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Increasing nutritional sources for the community through a household-scale aquaponics system during the covid-19 pandemic

Meningkatkan sumber gizi masyarakat melalui sistem aquaponik skala keluarga pada masa pandemi covid-19

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ABSTRACT

Introduction: *The growth of water spinach (Ipomoea reptans Poir) and pak choy (Brassica rapa Chinensis) in the aquaponics system with catfish (Clarias gariepinus) and their production cost were studied. The household-scale aquaponics system is made from inexpensive and easily obtained materials for each family to meet their nutrition needs.* ***Methods:*** *Experiments arranged in a complete randomized design (CRD) and obtained growth data were analyzed using Anova followed by DMRT. The manufacturing and operational cost of the aquaponics system is also calculated based on the local price.* ***Results****: The study results showed that the highest average fresh weight (37.3 g) and leaf number (43.7) of water spinach were obtained from growing bed A in the first planting period. Meanwhile, the highest fresh weight and leaf number of Pak Choy were 10.4 g and 7.7, respectively. At the final observation, the catfish's average body weight and length gain per week were 5.0 g and 2.5 cm, respectively.* ***Conclusion****: The total cost of a household-scale aquaponics system was IDR 1,868,500.00 (about USD 205) without labor costs. It suggested that this aquaponics system is affordable for most Indonesian families.*

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ABSTRAK

Pendahuluan: Pertumbuhan kangkung (*Ipomoea reptans* Poir) dan pakcoy (*Brassica rapa* Chinensis) pada sistem akuaponik dengan ikan lele (*Clarias gariepinus*) dan biaya produksinya telah dipelajari. Sistem aquaponik skala rumah tangga dibuat dari bahan yang murah dan mudah diperoleh untuk setiap keluarga untuk memenuhi kebutuhan gizinya. **Metode**: Percobaan disusun dalam Rancangan Acak Lengkap (RAL) dan data pertumbuhan yang diperoleh dianalisis menggunakan Anova dilanjutkan dengan DMRT. Biaya produksi dan operasional sistem akuaponik dihitung berdasarkan harga lokal. **Hasil:** Hasil penelitian menunjukkan bahwa rata-rata berat segar tertinggi (37,3 g) dan jumlah daun kangkung tertinggi (43,7) diperoleh dari *growing bed* A pada masa tanam pertama. Sedangkan bobot segar dan jumlah daun pakcoy tertinggi berturut-turut adalah 10,4 g dan 7,7. Pada pengamatan terakhir, rata-rata bobot badan dan pertambahan panjang lele per minggu masing-masing sebesar 5,0 g dan 2,5 cm. **Kesimpulan:** Total biaya sistem aquaponik skala rumah tangga adalah Rp 1.868.500,00 (sekitar USD 205) tanpa biaya tenaga kerja. Sistem akuaponik ini dipertimbangkan dapat terjangkau untuk sebagian besar keluarga Indonesia.

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INTRODUCTION

Since March 2020, the Covid-19 pandemic has been hit worldwide, including Indonesia. Many sectors have been disrupted, including agriculture (Edi, 2020). Therefore, agricultural innovations must be carried out to produce food and protein sources at an affordable cost. It is necessary to use existing land to produce food optimally. Aquaponic techniques are one solution offered to overcome this problem. Aquaponics is an appropriate technology that combines aquaculture and hydroponic techniques that use organic production methods due to nutrient-rich water sourced from aquatic species used for crop production (Castillo-Castellanos et al., 2016). This cultivation technology can produce vegetables as a source of vitamins and fish, and animal protein in a limited space. Furthermore, this program is in line with the government's program to reduce stunting in Indonesia by fulfilling family nutrition. In this

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study, we produced spinach (*Ipomoea reptans*) and Pak Choy (*Brassica rapa*) by utilizing the waste of Sangkuriang catfish (*Clarias gariepinus*) through an aquaponics made from inexpensive and easy to find materials that have to be able accessed by the low-income community. Edi (2020) proposed a hydroponics cultivation technique to provide food needs during the covid-19 pandemic. Hence, vegetable crop species may be harvested in a short time, mainly herb and or leafy vegetables (Dubbeling et al., 2010). Therefore, home gardening can play an important role in advancing food and nutrition security during and after the COVID-19 pandemic and strengthening the provisioning of ecosystem services at once (Lal., 2020). Water spinach and Pak Choy are popular vegetables in Indonesia because they are easily cultivated and are relatively inexpensive but rich in vitamins and minerals. According to Rahman & Parkpain (2004), water spinach contains vitamin A, C, calcium, iron, potassium, and phosphorus. Pakcoy is a vegetable species widely served in Chinese cuisine and popular in Indonesia. Each 100-gram portion of the Pakcoy plant contains 1.7 g of protein, 1.7 g of fat, 0.2 g of carbohydrate, 3.1 g of vitamins and minerals such as 2.3 g of β-carotene, 53 mg of vitamin C, and 102 mg of calcium (Tay & Toxopeus, 1994). Moreover, Utomo et al. (2017) found that minerals such as Ca, Mg, Sodium, Potassium, Fe, Mn Cr, and P in aquaponics vegetable samples are significantly higher than those in non-aquaponics. Sangkuriang catfish is a superior variety based on the Minister of Fisheries and Marine Decree. No. Kep.26/Men/2004. Catfish is a fish species preferred by most people because the price is affordable for all people and fast-growing. Catfish is also the most common aquaponics system after tilapia and ornamental fish (Love et al., 2015). According to the results of research by Ubaidillah & Hersoelistyorini (2010), every 0.05 grams of catfish sample contains 15.74% protein. Catfish are resistant to low water quality and a low level of dissolved oxygen (DO) due to being able to breathe directly from the air (Bosma et al., 2017). Hence it is favored extensively by freshwater farmers in the semi-arid region of Southeast Timor Province (Kallau et al. (2016). A study conducted by Hasan et al. (2018) showed that aquaponic water spinach with catfish produced the highest catfish weight.

The objective of this study is to observe the growth and production cost of leafy vegetables (water spinach and Pak Choy) and animal protein (Sangkuriang catfish) in a household-scale aquaponic system.

METHODS

Vegetable seeds and germination

Water spinach (*Ipomoea aquatica* Bangkok LP-1) seeds with 80% purity and 90% viability and Pakcoy (*Brassica rapa* var. Chinensis) (Nauli F1, East-West Seeds) with 98% purity and 99% viability, respectively, obtained from agricultural shops in Bogor, West Java. Water spinach and Pak Choy seeds are sown in a plastic tray moistened with enough water to germinate (Figure 1). The five seedlings of water spinach or one seedling of Pak Choy were put into a perforated mineral water plastic cup (volume 180 ml) before being transferred to aquaponics systems.

Catfish seeds

Sangkuriang catfish (*Clarias gariepinus*) seeds (16.3 g body weight and 12.6 cm body length) were obtained from a local farmer in Cibinong, Bogor, West Java. A-200 catfish seeds were grown in each fish tank of the aquaponics system.

Aquaponics planting

Each plastic cup containing water spinach or Pak Choy seedlings was placed on a grow bed hole. Grow beds of the aquaponics system consist of five-3 inches diameter PVC pipes (A to E) arranged vertically up to 2 m above catfish tanks, and each grow bed consists of nine (1-9) plant holes.

The leaf number and fresh weight were observed every week. Meanwhile, the catfish growth (weight and length) was observed every week for eight weeks. Catfish were fed every day at 2.5% body weight and harvested every four weeks during the planting period (8 weeks). Pak Choy was harvested after four weeks of transplanting.

Experimental design and analysis

Experiments were arranged in a complete randomized design (CRD) with three plant samples from each grow bed to determine the best growth of each grow bed. The experimental data were analyzed using Analysis of Variance (ANOVA and DMRT with SPSS 16.0 software.

Simple cost analysis

A simple cost analysis assumes the household scale aquaponics system in the home yard without a greenhouse and labor cost.

RESULTS AND DISCUSSION

Water spinach

In general, the growth of water spinach in the first planting period was higher than in the second period. In the first planting period, the average leaf number and fresh weight of water spinach were 6.9 leaves and 8.5 g per week, respectively, while the second planting period was 3.7 leaves and 5.9 g per week. The decrease in growth is due to reduced nutrition derived from fish and feed wastes absorbed by plants. According to Satari (1962), fish droppings contain N, P, K, Ca, and Mg.

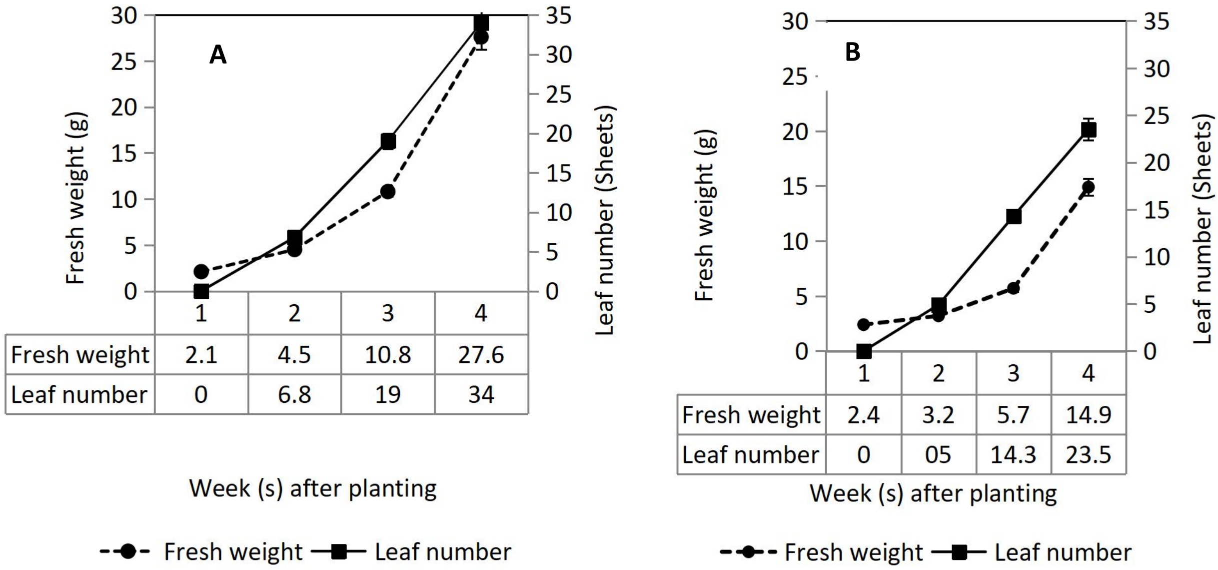


Figure 1. Water spinach growth in the aquaponic systems in First Planting Period (A) and Second planting period (B)

Statistical analysis showed the highest leaf number of water spinach obtained from growing beds D (43.7 sheets). It was significantly different (p <5%) with grow beds A and C. Meanwhile, there was no significant difference in the average leaf number among growing beds in the second harvest. The highest average plant weight in the first planting period (37.3 g); however, it was not significantly different from other grow beds. The highest plant weight (26.4 g) was obtained from growing bed D, which was significantly different (p <5%) from the results on other grow beds (Fig. 2). It seemed that grow bed A has more nutrient supply than the others due to the irrigation system of vertical aquaponics flowing from top to bottom.

The total wet weight yield in the first period was higher than in the second period. The nutrients absorbed by water spinach in the second period were much lower than in the first planting period. According to Seawright et al. (1998), nutrient concentrations excreted by fish and subsequently absorbed by plants quickly departed from initial conditions.

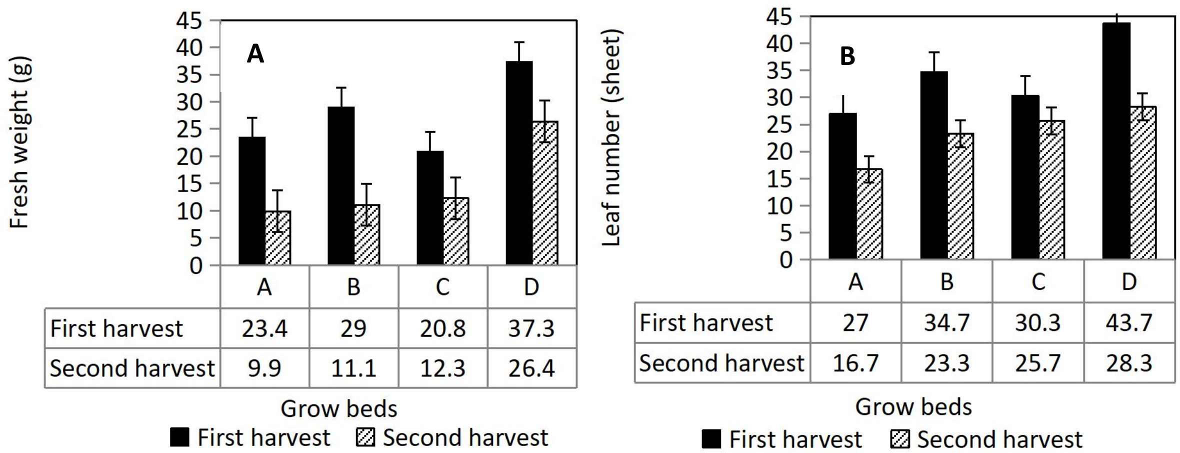
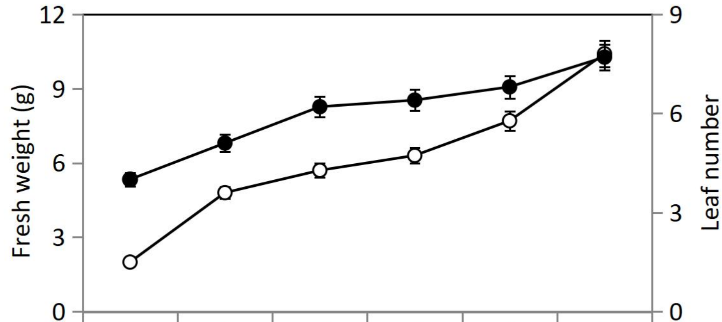


Figure 2. Fresh weight and leaf number of water spinach in the first harvest period (A) and second harvest period (B) in aquaponic systems

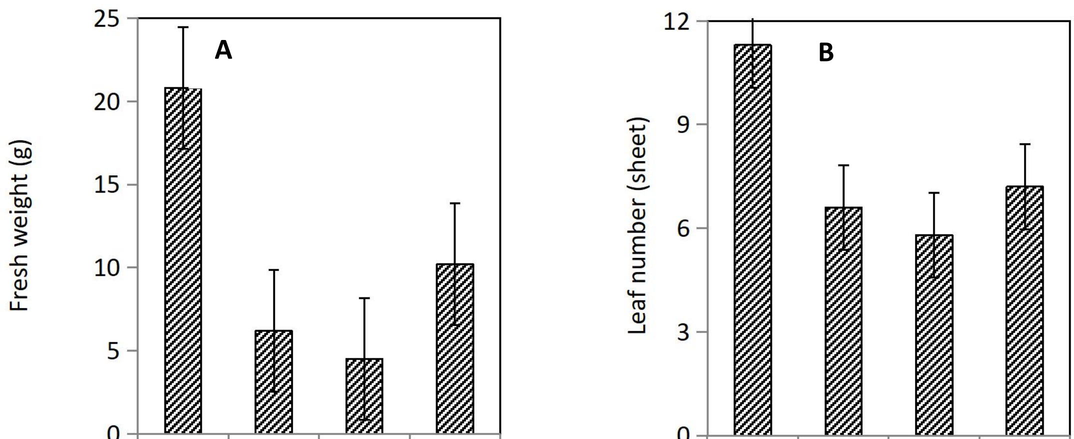
Pak choy

At the final observation (5th week), the fresh weight and leaf number of Pak Choy were 10.4 g and 7.7, respectively, which means the fresh weight and leaf gain were 2.08 g and 1.54 leaves per week. This result was lower than another study by Priadi et al. (2019) using 61.1 g weight and 23.3 cm catfish seeds. It seemed that it was affected by the nutrition volume from catfish wastes. The study conducted by Astuti & Larasati (2019) found that water pH 9-10 affected the nitrogen absorption that caused Pak Choy yellowish leaves and a small hump.



	0	1	2	3	4	5
Fresh weight	2	4.8	5.7	6.3	7.7	10.4
Leaf number	4	5.1	6.2	6.4	6.8	7.7

Figure 3. Pak Choy growth patterns in aquaponic systems using catfish for five weeks



	A	B	C	D
Harvest	20.8	6.2	4.5	10.2

	A	B	C	D
Harvest	11.3	6.6	5.8	7.2

Figure 4. The fresh weight (A) and leaf number (B) of water spinach for 5 weeks in the aquaponics system using Sangkuriang catfish

Catfish growth

The result showed that the average body weight and length gain per week for the final observation period (week eighth) were 5.0 g and 2.5 cm, respectively. Setiadi et al. (2018) found that the aquaponics system of *Brassica* sp. - Red tilapia (*Oreochromis niloticus*) resulted in better water quality and survival rates, weight, length, and the biomass of Red tilapia than those without it.

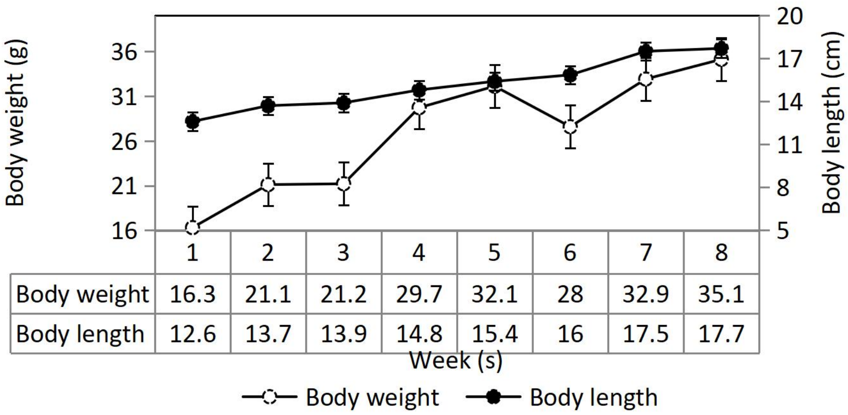


Figure 5. Catfish growth for eight weeks in the aquaponics system

Aquaponics production cost

Table 1. shows that the total cost of aquaponics water spinach using Sangkuriang catfish was IDR 1,868.500. (approximately USD 133.5). There are no labor costs because it is assumed that the work was done exclusively by the family members. There will be an additional cost of IDR 500,000 (approximately USD 35.7) if a worker is hired. This aquaponics system construction is made from a cheap, durable, and easily accessible material in the building materials and aquarium shop and does not require special skills to build. The cost of tools needed to make that aquaponics system has not to be included in the cost of production due to the fact that it is assumed that the essential tools are available in households (Johnson, 2016). That production cost was competitive with a mini aquaponics system called "vertiminaponik" developed by the Jakarta Assessment Institute for Agricultural Technology (BPTP) due to the use of a fiberglass container for the fish tank (ID 2,737,000) (Rokhmah et al., 2014).

The vertical aquaponics system is commonly found in urban areas to maximize space and for demonstration and exhibition purposes (Palm et al., 2018). The vertical aquaponic system reduced the spatial requirement for plants to make the production more sustainable (Khandaker & Kotzen 2018). Besides that, the aquaponics project is to strengthen the food sovereignty and innovation hobby at once (Sundari et al., 2019).

Table 1. The production cost of aquaponics of water spinach and Pak Choy using catfish in the household-scale aquaponics system

Items	Amount		Price (IDR)	Total price (IDR)
Infestation cost				
Lightweight steel truss 0,75 mm	4	pcs	100,000	400,000
Plastic sheeting	1	pc	125,000	125,000
Aquarium aerator 5 W	1	pc	35,000	35,000
Aquarium pump 25W	1	pc	60,000	60,000
PVC pipe 0,50 inches	1	pc	22,000	22,000
PVC knee 0,50 inches	2	pcs	2,500	5,000
PVC pipes 3,00 inches (grow beds)	2	pcs	97,000	194,000
PVC knee 3,00 inches	5	pcs	10,000	50,000
PVC pipe cap 3,00 inches	8	pcs	7,000	56,000
PVC pipe cap 6,00 Inches (filter)	1	pc	310,000	310,000
PVC pipe cap 6,00 inches	2	pcs	20,000	40,000
Total Investment cost				**1,297,000**
Operational cost				
Fixed cost				
Electricity per month	22	kWh	1,300	28,080
Variable cost				
Water spinach seeds	1	pack	14,000	14,000
Pak Choy seeds	1	pack	21,000	21,000
Catfish seeds	200	seeds	600	120,000
Catfish feed	25	kgs	12,000	300,000
Growing medium (Rockwool)	2	slabs	55,000	110,000
Net Pot (plastic cup 220 ml)	1	packs	6,500	6,500
Total operational cost				**571,500**
Total cost				**1,868,500**

CONCLUSION

The household-scale aquaponics system is feasible to be developed because it is helpful to improve family nutrition for low-income communities in rural areas and a creative hobby for urban communities that do not have enough space for farming practices.

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