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## AN UNDERSTANDING ON THE FEASIBILITY OF AQUAPONICS IN INTENSIVE AQUACULTURE POND

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### ARTICLE INFO ABSTRACT

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The study was conducted in a peri-urban village named, Panchpy under Gafargaon upazila of Mymensingh district with stinging catfish (*Heteropneustes fossilis*) and carps ponds to produce aquaponics vegetable *kolmi* (water spinach, *Ipomoea aquatica*) towards using waste substances of intensive stinging catfish ponds. Aquaponic plant (water spinach, *Ipomoea aquatica*) was grown in floating trays in the selected ponds. The water quality parameters including, temperature, pH, dissolved oxygen, nitrite and ammonia were measured during study period. The level of ammonia was higher in catfish pond compared to carps pond water. Inversely, the dissolved oxygen content of catfish pond water was lower than that of carps pond. In the stinging catfish pond, the mean value ( $\pm$  SE) of plant length, weight, number of branches and leaves were recorded at  $27.67 \pm 1.76$ ,  $62.67 \pm 2.03$ ,  $13.00 \pm 1.15$  and  $55.33 \pm 3.18$ , respectively. The corresponding values  $19.33 \pm 1.45$ ,  $46.67 \pm 1.86$ ,  $9.33 \pm 1.45$  and  $43.00 \pm 2.88$ , respectively in carps pond, were significantly lower than that of catfish pond. Overall the percent weight gain of *kolmi* was higher in catfish pond. A positive correlation was found between the length and weight of *kolmi* produced in both catfish and carp ponds, however  $R^2$  value of that relationship was higher for catfish pond due to higher level of available waste nutrients in water. This indicates that the potential of aquaponics research and development in intensively feed catfish aquaculture ponds at the farmer level that can feed the growing population in both rural and urban areas of Bangladesh.

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## INTRODUCTION

The term *aquaponics* is a portmanteau of the terms *aquaculture* and *hydroponic* (Mohamad et al., 2013). Aquaponics has been recognized as a sustainable food production system that combines a traditional aquaculture (raising aquatic animals such as snails, fish, crayfish or prawns in tanks) with hydroponics (cultivating plants in water) in a symbiotic environment. In aquaculture, effluents accumulate in the water create pollution to the aquatic environment that in turn increases the toxicity to the fish (Rakocy et al., 2004). This kind of polluted water can be linked to the hydroponic system where the by-products from the aquaculture are filtered out by the plants as vital nutrients, after which the cleansed water is re-circulated back to the animals.

Aquaponics system consists of two main parts, with the aquaculture part for raising aquatic animals and the hydroponics part for growing plants. Aquatic effluents resulting from uneaten feed of raising animals like fish accumulates in water due to the closed system. The effluent-rich water becomes toxic to the aquatic animal in high concentrations but these effluents possess various nutrients which are essential for plant growth. Although consisting primarily of these two parts, aquaponics systems are usually grouped into several components or subsystems responsible for the effective removal of effluents, for adding bases to neutralize acids, or for maintaining dissolved oxygen in water (Rakocy et al., 2006). Typical components of indoor aquaponics systems are rearing tank, solids removal bio-filter, hydroponics subsystem and sump. Generally plants are grown in aquaponics systems, with their roots immersed in the nutrient-rich effluent water. This enables them to filter out the ammonia from the effluents which is toxic to fish. After the water has passed through the hydroponic subsystem, it becomes cleaned and oxygenated, and can return to the aquaculture vessels (Wilson and Brian, 2006).

Recent advances by researchers and growers alike have turned aquaponics into a working model of sustainable food production. The integration of fish and plants results in a polyculture that increases diversity and yields multiple products. Over the last three decades, Bangladesh has got tremendous development in the area of aquaculture (DoF, 2014). Aquaculture development as a whole in the country in combination with production technology, favorable socioeconomic condition and culture environment has already proven successful in terms of increasing productivity, improving profitability and maintaining sustainability (Toufique and Belton, 2014). However, the intensive aquaculture systems particularly *Pangasius* catfish (*Pangasianodon hypophthalmus*) aquaculture has got several problems such as sediment deposition in the pond bottom, water pollution, poor fish growth and production and local environmental degradation (Haque, 2009; Ali et al., 2011; Anka et al., 2013). Stinging catfish (*Heteropneustes fossilis*) aquaculture has been developing along with *Pangasius* with similar kind of problems. This kind of problems could be minimized integrating aquaculture with hydroponics (Tyson et al., 2011). Aquaponics is relatively a new practice of aquaculture in Bangladesh for which very little works have been carried out. In this context, this research initiative was taken at the farmer level with the objectives to determine water quality parameters of intensive stinging catfish ponds where aquaponics system was tested to have an understanding of production performance of an aquaponic plant, water spinach, *Ipomoea aquatica*, which is called *kolmi* in Bengali.

## MATERIALS AND METHODS

### Location of the study area

This study was conducted at Gafargaon upazila of Mymensingh district where intensive catfish aquaculture is growing rapidly (Ahmed, 2009). In 2012, Mymensingh district was ranked first for pond fish production in Bangladesh, producing 2,43,100 MT and contributing 18% to the total pond fish production (FRSS, 2011-12). The intensive catfish culture (such as *Pangasius* catfish, stinging catfish) has been developing in all the upazilas of Mymensingh district in different scales. The number of ponds in Gafargaon upazila was 10,259 in 2000 and which was 11,200 in 2014 indicating the steady growth of aquaculture farms in the study area (DoF, 2015).

### Selection of the study site

The experiment was conducted in the catfish and carps ponds of Panchpy village at Gaffargaon upazila of Mymensingh district (Fig. 1). The study site was taken due to having available stinging catfish ponds which is the growing intensive production system of aquaculture and closed proximity of the location to the peri-urban community of Gaffargaon upazila town having increasing demand of fish and vegetables regularly.



**Figure 1.** Map (source: <http://www.banglapedia.org>) of Gaffargaon upazila showing the study site (encircled).

### Experimental design

This experiment was carried out in two ponds, one for stinging catfish (locally called shing) culture and other one for carps polyculture. The culture characteristics of catfish and carps are summarized in the Table 1. The catfish pond was stocked with shing (*H. fossilis*) and koi (*Anabas testudineus*) at the stocking density of 98,800/ha by the farmers as per their common practices. On the other hand, carps culture was carried out at the stocking density of 12,350/ha as per their traditional practices (Table 1).

This experiment was designed to assess aquaponics systems comparatively in catfish and carps pond following independent sample T-test, statistically. In each pond, 3 plastic trays each with the size of 0.12 m<sup>2</sup> were set in catfish pond and similar sized 3 trays were set in carps pond. These two sets of trays were designated as two different treatments (T<sub>1</sub> and T<sub>2</sub>). Four plastic bottles were set with each tray for floating the trays on the pond surface. On the floor of each tray, a thick layer of pond sediment taking from the same pond was made. In each of the tray, 6 cuttings of *kolmi* were planted in both of the treatments. Before planting of the cuttings, the weight, number of branches, leaves etc. of an individual cutting were measured. At the end of this experiment, about one month later, the final length, weight, number of branches, leaves etc. of an individual plant were also measured.

**Table 1.** Culture characteristics of catfish and carps in experimental ponds

Attributes	Stinging catfish culture	Carps culture
Stocking density	98800 fingerling/ha	12350 fingerling/ha
Species combination	Stinging catfish (80%), Climbing perch (20%)	Rohu (35%), Catla (20%), Silver carp (10%), Mrigal (15%), Common carp (20%) etc.
Culture period	6-7 month	6-10 month
Feeding	Commercial feed	Supplementary feed (rice bran, wheat bran)
Harvesting pattern	Harvest at the end	Partial harvesting (Using cast net)
Production	3458 kg/ha	3050 kg/ha
FCR	2.2	0.9
Water exchange	Only discharge of water during monsoon	Only discharge of water during monsoon

### Study of water quality parameters

To understand the environmental condition of pond, the physico-chemical parameters of water were needed to be measured. The main parameters including temperature, pH, dissolved oxygen, nitrate and ammonia were measured before starting the experiment. Water quality testing kits (Model: Sera test kit) were applied to test physico-chemical parameters of the ponds water. Initially the measuring vials were rinsed well with pond water which was being tested. The collected water sample from the mid-layer of the pond was tested on the pond side following the instructions labelled on Sera test kit to determine the water quality parameters.

### Study of growth parameters of water spinach

For determining the growth parameters, length, weight and number of leaves and branches were taken into consideration. The height of *kolmi* was measured from bottom to the tip of the plants by a centimeter scale. Accordingly, the weight of *kolmi* was measured by an electronic balance (Model: HKD-620AS-LED) in grams. The number of leaves and branches of *kolmi* was recorded manually based on eye observation. The percent gain of growth parameters of the aquaponic plan were measured using the following formula.

$$\% \text{ gain} = \frac{\text{Final stage} - \text{Initial stage}}{\text{Initial stage}} \times 100$$

### Data processing and analysis

The recorded data were entered into the spreadsheet in MS Excel 2010 and then summarized properly before statistical analysis. After entering the data, the descriptive statistical analyses were done by MS Excel. The inferential T-test was carried out using SPSS (Statistical Package for Social Sciences) version 16.

## RESULTS AND DISCUSSION

### Water quality parameters

Aquaculture production depends on physical, chemical and biological qualities of pond water to a greater extent. The successful pond management requires an understanding of water quality. Intensification of pond makes the water quality undesirable with a number of water quality parameters. Pond water quality is largely defined by temperature, transparency, turbidity, water color, carbon dioxide, pH, alkalinity, hardness, unionized ammonia, nitrite, nitrate, primary productivity, biological oxygen demand and plankton population (Bhatnagar and Devi, 2013). The average mean values of tested water quality parameters such as temperature, pH, dissolved oxygen, nitrate and ammonia of the experimental ponds are presented in Table 2. Apart from dissolved oxygen and ammonia, other water quality parameters were within the suitable range of aquaculture in Bangladesh. However, ammonia content in catfish pond water was significantly ( $p < 0.05$ ) higher than that of carps pond water. The accepted level of ammonia should be under the range of 0.05 to 0.10 mg/l (Shoko et al., 2014) and above range it is toxic to the cultured fish (Francis-Floyd et al., 2009). Higher level of ammonia content was found associated with lower level of dissolved oxygen in the catfish pond water (Table 2). In this situation, aquaponics system tested in the catfish pond could be the solution to maintain acceptable level of water quality parameter.

**Table 2.** Average (Mean  $\pm$  SE) values of water quality parameters between two treatments throughout the study period

Water quality parameters	Catfish pond	Carps pond
Temperature ( $^{\circ}$ C)	28.00 $\pm$ 0.00	28.00 $\pm$ 0.00
pH	7.43 $\pm$ 0.03	7.73 $\pm$ 0.03
Dissolved oxygen (mg/l)	4.0 $\pm$ 0.00	6.0 $\pm$ 0.00
Nitrite (mg/l)	0.00	0.00
Ammonia (mg/l)	0.05 $\pm$ 0.00	0.02 $\pm$ 0.00

### Growth and production of aquaponic plant

The initial length of a cutting of *kolmi* both in stinging catfish and carps pond was 7.00 cm which was differed significantly ( $p < 0.05$ ) between the catfish (27.67  $\pm$  1.76 cm) and carps (19.33  $\pm$  1.45 cm) pond after the end of trial (Table 3). Similarly, final weight of a cutting was significantly higher in catfish pond compared to carps pond. The number of branches per individual cutting during plantation was none, however, this was significantly higher in stinging catfish pond (13.00  $\pm$  1.15) compared to carps pond (9.33  $\pm$  1.45) after one month of trial (Table 3). As with branches, the number of leaves were higher in the trays placed in the catfish ponds than that of carps ponds. Accordingly total biomass (kg/m<sup>2</sup>) of water spinach was significantly higher in catfish pond compared to that of carps pond.

Overall, the growth performances of aquaponic plant were encouraging in stinging catfish ponds compared to carps ponds. This was due to the presence of nitrogenous waste available in the stinging catfish ponds. According to Mizanur et al. (2004), intensive aquaculture ponds sediments has various fertilizing components such as nitrogen, phosphorous, sulphur etc. which are very useful for growth and production of aquaponic plants. Moreover, water spinach is an efficient plant having clustered roots that can absorb nutrients from the water very efficiently (Kibria and Haque, 2012).

**Table 3.** Mean value ( $\pm$ SE) of growth parameters of water spinach in stinging catfish and carps pond

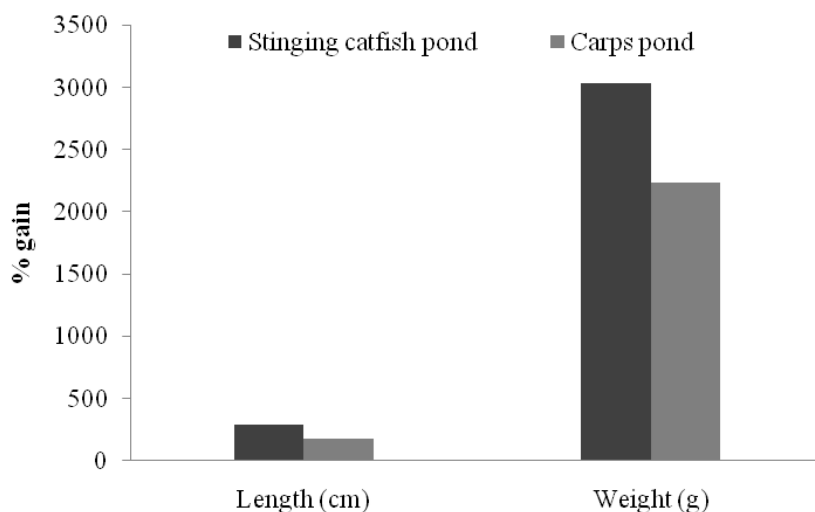
Growth parameters	Catfish pond			Carp pond		
	Initial	Final	% gain	Initial	Final	% gain
Plant length (cm)	7	27.67 $\pm$ 1.76	295.29	7	19.33 $\pm$ 1.45	176.14
Plant weight (g)	2	62.67 $\pm$ 2.03	3033.33	2	46.67 $\pm$ 1.86	2233.33
No. of branches	1	13.00 $\pm$ 1.15	1200.00	1	9.33 $\pm$ 1.45	833.00
No. of leaves	1	55.33 $\pm$ 3.18	5433.00	1	43.00 $\pm$ 2.88	4200.00
Total biomass (kg/m <sup>2</sup> )		3.13 $\pm$ 1.8			2.33 $\pm$ 1.3	

### Relative length and weight gain

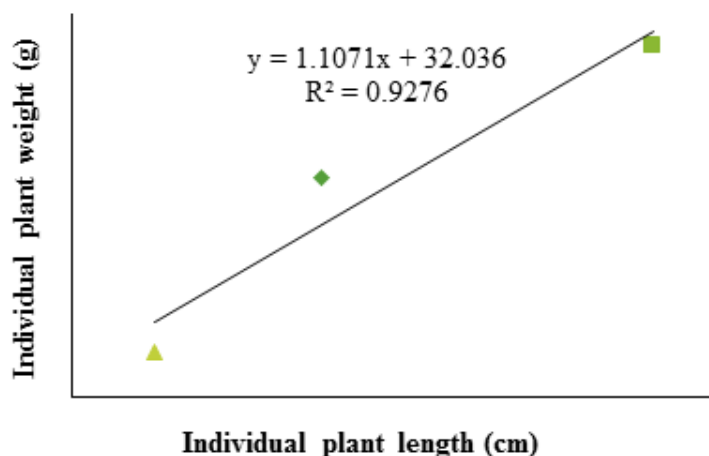
The percent length gain of the water spinach grown in the trays placed in catfish ponds was significantly ( $p < 0.05$ ) higher than that of carps pond (Figure 2). Similarly, the percent weight gain of water spinach grown in the tray placed in stinging catfish pond was higher ( $p < 0.05$ ) than carps pond. This was due to the fact that stinging catfish pond has the waste in the form of ammonia in water which has been used by water spinach as fertilizer (Turcios and Papenbrock, 2014).

### Relationship between plant growth parameters

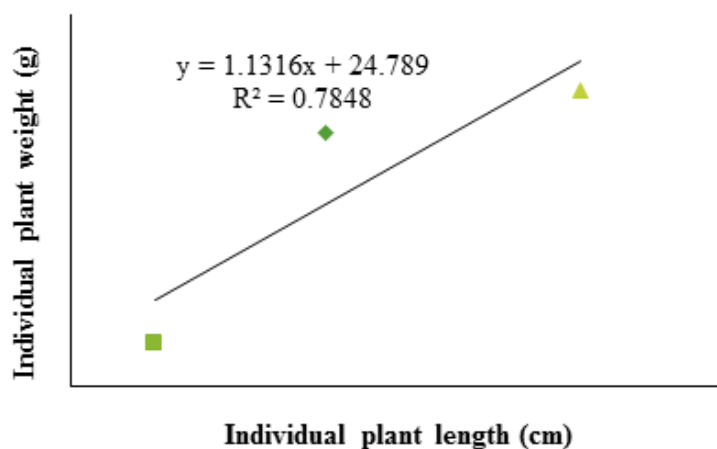
There was a positive relationship found between plant weight (g) and length (cm) produced in the trays of catfish pond (Figure 3). The increasing live weight of individual plant of water spinach was depended largely ( $R^2 = 0.9276$ ) on the increasing growth in length. The similar type of relationship was found for water spinach grown in the tray placed in carps pond (Figure 4), however, this relationship between weight and length was not as stronger as in catfish ponds.



**Figure 2.** Comparative percent length and weight gain of live water spinach grown in the tray placed in stinging catfish and carps pond.



**Figure 3.** Relationship between *kolmi* weight (g) and length (cm) in stinging catfish pond.



**Figure 4.** Relationship between *kolmi* weight (g) and plant length (cm) in carps pond.

According to DEPI (2002), the length-weight relationship of water spinach depends on the fertility of media from where nutrients are supplied. The plant's length-weight relationship is attributed to a variety and concentration of nutrients, of which nitrogen is the dominating factor. Waste water of stinging catfish ponds supplied various nitrogenous components of which ammonia has considerable fertilizing supports to the plant under floating condition on the pond surface (Kibria and Haque, 2012).

## CONCLUSION

Aquaculture industry is now contributing to increasing demand of animal protein along with livelihoods of millions of people but full potential of aquaculture has not been realized yet and further development is required to keep up demand for nutrition from various sources. This study proved that floating aquaponics system could be developed in the intensive aquaculture ponds in Bangladesh to ensure production of nutrient rich fish and micro-nutrient rich vegetables in the balanced environmental condition of ponds. Further large-scale research works need to be carried out to design and construct proper floating aquaponics system with appropriate ratio of pond area so that maximum waste materials could be minimized.

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