Performance of Lettuce and Water Spinach

in Koi Fish-based Aquaponics System

ABSTRACT

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

Keywords: Aquaponics, Biofilter, Water spinach, Koi, Lettuce

INTRODUCTION

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

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

Vegetable plants that are often used in aquaponic systems are including lettuce (*Lactuca sativa L.*) and water spinach (*Ipomoea reptans P.*). According to Rokhmah (2014), lettuce is a plant that is widely used in aquaponic systems, because it is short lived and is relatively less problematic with pests compared to fruiting plants. Land water spinach is a fast-growing plant, has lush roots and is not too strong, and its maintenance requires continuous water (Nugroho and Sutrisno 2008).

41   The different types of plants will produce different uptake of organic matter, so that the
42 use of both types of plants in aquaponic systems can reduce organic materials. The koi fish is
43 used to see the growth response of the two types of plants. In addition, koi is an ornamental
44 fish that has economic value that encourages the community to increase production through
45 intensive cultivation. Koi fish is an Asia-origin carp are currently listed among the most
46 important ornamental species as they can be reared in all countries throughout the world
47 (Hekimoğl et al 2014). In Indonesia, production of koi carp was reached 83,885 MT in 2012
48 (Kumar et al, 2015).

49   The purpose of this research is to compared growth performance of spinach and
50 lettuce in aquaponic system for rearing of koi fish.

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

58 **Research Materials**
59 The vegetables used in this study were land lettuce and water spinach aged 1 to 2 weeks from
60 seeding. Rockwool served as the place for the roots of plants to stick, so the plants can be
61 stuck firmly in the pot. Koi fish used in this experiment were about 3-7 cm long.
62

63 **Research Tools**
64 Two pieces of fiber tub with a diameter of 30 cm and a depth of 100 cm were used as the
65 container for the fishes. Pump was used to draw water from the cultivation container to the 4"
66 PVC pipe. Two pieces of pumps with a size of 90 watts (4 meters) and 25 watts (2 meters), and
67 one heater for stabilizing water temperature were also used. 4" PVC pipe and ½" PVC pipe was
68 placed to drain water and retain water for the plants. As many as 228 pieces of Plastic cups
69 were used as a place to put the plants. Kenko brand digital scales with accuracy of 0.1 gram
70 was utilized to measure fish weight.
71

72 **Research Methodology**
73   The research methodology used in this study was the experimental method using
74 Randomized Block Design (RBD) with 2 treatments repeated 6 times. The treatment consist :
75 Treatmen A   : lettuce and koi fish in aquaponic system

76 Treatment B   : waterspinach and koi fish in aquaponic system

77

78 **Research Procedure**

79 **Container Preparation**

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

82

83   **Fish Acclimatization**

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

90

91   **Preparation of Aquaponic Installation**

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

100

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

105

106   **Research Implementation**
107   Research was carried out for 30 days. The density of koi fish was as much as 354 fishes.
108   Feeding was done twice a day at 07.00 and 15.00 WIB with feeding rate of 10% of total body
109   weight of fishes. The feed use commercial crumble feed with crude protein contain 35% . After
110   that, the number of fish that die was counted every day. The weight and length of fish fry were
111   measured once a week to 30% of the total fish sample. Observation of plants was carried out
112   once a week by measuring the length of the plant stems and increasing leaflets.

113   **Observation Parameters**

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

119

120   **AG = Wt – Wo**

121
122   b. Growth rate
123
124   **SGR = (Ln Wt – Ln Wo) / T x 100%**
125
126   Note :
127   AG   = Absolute Growth (g)
128   SGR = Specific Growth Rate (% day)
129   Wo = Initial weight of fish (g)
130   Wt   = Final weight of fish (g)
131   T   = Cultivation period (days)
132
133   **Survival Rate**
134   Fish survival was calculated using the following formula (Effendie 1979):
135   **SR = Nt/No x 100%**

136   Keterangan :
137   SR = Survival of fish sample (100%).
138   Nt = Number of test fish at the end of the study (fish)
139   No = Number of test fish at the beginning of the study (fish)
140
141   **Plant Observation**
142   Measurement of the length of plant and counting the increase of leaflets were carried out
143   regularly once every 7 days, starting from the beginning of the research until the last day of
144   observation.

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

152   **RESULTS AND DISSCUSSIONS**

153   **Fish Growth**
154   At the beginning of the experiment, the average weight of koi fish was 0.88 grams / fish and
155   increased after 30 days of cultivation. The final weight of koi fish was 3.93 grams / fish and
156   4.15 grams/fish (Fig 1).

157
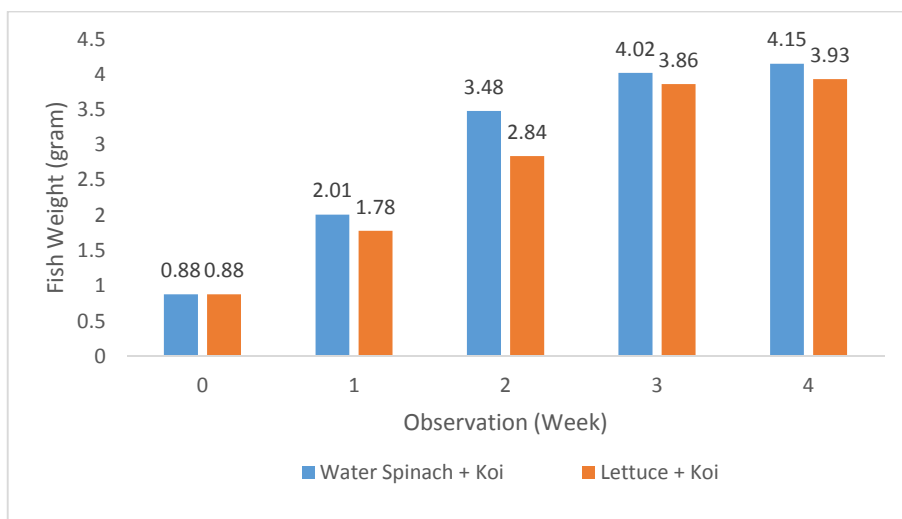
Figure 1. Average weight increase of koi fish

The growth of koi fish is different when combined with different plants (Table 1). The results showed that absolute growth and the growth rate of koi fish combined with water spinach had a higher value. This is related to the complexity root structure of water spinach so that it becomes a good biofilter and produces water quality that supports the growth of koi fish.

Table 1. Absolute Growth and SGR of Koi Fish

Treatment	Fish growth	
	Absolute growth (g)	SGR (% day)
A (Fish koi and water spinach)	3.27	0.0395
B (Fish koi and lettuce)	3.05	0.0371

Feeds with high protein content will support fish growth, especially the increase of biomass in fish. The feed test was fullfilled the need of koi fish nutrition (35%). Feed protein nutrition for enlargement of koi fish ranges from 32% - 41%. (Ayu, 2013). Growth in koi fish is not optimal because physiologically 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, either combination with water spinach and lettuce, which cultivated in the aquaponics system showed an outstanding value, with 100% of survival rate.

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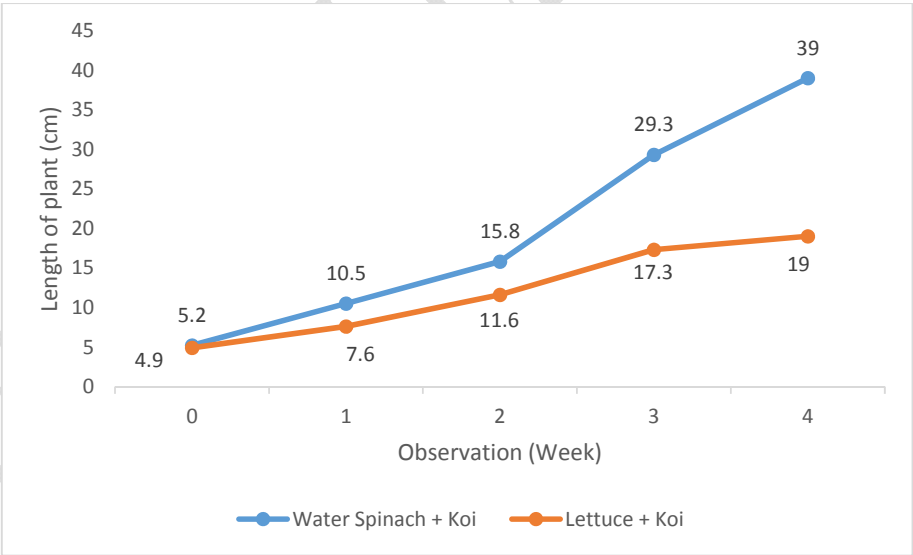

Figure 2. The growth of plant length

The increase in the number of leaflets during the research ranged from 12-15 stands of leaves in water spinach plants, whereas in lettuce plants there were 9-13 strands of leaves (Figure 3). At the beginning of planting, the plants have an average of 4 leaves each. But after the cultivation period, each treatment of plants had a different number of leaves. The highest leaf growth was found in treatments with water spinach plants and koi fish, which had 19

213 leaves. The addition of leaf blade occurs because of the availability of sufficient nutrients to be
214 absorbed by plants.

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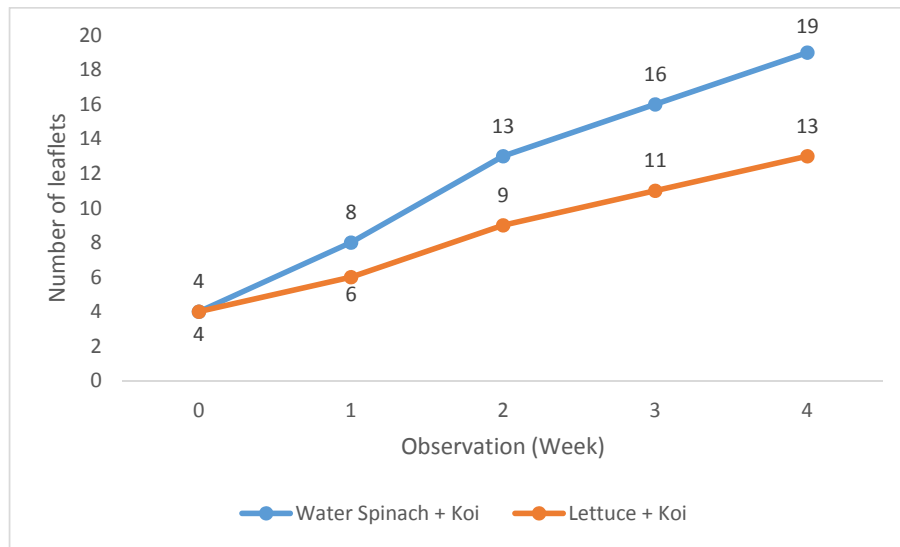
Figure 3. The number of leaves

219   Leaves are vegetative organs of plants, their numbers greatly affect plant growth because
220 the leaves are the organ where photosynthesis occurs. The more leaves there are in plants, the
221 greater the production will be. In addition, the results of photosynthesis will affect plant
222 growth and development (Mayani 2015). Plants that do not get additional nitrogen will grow
223 stunted and the leaves formed will be smaller, thinner and the number will be lesser, while the
224 plants that get enough nitrogen then the leaves formed will be larger and wider (Lakitan,
225 1996).

226 **CONCLUSION**

227   The result of this research showed that the use of water spinach plant in aquaponic system
228 is more effective than lettuce. The combination of koi fish and water spinach plant produced
229 the highest productivity of plant, such as stem length of 39 cm and the addition of 15 leaflets.
230 The combination also produced the highest absolute growth of 3.27 grams / fish and survival
231 rate of 100%.

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233   **REFERENCES**

234 Dauhan, R. E. S., E. Efendi dan Suparmono. 2014. Efektifitas Sistem Akuaponik dalam
235   Mereduksi Konsentrasi Amonia pada Sistem Budidaya Ikan. *Journal Rekayasa dan*
236   *Teknologi Budidaya Perairan,* 3 (1): 297-302.

237 Edi, S. 2014. Pengaruh Pemberian Pupuk Organik Terhadap Pertumbuhan dan Hasil Tanaman
238   Kangkung Darat (*Ipomoea reptans* Poir). *Jurnal Agroteknologi*, 3 (1): 17-24.

239 Gunardi, B. dan D. R. Hafsari. 2008. Pengendalian Limbah Amoniak Budidaya Ikan Lele dengan
240   Sistem Heterotrofik Menuju Sistem Akuakultur Nir-Limbah. *Jurnal Riset Akuakultur* 3.

241 Hekimoğlu, M.A, C. Suzer, Ş. Saka, K. Fırat. 2014. Enzymatic Characteristics and Growth
242   Parameters of Ornamental Koi Carp (Cyprinus carpio var. Koi) Larvae Fed by Artemia
243   nauplii and Cysts. Turkish Journal of Fisheries and Aquatic Sciences 14: 125-133

244 Kumar, R. , T. Raja Swaminathana, RG. Kumar, A Dharmaratnama, V.S. Basheera, J.K. Jena.
245   2015. Mass mortality in ornamental fish,Cyprinus carpiokoi caused by abacterial
246   pathogen,Proteus hauseri. Acta Tropica 149 (2015) 128–134

247 Mayani, N., T. D. Kurniawan dan Marlina. 2015. Pertumbuhan Tanaman Kangkung Darat
248   (*Ipomoea reptans* Poir) Akibat Perbedaan Dosis Kompos Jerami Dekomposisi Mol Keong
249   Mas. *Jurnal Lentera*, 15 (13) : 59-63.

250 Ogunji J., R. S. Toor., C. Shulz dan W. Kloas. 2008. Growth Performance, Nutrient Utilization of
251   Nile Tilapia (*Oreochromis niloticus*) Fed Housefly Maggot Meal (Magmeal) Diets. *Turkish
252   Journal of Fisheries and Aquatic Sciences,* 8 : 141-147.

253 Ratna, A. 2012. Pemberian Pakan Dengan Kadar Serat Kasar Yang Berbeda Terhadap Daya
254   Cerna Pakan Pada Ikan Berlambung Dan Ikan Tidak Berlambung. Jurnal Ilmiah Perikanan
255   dan Kelautan Vol. 4 No. 2, November 2012.

256 Rika. 2008. Pengaruh Salinitas terhadap Pertumbuhan dan Kelulushidupan Ikan Hasil Strain
257   GIFT dengan Strain Singapura. *Skripsi*. Universitas Diponegoro. Semarang.

258 Rokhmah, N. A., C. S. Ammatillah dan Y. Sastro. 2014. Vertiminaponik, Mini Akuaponik untuk
259   Lahan Sempit di Perkotaan. *Buletin Pertanian Perkotaan,* 4 (2): 14-22.

260 Sari. M., M. Hatta. Dan A. Permana. 2014. Pengaruh Ketinggian Air Dalam Pemeliharaan Larva
261   Ikan Hias Botia (*Chromobotia macracanthus* Bleeker). Acta Aquatica. 1:1. 2014. 24-30
262   hlm. ISSN: 2406-9825.

263 Siswadi dan T. Yuwono. 2015. Pengaruh Macam Media terhadap Pertumbuhan dan Hasil
264   Selada (*Lactuca sativa* L.) Hidroponik. *Jurnal Agronomika,* 9 (3): 257-264.

265 Wasonowati, C., S. Suryawati dan A. Rahmawati. 2013. Respon Dua Varietas Tanaman Selada
266   (*Lactuca sativa* L.) terhadap Macam Nutrisi pada Sistem Hidroponik. *Jurnal
267   Agroekoteknologi (Agrovigor)*, 6 (1) : 50-72.

268 Widyastuti, Y. R. 2008. Peningkatan Produksi Air Tawar melalui Budidaya Ikan Sistem
269   Akuaponik. *Prosiding Seminar Nasional Limnologi IV LIPI*. Bogor: 62-73.

270 Effendie, M.I. 1997. *Biologi Perikanan*. Yayasan Pustaka Nusatama. Yogyakarta.

271 Fathulloh, A.S. dan N.S. Budiana. 2015. *Akuaponik Panen Sayur Bonus Ikan*. Penebar Swadaya:
272   Jakarta.

273 Gaspersz, V. 1991. *Metode Perancangan Percobaan*. CV.ARMICO: Bandung.

274 Lakitan, B. 1996. *Fisiologi Pertumbuhan dan Perkembangan Tanaman*. PT Raja Grafindo
275   Persada. Jakarta.

276   Mudjiman, 2008. Makanan Ikan. Edisi Revisi,Penebar Swadaya. Jakarta. 148 hal.

277   Nugroho, E. dan Sutrisno. 2008. *Budidaya Ikan dan Sayuran dengan Sistem Akuaponik*.
278   Penebar Swadaya. Bogor.

279   Ayu, D. 2013. Variasi Kombinasi Tepung Labu Kuning (*Cucurbita moschata* D.) dan Tepung
280   Azolla (*Azolla pinnata* R.br.) pada Kecerahan Warna Ikan Koi (*Cyrinus carpio* L.) *Skripsi.*
281   Universitas Atma Jaya Yogyakarta. Yogyakarta.

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