Research in
ISSN : P-2409-0603, E-2409-9325
AGRICULTURE, LIVESTOCK and FISHERIES
An Open Access Peer Reviewed Journal

Open Access
Research Article

Res. Agric. Livest. Fish.
Vol. 5, No. 1, April 2018 : 93-106.

AQUAPONIC PRODUCTION OF TILAPIA (*Oreochromis niloticus*) AND WATER SPINACH (*Ipomoea aquatica*) IN BANGLADESH

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ARTICLE INFO

Received
07 January, 2018

Accepted
24 January, **2018**

Online
30 April, 2018

Key words
Aquaponics
Water spinach
Tilapia
Production
Bangladesh

ABSTRACT

The experiment was conducted to assess the water spinach production in aquaponic system using two different media for a period of 90 days. Only brick lets was used as media in treatment T_1, whereas in treatment T_2 media had mixture of brick lets and used tea leaves. Six 20 liter plastic containers and a 750 L water tank were used for vegetable bed and fish rearing respectively. Fish and water spinach were sampled fortnightly. The highest average plant height, weight and number of leaves recorded in T_1 were 35.96 ± 4.75 cm, 59.09 ± 23.85 g and 93.90 ± 38.52, respectively. Total production of water spinach in T_1 and T_2 was 1.26 and 0.98 kg, respectively. At the end of the experiment, % length and weight gain was 33.81 and 174.06, the survival rate and FCR was found to be 98.33% and 1.56, respectively. The total production of fish was 29.44 tons/ha/90 days. The system produced higher amount of fish as well as vegetable with minimum water use having no environmental pollution. The system efficiently utilized fish waste in plant production through a symbiotic relationship between the fish and plants. Therefore, the system could be installed in high density city areas to produce fish and vegetable from the rooftop and backyard to address the environmental problems.

To cite this article: Akter B, SC Chakraborty and MA Salam, 2018. Aquaponic production of Tilapia (*Oreochromis niloticus*) and water spinach (*Ipomoea aquatica*) in Bangladesh. Res. Agric. Livest. Fish. 5 (1): 93-106.

INTRODUCTION

Aquaponic is a bio-integrated multi-trophic system which links recirculating aquaculture (culture of fish) with hydroponic (culture of soil-less plants) that results in a symbiosis between fish, microorgnisms and plants (Figure 1). Within this synergistic interaction, the respective ecological weakness of aquaculture and hydroponics are converted into strength (Goddek et al., 2015).Though the concept of modern aquaponic system has been developed in the late 70s and early 80s (Love et al., 2014), but very new in Bangladesh. Aquaponics can be considered a sustainable agricultural production system as it does not deplete any non-renewable resources that are essential to agriculture in order to sustain the agricultural practices (Lehman et al., 1993).

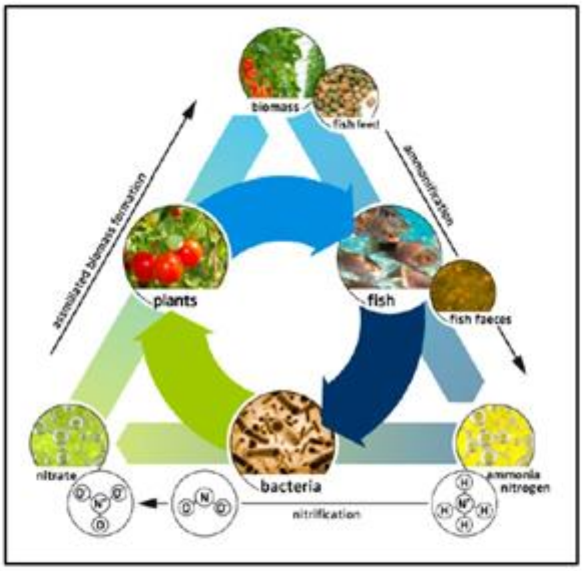

Figure 1. Principles of the aquaponic system (Goddek et al., 2015)

In these integrated systems, nutrients, which are excreted directly by the fish or generated by the microbial breakdown of organic wastes, are absorbed by plants cultured hydroponically (Rackoy et al., 1989; Adler et al., 2003). Systems that grow additional crops by utilizing by-products from the production of the primary species are referred to as integrated systems. If the secondary crops are aquatic or terrestrial plants grown in conjunction with fish, this integrated system is referred to as an aquaponic system. Plants grow rapidly with dissolved nutrients that are excreted directly by fish or generated from the microbial breakdown of fish wastes. In closed recirculating systems with very little daily water exchange (less than 2 percent), dissolved nutrients accumulate in concentrations similar to those in hydroponic nutrient solutions (Rackoy et al., 2006).

Naturally, some plant species are better adapted to this system than others (Rakocy et al., 1993). There are some advantages of aquaponic system as it recycles water and nutrients which isenvironmental friendly. In addition, eliminates the use of chemicals and pesticides. In aquaponic system a wide verities of plant as water spinach, Indian spinach, tomato, mint, cabbage, capsicum, lettuce, cucumber etc. can be easily grown. Among them water spinach is a wonderful green-leafy vegetable have been extensively investigated as new sources of natural antioxidants as well as other bioactive compounds of human health benefits (Lakshmi and Vimala, 2000). It is also found in wild environment but Kalmishak is susceptible to aquatic pollution, water carrying pathogens, various chemicals, insecticides, pesticides etc. As water spinach is a nutritious food it is widely cultivated in polluted water which is harmful for human health. In this situation the aquaponic system will provide pollution, insecticide and pesticide free water spinach growing environment.

On the other hand, fishes those are hardy, high growth potential and can tolerate a wide range of water quality parameters are suitable for culture in aquaponic system (Johanson, 2009). For this purpose Tilapia tend to be the fish of choice in most aquaponic systems. Tilapia (*Oreochromis niloticus*) is exceptionally hardy and grows well in high density systems. The market price for live tilapia is high in nationwide and at the high density grown in most systems (Rakocy, 1999). Therefore, the present study was conducted to assess the combined production of tilapia and water spinach in aquaponic system using two different media.

MATERIALS AND METHOD

Study area and duration of the experiment

The whole duration of the experiment was 96 days, from 08th June to 12th September 2014, to assess water spinach production in aquaponic system using two different media, in the Aquaponic Laboratory which situated in the southern side of the Faculty of Fisheries, Bangladesh Agricultural University, Mymensingh, Bangladesh.

Experimental layout

Various types of aquaponic system exist among which media based aquaponic system was chosen to conduct the present experiment. The design of the study comprises a fish holding tank and six food grade plastic containers to hold the media. Two types of media were used in this experiment that was 100% brick lets (8-10 cm size) and brick lets mixed with used tea leaves (1:1 by volume). All the beds were in equal size (43.7 x 26.8 x 24.5 cm^3) for the treatments. The treatments were indicated as T_1R_1, T_1R_2, T_1R_3, T_2R_1, T_2R_2 and T_2R_3 (Figure 2). The size of the circular fish tank was 68 cm×51 cm (750 Volume liters). Two 10 watt air pumps with two ports fitted with 4 air stones were used in fish tank to supply oxygen. The waste water from the fish tank was irrigated to the vegetable bed by a 12 watt submersible water pump.

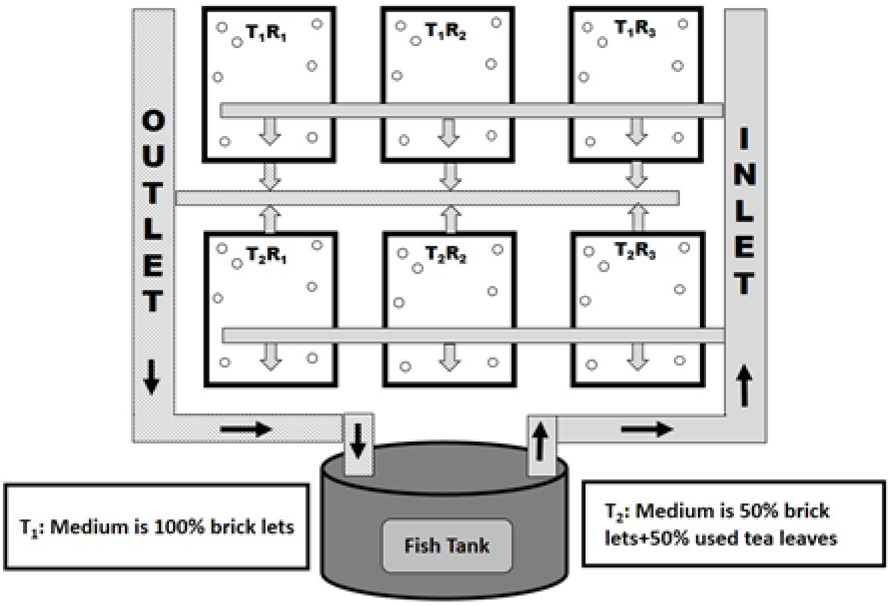

Figure 2. Experimental design of the study

An inlet and outlet pipes were set to the tank. The water was re-circulating the system. Two small PVC pipes were connected to the plastic pipe where containers containing plants were placed. Small pipes were connected to the end of the plastic pipe through which waste water circulated from the fish tank with the help of water pump. A PVC pipe was connected to each container with another plastic pipe to the outlet pipe to drain the water in the fish tank.

Fish tank preparation

The fish tank was bought from local market and prepared before starting the experiment. Preparation of tank included cutting of upper end, washing, liming, plumbing pipes; setting brick lets and fills up the tank with underground water. At first, the upper part of the tank was cut out to make an opening for feeding the fish and cleaning the tank. The tank was then washed with disinfectants mixed water. It is essential to wash the fish tank before starting the fish culture to remove the chemicals if any. The pipes were set to make an inlet and outlet. Two air pumps with four air stones were set to supply dissolve oxygen. The tank was then filled with brick lets of 2-5 cm diameter up to six inches at the bottom of the tank. Before placing the brick lets they were washed with clean water and finally the tank was filled with water from overhead tank. A separate filter was used to filter the fish tank water and placed over the fish tank (Figure 3).

Figure 3. A 750 liter water tank used for Fish rearing.

Figure 4. Releasing fish in the fishtank.

Stocking of fish

Mono sex tilapia fingerlings were used as the experimental animals which was brought from a local hatchery and used in another aquaponic experiment. The collected fish was acclimatized and released to the experimental fish tank. Good and healthy fingerlings were selected for the experiment. Before stocking the fingerlings were disinfected with potassium permanganate solution (2 mg/L for 4 to 5 hours). Prior to release fingerlings the fish was acclimatized for 15 minutes for each degree change in temperature and for every unit change in p^H. After acclimation, 60 fingerlings of tilapia were released into the tank on 4th June, 2014 (Figure 4).

Feeding the fish

The commercial floating feed (1-- 3 mm size) containing 30% protein was used to feed the fish. The feed was bought from the local fish dealer. The feed was supplied twice daily, first in the morning at 9:00 AM and in the afternoon at 5:00 PM at the rate of 3% body weight initially. Over feeding was avoided as uneaten feed make the fish tank water unsafe for fish and will lead to water quality degradation. Later on the feed was reduced to 3%of the fish body weight.

Sampling of fish

On 4th June 2014 during releasing the 1st sampling was done. It was carried out bi-weekly. Scoop net was used for sampling. At the sampling time no feed supplied to the fish. Ten fishes were caught randomly from the tank and collected to another bucket containing aerators. Then length and weight of each ten fishes were measured carefully. The length was taken with a measuring scale (Figure 5) and weight was taken with an electronic compact balance (KD-S/F-en) (Figure 6). All the data were recorded carefully. After recording, the fishes were released to the tank immediately. The last sampling was done on 4th September 2014. During the last sampling all the fishes were harvested and measured the weight and length.

Figure 5. Measuring length of fish

Figure 6. Measurement of Fish weight

Growth parameters

The following parameters were used to evaluate the growth of fish such as length gain (cm), weight gain (g), percent weight gain, specific growth rate (SGR), food conversion ratio (FCR), survival rate (%) and fish production (Kg/ha).

Length gain

The fish length gain was measured following the formula:

Length gain (cm) = mean final length (cm) – mean initial length (cm)

Weight gain

The weight gain of the harvested fish was measured with the formula:

Weight gain (g) = mean final weight (g) - mean initial weight (g)

Percent weight gain

This is fairly straight forward measure of overall increase in the mean body weight over a time period.

$$= \frac{\text{Mean final weight} - \text{Mean initial weight}}{\text{Mean initial weight}} \times 100$$

Specific growth rate (SGR)

The specific growth rate is the immediate change in weight of fish calculated as the percentage increase in body weight per day over given the time interval. The specific growth rate (SGR) was determined by following formula:

$$\text{SGR}(\%\text{per day}) = \frac{\text{Log}_e W_2 - \text{Log}_e W_1}{T_2 - T_1} \times 100$$

Here, W_2 = Mean final weight (g),

W_1 = Mean initial weight (g),

T_2-T_1 = Express the duration of experimental period

Food conversion ratio (FCR)

FCR expressed by the rate of food consumed to weight gain was determined by the following formula:

$$\text{FCR} = \frac{\text{Amount of dry feed (kg)}}{\text{Weight gain (kg)}}$$

Survival rate (%)

The survival rate of the fish was calculated from the number of fish harvested from the each treatment at the end of experiment and those data at the start of the experiment. The survival rate was estimated by the following formula:

$$\text{Survival rate} = \frac{\text{No.of fish harvested}}{\text{No.of fish stocked}} \times 100$$

Fish production

The production of fish in the treatment was determined by multiplying the mean increased weight (g) of each fish by the total number of fish. Production was calculated by the following formula:
Fish production= No. of fish harvested× mean increased weight

Bed preparation for water spinach culture

Cheap, locally available, and good quality food grade plastic containers were used as kolmi culture bed. Six plastic containers were bought from local market. The size of the cane was 43.7 × 26.8 × 24.5 cu cm. Upper side of each cane was cut out by using a sharp knife. One pore was made in one side of each plastic cane to make outlet for re-circulating water 3 inches above the bottom of the cane. They were cleaned properly and sun dried before use. Plastic canes were placed side by side and another 15% area was kept for maintenance.

Brick lets media

Bricks were bought from local brick field. Using hammer they were broken into 2-3 cm size. Brick lets were washed properly before using in the canes. Three plastic canes were filled with the brick lets and indicated as T_1R_1, T_1R_2 andT_1R_3 (Figure 7).

50% brick lets and 50% used tea leaves

Brick lets were collected locally for the experiment. The size of brick lets were 2-3 cm. They were cleaned properly. Used tea leaves were collected from local tea stall. Same amount of brick lets and used tea leaves (in volume) was filled layer by layer by using spade in three containers and indicated as T_2R_1, T_2R_2 and T_2R_3. Then the containers were kept side by side outside of the Aquaponic lab on a bamboo. A plastic PVC pipe was perforated by drill machine and used for inlet of water to the vegetable beds (Figure 8)

Figure 7. Preparation of Brick lets medium

Figure 8. Mixture of Brick lets and used tea leaves media

Figure 9. Water spinach sapling plantation in the container

Planting of water spinach sapling

After putting the media in the plastic cane, water spinach saplings were collected from the Horticulture Farm at Kewatkhali at the first gate of BAU and planted on it. The kolmi saplings measuring 5 cm height that used for plantation in the experiment. Total number of planted saplings was 24. Four saplings were planted in four corners of each of the bed. Plantation was done on 12th June, 2014 (Figure 9).

Watering to the vegetable beds

Watering was started after plantation was done in the containers containing media. Only fish tank water was used for watering. Watering was done by using a porous PVC pipe. Pipes were cleaned regularly to provide maximum waste water supply. A motor was used for watering of plant from fish tank to beds (Figure 13). In night time waste water supply was stopped. No fertilizer was used in the vegetable beds. Initially 10-15 days was required to slowly grow denitrifying bacteria in the beds and nitrification started in full swing. After that time plants grew well. Less weeding usually required in aquaponic system, however, wedding was done regularly when any unwanted plants grow in the system.

Harvesting

After 15 days of planting water spinach plants become harvestable size.

Plant growth data collection

The experiment was conducted to assess water spinach production in aquaponic system using two different media. So some data recorded for proper study as plant height, harvested plant weight, and number of leaves.

Plant height

Plant height was measured biweekly. They were measured by measuring the height of the main plant from the bedding media of the container to the top of the main plant stem. Measurement was done by measuring scale (Figure 11). After measurement procedure was done the plants were harvested by cutting them 5 cm above the bedding media.

Figure 10. Watering to the plants

Figure 11. Measuring plant height

Number of leaves

Number of leaves on each plant were counted and recorded. Each and every visible leaf on the plant, including the new leaves just beginning to emerge was counted and recorded carefully.

Weight of water spinach plants

The water spinach plants were harvested fortnightly by cutting through knife after recording the plant height and number of leaves. During the harvesting time plants was weighed by using an electric balance. At the end of the experiment plant were harvested along with root and taken root weight (Figure 15). All weight was recorded carefully in a note book.

Figure 12. Collection of plant data at the end of the experiment

a). Plant after harvest **b).** Weighing of plant

c). Plant height along with plant root

Data processing and analysis

The data entry was done in “Microsoft Excel 2007”. Collected data were summarized carefully before final tabulation. Preliminary data were transferred into master sheet and prepared tables and Figurers to show the findings of the experiment. After completion of the data entry in “Microsoft Excel 2007” it was used to perform descriptive statistical analysis of data. M-Stat was also used to calculate the significance level of the three treatments data.

RESULTS

Fish production

Fish growth pattern

Culture of Tilapia was started on 4th June and reared for 90 days. At the end of the experiment all the fishes were harvested on 4th September. The initial mean length of the fish was 15.26 ± 1.41 cm and the mean weight was 60.06 ± 17.68 g. The average length and weight was increased up to 5.15 ± 0.2 cm and 104.54 ± 27.86 g (Table 2). Among the different sampling dates, there was a significant ($P \leq 0.01$) difference in average length and weight of fish (Table 1). The collected data of average length and weight of fish in each sampling is presented in Figure 13.

Length and weight measurement of tilapia

Tilapia was cultured from 4th June to 4th September. The initial mean length of fish was 15.26±1.41 cm and the initial mean weight of fish was 60.06 ± 17.68 g. Both maximum average length and weight was found in 4th September which was 20.41 ± 1.61 cm and 164.6 ± 45.54 g (Table 1 and Figure 13).There was significant ($P<0.01$) differences in mean length and weight of fish in different dates.

Table 1. Fish length and weight observed in different sampling dates

Date of Fish Sampling	Fish length (cm)	Fish weight (gm)
04.06.14	15.26 $\pm$ 1.41 ^{E}	60.06 $\pm$ 17.68^{E}
19.06.14	16.09 $\pm$ 0.96 ^{DE}	77.39 $\pm$ 15.95^{DE}
04.07.14	16.55 $\pm$ 1.54 ^{DE}	82.60 $\pm$ 27.09 ^{DE}
19.07.14	17.28 $\pm$ 1.68 ^{CD}	93.04 $\pm$ 24.39 ^{CD}
04.08.14	18.39 $\pm$ 1.86 ^{BC}	118.7 $\pm$ 43.18 ^{BC}
19.08.14	19.35 $\pm$ 1.67 ^{AB}	135.0 $\pm$ 38.21 ^{B}
04.09.14	20.41 $\pm$ 1.61 ^{A}	164.6 $\pm$ 45.54 ^{A}
Level of Significance	**	**

**Mean values are significantly different ($p<0.01$)

From the above fish length and weight data it observed that there was no significant difference of both fish length and weight among three dates 4th June, 19th June and 4th July. It can also be interpreted that there was a significant variation in increase in both fish length and weight between 4th June and 4th September.

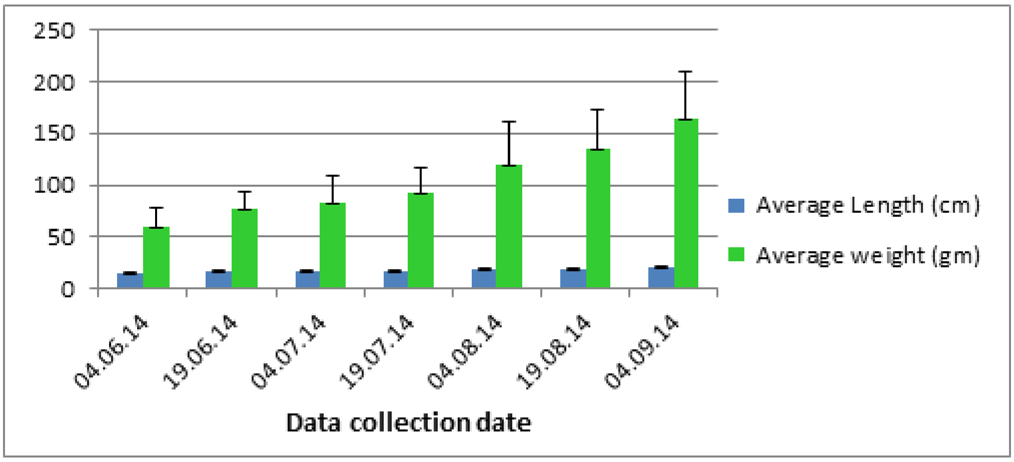

Figure 13. Length and weight of fish observed in different dates.

Fish growth performances

The growth performances of fish in terms of length gain, weight gain, percent weight gain, daily growth rate, food conversion ratio, survival rate and production of fish are presented in Table 2.

Production

At the end of the experiment, total fish production was recorded in kg and then converted to ton/ha. The total production was 29.44 tons/ha/90 days (Table 2). There was 15% (112.5 L) space of the tank 750 L kept for maintenance. The survival rate of the fish in this system is 98.33% it is due to death of one fish from total 60 fish. The death occurred due to exposed to high temperature, degradation of water quality and exophthalmia of fish.

Table 2. Growth performances of tilapia Fish observed over the study period

Growth Performances	Value
Mean initial length (cm)	15.26 ± 1.41
Mean final length (cm)	20.41 ± 1.61
Length gain (cm)	5.15 ± 0.2
% length gain	33.81
Mean initial weight (g)	60.06 ± 17.68
Mean final weight (g)	164.6 ± 45.54
Weight gain (g)	104.54 ± 27.86
% weight gain	174.06
Daily growth rate (g)	103.50
Feed conversion Ratio (FCR)	1.56
Survival rate (%)	98.33
Production (tons/ha/90 days)	29.44

Plant growth and yield

Plant growth performances include plant height, weight and numbers of leaves which was recorded during the study period. Plant growth and yield data are given in Figure 14.

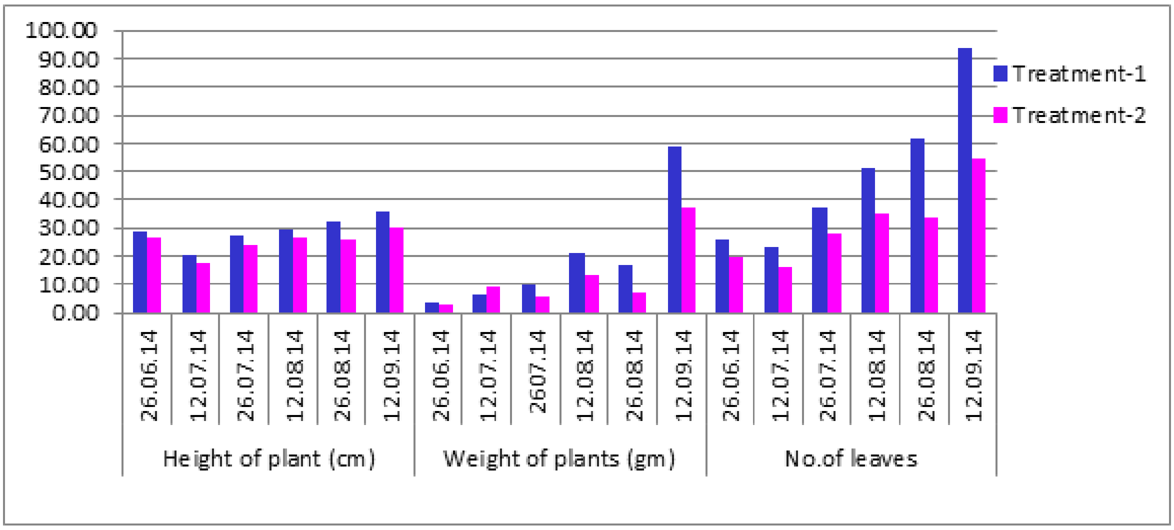

Figure 14. Observation of Water spinach height, weight and Number of leaves during the study period.

Plant height

After planting of water spinach heights were measured in regular basis at 15 days interval. The highest average plant height was 35.96 ± 4.75 cm which was found in treatment T_1 on 12 September (Table 3). At the same time in treatment T_2 it was 29.92 ± 7.09 cm. So it is observed from the data that there were no significant differences of plant height in the two treatments.

Table 3. Plants height observed in two treatments during study period

Date of Sampling	Treatment T_1	Treatment T_2	Level of Significance
26.06.14	28.76 $\pm$ 4.83	26.7 ± 4.39	NS
12.07.14	20.49 $\pm$ 2.57	17.64 ± 2.0	NS
26.07.14	27.53 $\pm$ 2.57	23.9 ± 2.60	NS
12.08.14	29.34 $\pm$ 2.34	26.8 ± 2.49	NS
26.08.14	31.93 $\pm$ 2.78	25.73 ± 3.69	NS
12.09.14	35.96 $\pm$ 4.75	29.92 ± 7.09	NS

NS: Non-Significant

Plant weight

The weight of leaves was recorded biweekly. The highest average weight of leaves were 59.09 $\pm$ 23.85 g which was found in T_1 on 12th September, whereas, the lowest average weight was 2.81 $\pm$ 0.78 g which found in T_2 at 26th June (Table 4 and Figure 14). The average leaves weight of two treatments was 350.44 $\pm$ 115.56 and 226.35 $\pm$ 37.94g respectively, where the highest value was found in the treatment T_1. There were significant ($P<0.05$) differences in leaves weight among the treatments that was found at 26th August. There is no significant difference of leaves weight in the other dates.

Table 4. Plants weight observed in Treatment-1 and Treatment-2

Date of Sampling	Treatment T_1	Treatment T_2	Level of Significance
26.06.14	3.87 $\pm$ 1.67	2.81 ± 0.78	NS
12.07.14	6.29 $\pm$ 2.97	9.02 ± 1.61	NS
26.07.14	9.55 $\pm$ 3.55	5.82 ± 2.66	NS
12.08.14	21.12 $\pm$ 1.68	13.54 ± 8.23	NS
26.08.14	16.87 $\pm$ 2.80 A	6.92 ± 3.3.93 B	*
12.09.14	59.09 $\pm$ 23.85	37.33 ± 31.96	NS

* Mean values are significantly different ($p<0.05$); NS: Non Significant

Number of leaves

Numbers of plant leaves were counted in every 15 day interval it was done before harvesting. The highest average numbers of leaves were 93.90 $\pm$ 38.52 which was found in T_1 on 12th September, whereas, the lowest mean leaves number was 16.25 ± 5.77 which found in T_2 at 12th July (Table 5 and Figure 14). The average number of leaves in two treatments was 879.75 $\pm$ 79.59 and 562.5 $\pm$ 40.95 respectively, where the maximum value was found in the treatment T_1. There were no considerable differences in leaves number among the treatment.

Table 5. Number of plant leaves observed in $T\text{-}_1$ and $T\text{-}_2$

Date of Sampling	Treatment T_1	Treatment T_2	Level of Significance
26.06.14	26 $\pm$ 6.23	19.58 ± 3.11	NS
12.07.14	22.92 $\pm$ 2.93	16.25 ± 5.77	NS
26.07.14	37.47 $\pm$ 9.35	28.33 ± 3.92	NS
12.08.14	51.50 $\pm$ 12.63	35.25 ± 10.63	NS
26.08.14	61.50 $\pm$ 26.56	33.42 ± 14.62	NS
12.09.14	93.90 $\pm$ 38.52	54.50 ± 24.76	NS

NS: Non Significance

Total Water Spinach production

Total 0.78 m^2 (7.79×10^{-5} ha) area was used for water spinach production in the growing media. Total production was 2.18 kg and in terms of tons/ha it was 28.23 tons/ha/90 days where treatment T_1 produced 1.27 kg (32.89 tons/ha/90 days) and in treatment T_2 produced 0.91 kg (23.57 tons/ha/90 days) (Table 6 and Figure 15).

Table 6. Production of Water Spinach in terms of tons/ha the two treatments

Treatments	Production (tons/ha/90 days)
T- $_1$ (Brick lets media)	32.89
T- $_2$ (Mixture of brick lets and used tea leaves)	23.57

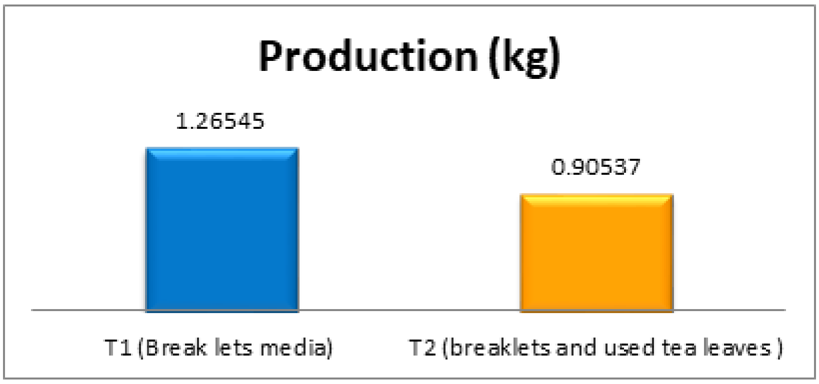

Figure 15. Total production of water spinach in the two treatments (Treatment-1 and Treatment-2).

Cost-benefit ratio of the system

Total expenditure was 1431 Tk. whereas, return includes sale of water spinach and fish

Table 7. Cost of various items required for water spinach and fish production

Materials	Units	Unit Cost (Tk)	Cost/Cycle (Tk)
Gazi Water Tank (750 L)	1	6000 (Life span 10 years) Based on four cycle per year	150
Grow bed	6	1200 (Life span 10 years) Based on four cycle per year	30
Water pump (25 watt)	1	1000 (Life span 4 years) Based on four cycle per year	62.5
Air pump (10 watt)	2	200 (Life span 4 years) Based on four cycle per year	12.5
Water Spinach Saplings (Tk)	24	0.25	6
Tilapia juveniles (Tk)	60	7	420
Fish Feed (Kg)	15	50	750
Total cost	-	-	1431

Table 8. Total predictable income from the system

Products	Amount (Kg)	Farm gate price (Tk/kg)	Total cost (Tk)
Fish	9.48	150	1422
Water Spinach	2.18	20	43.6
Total revenue	-	-	1465.6

Profit/Loss = (Income - Invested cost) Tk.
= (1465.6 – 1431) Tk.
= 34.6 Tk.
Profit= 34.6 Tk.

Benefit Cost Ratio (BCR) = $\frac{\text{Total Return}}{\text{Total Cost}}$

$=\frac{1465.6}{1431}$

=1.02

From the above ratio it can be revealed that the overall BCR of aquaponic plant and fish production is 1.02. It indicating that it is profitable from the viewpoints of other conventional aquaculture system.

DISCUSSION

Fish growth performances

The tilapia was the experimental fish in the present aquaponic study where fish density was at the rate of 10 fish/L. The production of tilapia was 9.709 kg/750L/90 days. Buzby and Lin (2014) cultured tilapia in three circular tanks at the rate of 10 fish/L obtained production in recirculating Aquaculture System (RAS) 214.85 kg/1100 L water/90 days and in Aquaponic System 212.87 kg/1100L water/90 days which was higher than the current study.

Connolly and Trebic (2010) conducted a study with mixed monosex Nile tilapia (*Oreochromis niloticus)* in a tank at a density 40 fish/m^{3}having average weight 29.26 ± 6.75 g/fish. The FCR was found 1.7 The current study also used monosex Nile tilapia at a density 10 fish/L having average weight of 60.06 ± 17.69 g/fish where the FCR found 1.56 which is more or less similar with above findings.

Plant growth and production

In the present study, water spinach was grown for 90 day in two media (T_1 and T_2) where maximum plant height was with the treatment T_1 of 35.96 ± 4.75 cm and 29.92 ± 7.09 cm in T_2 in 12 September with no significant differences in the plant height in different dates between the treatments. The water spinach production was 1.27 and 0.91 kg in T_1 and T_2 respectively. Bethe (2014) conducted an experiment with water spinach in NFT system in three treatments (T_1, T_2 andT_3) and obtained production of 4.73, 5.56 and 4.39 kg respectively. Salam et al. (2013) conducted an experiment on raft and rack in pond condition with three different treatments growing water spinach and control was empty pond to assess the nutrients removal by the plants. They found the production of water spinach 997 and 923 kg/ha/90 days. On the other hand, in the present study production of water spinach in T_1 and T_2 was 3289 and 2357 kg/ha/90 days. The present production was much higher than the production of Salam et al. (2013) may be due to in two different environments.

CONCLUSION

Therefore, it can be concluded that the aquaponic system can produce fish and vegetable from the integration of aquaculture and hydroponics vegetable production using less water and without soil and fertilizer. The system can be best fitted in the urban and peri urban context for reducing environmental pollution and climate change gases. Moreover, the brick lets media gave higher production than the mixture of used tea leaves and brick lets. However, both the media were efficiently removed the fish tank wastes and made the water clean and safe for the fish rearing throughout the study period. Hence, it can also be remarked that the aquaponic system is competent to produce sufficient amount of fish and vegetable by recycling the fish waste water from the tank.

CONFLICT OF INTERESTS

There is no conflict of interests.

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