is analysed with Duncan's multiple distance test with α
146 level of 5% (Gasperz 1994).

147 **RESULTS AND DISCUSSIONS**

148 **Fish Growth**

149 At the beginning of the experiment, the average weight of koi fish was 0.88 grams / fish
150 with a total length of 3.6 cm. After 30 days of cultivation, the final weight increases. Increase in
151 weight in koi fish was 3.93 grams / fish with a total length of 7.3 cm.

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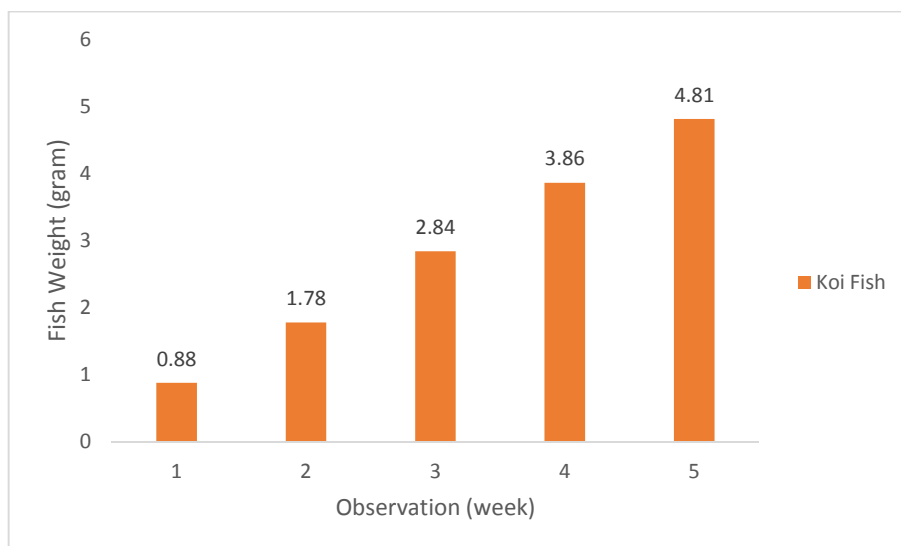


Figure 1. Average of weight increasing of koi fish

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156 The average growth rate in koi fish is 0.057%. Feeds with high protein content will support
157 fish growth, especially the increase of biomass in fish. Feed protein nutrition for enlargement
158 of koi fish ranges from 32% - 41%. The high protein requirements are mostly used to increase
159 the colour brightness, so that the feed given with the protein content is still insufficient for the
160 growth of koi fish (Ayu, 2013). Growth in koi fish is not optimal because when viewed from its
161 physiology, koi fish do not have a stomach so that the digestibility runs longer and the feed
162 that had been eaten will be decomposed slowly in the enlarged front intestine (Ratna Ayu
163 2012).

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165 **Rate of Survival of Fish**

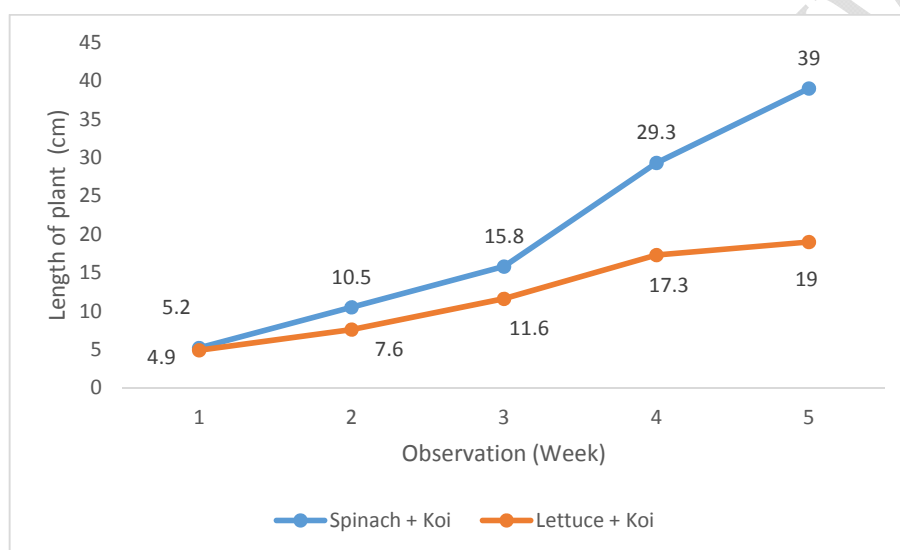
166 Survival is closely related to whether or not food is adequate, fish health, and whether
167 cultivation environments is good or bad (Rika 2008). The protein content in feed can be used
168 as a form of antibody that function against foreign substances that enter the body of the fish
169 (Mudjiman,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

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

179 **The Growth Leaf and Length of The Plants**

180 The average length of water spinach plants at the end of cultivation period ranged from
181 38.7 cm - 39.0 cm, while the lettuce plants were 19.0 cm - 20.7 cm (Figure 2). According to

182 Wasonowati (2013), plant growth is influenced by internal and external factors. Internal
183 factors that influence plant growth are related to physiological processes, while external
184 factors that affect plant growth including solar radiation, temperature, water, and nutrient
185 supply. There are 3 important things that affect stem growth, like the presence of light, growth
186 regulators and nutrients. The availability of water and nutrients affects the growth of
187 segments, especially by cell expansion. Plants that lack light will show symptoms of etiolation,
188 where plants will grow very fast in dark places but the condition of plants is weak and the
189 stems are not sturdy (Siswadi and Teguh, 2015). The increase of plant height and number of
190 leaves, is in line with increasing plant age (Edi, 2014).
191



192
193 **Figure 2.** The growth of plant length
194

195 The increase in the number of leaflets during the research ranged from 12-15 stands of
196 leaves in water spinach plants, whereas in lettuce plants there were 9-13 strands of leaves
197 (Figure 3). At the beginning of planting, the plants have an average of 4 leaves each. But after
198 the cultivation period, each treatment of plants has a different number of leaves. The highest
199 leaf growth was found in treatments with water spinach plants and koi fish, which had 19
200 leaves. The addition of leaf blade occurs because of the availability of sufficient nutrients to be
201 absorbed by plants.

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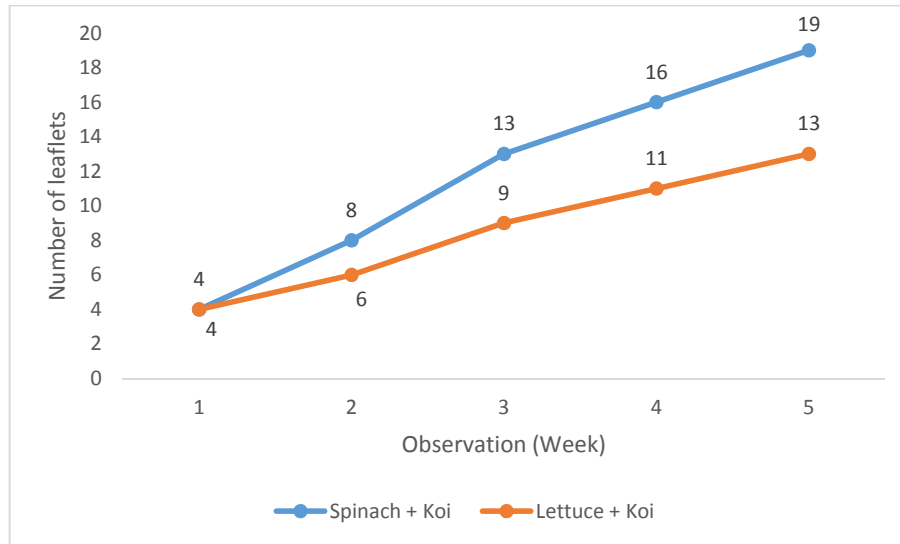


Figure 3. Graph of Number of Leaves

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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).

213 **CONCLUSION**

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

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