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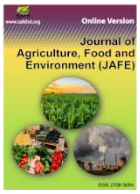

Original Article

Comparative assessment of biomass production in wish pond and wish pond-aquaponics system

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Keywords

Wish pond, Aquaponics, Fish, Vegetables, Nutrient, Tilapia

A B S T R A C T

The research was conducted for 120 days from 01 March 2019 to 30 June 2019 at Saver, Doshaid the peri-urban area near Dhaka city. The objective of the study was to assess the growth performances of tilapia and vegetable production in the wish pond and wish pond-aquaponics systems. The initial length and weight of tilapia juvenile (*Oreochromis niloticus*) of 5.17±0.14 to 5.15±0.12cm and 3.24±0.30 to 3.35±0.13g were stocked at the rate of 200 fish/m^3 pond area in wish pond aquaponics and wish pond system, respectively. The Brinjal, chilli and mint were planted in both wish pond and wish pond-aquaponics systems. A commercial floating pellet feed of 30% protein was fed the fish at the rate of 5% body weight twice daily. Both the wish pond-aquaponics and wish pond waster was aerated with air pump and stones. The wish pond-aquaponics water was filtered through the vegetable media but wish pond water was not such filtration system rather partial water change was done in each month. The survival rate and total production of fish were higher (89.17±3.82%, 34.88±2.22 tons/ha/120 days) in wish pond-aquaponics system than the wish pond system (76.67±2.08, 26.33±0.87 tons/ha/120 days). Moreover, the vegetables production was also found higher in wish pond-aquaponics system (Brinjal 40.97±5.25, Chilli 9.54±0.84 and Mint 12.81±1.22) than the wish pond system (Brinjal 30.58±2.06, Chilli 7.92±0.16 and Mint 10.08±0.29). Water quality and nutrient utilization was comparatively better in wish pond-aquaponics system as the water was filtered by brick lets and plant roots and nutrients utilized by the plants which was absent in wish pond system. Therefore, the wish pond-aquaponics system performed better than the wish pond system and proved the system is environmental friendly and sustainable.

Introduction

From the ancient time Bangladesh is full of different types of water bodies and has blessed with plenty of fishes and other aquatic organisms. Once upon a time Bengalis were fully dependent on fishes as their principal food. However, at present, it is a matter of great regret that this proverb is nothing but just due to the gradual decline of natural fishes day by day in the country. Today, many species of fishes have been extinct and others are endangered. As a result, people more specifically the poor are deprived of the required protein and other nutrition from natural sources.

For the eradication of the problem different types of aquaculture systems have been discovered among which 'Integrated Aquaculture' is getting popular than the monoculture of fish. It refers to intensive and synergistic cultivation; using water-born nutrient and energy transfer among the various species occupying different trophic levels, i.e. different (but adjacent) links in the food chain. The more general term 'Integrated Aquaculture' is used to describe the integration of fish culture with other crops or livestock production for optimizing the water use and two to three outputs from one particular system. Moreover, the land gets shrinking, reckless population growth, manmade environmental pollution and the impact of climate change creates new challenges to the country's agriculture sector that has emphasized to integrate crop and fish farming like aquaponics (Salam, 2014). A new concept of this culture system is 'Wish Pond' which is very innovative and more beneficial especially to the poor people. The system was given the name "WISH ponds," derived from the combination of the words "water" and "fish" to reflect the integration of fish cultivation with water for storage and vegetable growing (Kwasek, 2015). In 2011, The WorldFish, in partnership with the Stung Treng Fishery Administration Cantonment and the Culture and Environment Preservation Association, aimed at improving the uptake of small-scale aquaculture by communities with limited experience in fish culture in Stung Treng Province in northeast Cambodia but in our country is a new concept till now which have many potential opportunities (Johnstone, 2012). By contrast, aquaponics refers to a system that combines conventional aquaculture (raising aquatic animals such as snails, fish, crayfish or prawns in tanks) with hydroponics (cultivating plants in water or media) in a symbiotic environment. It is an environmentally friendly system and use only a fraction of water than the conventional system. Therefore, the present research has been designed to see the performance of wish pond and a combination of wish pond aquaponics system. Aquaponics-wish pond is a small scale homestead gardening where produces fish and vegetable produce in an integrated approach. In aquaponics, the integration of fish and plants result in a polyculture that increases diversity and yields of multiple products where fish and vegetables are grown in a mutually beneficial and symbiotic relationship (Salam MA. 2012). Aquaponics is an integrated fish and vegetable culture system that has been designed to provide an artificial and controlled environment that optimizes the growth of fish and hydroponic vegetables while saving water resources and acts as a safeguard for the environment (Endut, 2011). The study was guided with a vision to find out which system improve biomass production and mitigate the water quality problem.

Materials and Methods

Location of Experiment and Materials used

The experiment was conducted at CDIP (Center for Development Innovation and Practices) Ashulia branch at Doshaid village the peri-urban areas of Saver, near the capital city of Bangladesh (23.887729 North and, 90.302027 East) from 01 March 2019 to 30 June 2019. After selection of farmer and tank site different type of materials such as- plastic sac bags, plastic containers, trays, wires, pipes, water pumps, electrical instruments, nylon nets, tarpaulin, bamboos, gravels etc. were collected from 'Savar Bazar' and suppliers.

Treatments of the investigation and design

The experiment was laid out in a Randomized Complete Block Design (RCBD) with one factor. The experiment was two treatments having three replications, three tanks were allocated for wish pond-aquaponics and another three for wish pond system.

Setting the wish pond

The wish pond was formed at the CDIP yard calculating 2.1 x 1.5 x 0.3 m^3. The soil available from excavating pond was accumulated with some elements such as ½ kg urea, ½ kg tsp, ½ kg muriate of potash, ½ kg wheat flour and 1-liter molasses to improve the vegetable yield. Then the soil was occupied into the sac bags and located them around the pond to have a resilient ridge. Subsequent to the sac bag arrangement at the pond adjacent, a tarpaulin and polythene lining were located internal the pond to enable and rise water allotment capability. Some bamboo splits and the pillar were castoff to tie the bag to save in place and then water as a supplement. Ponds were filled with adjacent deep tube wile water. The scheme was fenced with bamboo and galvanize plastic net to guard the vegetables against the native birds and animals. The rack was also constructed for the blackthorns like bean, gourd and in adding bamboo branch was located to provision the vegetables not dropping in the pond. In Cambodia, the wish pond system consisted of concrete tanks (3 m x 4 m x 1.2 m) (Kwasek, 2015). The preparation technique was a new concept in current research to decrease the setup cost.

Setup aquaponics system

Aquaponics set up was interrelated with three wish pond systems accessible with electricity and safety. Six food-grade plastic bottles (20 L) were recycled to assist the aquaponics vegetable manufacture. A twenty-watt aquarium filter pump was used to drive the water from the wish pond to the bottles where brick lets were recycled as grow bed and vegetable saplings were implanted. The brick-lets were imaginary to screen the fish water and logically gathered microbes would transform the ammonia to nitrite and then nitrate to create the water harmless for the fish and delivers food for the vegetable plants.

Planting vegetable seedlings and stocking of fish

Various kinds of seasonal vegetables such as- Brinjal, Chilli and Mint were implanted in the sac bags. They were implanted both on the upper of the sac and alongside the sac by creation a small hole on the sac wall. In the aquaponics system, vegetable plants were implanted through the bricks and gravels. Tilapia (*Oreochromis niloticus*) juveniles were discharged at the ratio of 200 fish in a separate pond. Commercial floating pellet feed comprising 30% protein was provided to feed the fish twice daily. Feed was specified at the rate of 5% body weight of the fish.

Sampling and harvesting of fish and vegetables

Sampling of fish was done monthly. In every sampling, ten fishes were tested casually caught from the pond by using a fine mesh net. The length and weight of the fish were calculated and the data were noted on the computer. Vegetable harvesting was varied from plant to plant nature. Mint was harvested after 30 days of the plantation. Other vegetables were harvested between 40-60 days. Resulting in the harvesting procedure, their quantity and numbers were noted. During each sampling, total length and weight of mint were taken by deducting the plastic glass weight and during each partial harvest weight of leaves, stem and root were dignified. After planting of Brinjal and Chilli saplings the number of leaves was counted and height was measured at 30 days' interval throughout the study period. The mature Brinjal and Chilli were weighed and recorded during harvesting. The fish and vegetables were lastly harvested after 120 days of trial.

Sampling of water

Water samples were gathered from the fish pond in ½ liter water bottle. The water samples were collected fourth throughout experimental time, first at the starting period, and another rest months of the experiment. After the collection of samples, they were brought to the Wazed Mia science research center at Jahangirnagar University for measuring total-N, electric conductivity (EC), hydrogen carbonate (HCO_3), potassium(K), sulfur (S), sodium (Na) calcium (Ca) and phosphorus (P). Water temperature (^oC), transparency (cm), dissolved oxygen (DO), ammonia nitrogen (NH_3), nitrite nitrogen (NO_2), nitrate-nitrogen (NO_3), and total dissolved solids (TDS) were measured fourth nightly by used

HANNA testing kit and miter without transparency. Transparency was measure by sickie disk.

Statistical analysis

Data noted for water quality, growth, and yield causative characters were collected and tabulated in proper form for statistical analyses. Analysis of variance was done following the RCBD design with the help of the MSTAT–C computer package programmer. Duncan's Multiple Range Test (DMRT) was performed for all the characters to test the differences between the means of the treatments.

Results and Discussion

Water quality parameters

Among water quality parameters temperature, TDS (Total dissolved solids), DO (Dissolved oxygen), NH_3 (Ammonia nitrogen), NO_2 (Nitrite nitrogen), NO_3 (Nitrate nitrogen) and pH were considered during the period of the experiment which were presented in Table: 01. There were no significant differences in temperature, TDS, NH_3, NO_2, NO_3 and pH water quality parameters between the two treatments. DO and transparency was significantly different as observed in wish pond aquaponics vs. wish pond treatments. DO and transparency was greater in wish pond aquaponics Table-1. The values of water temperature under different ponds were varied from 23.40±0.10 to 32.23±0.15°C during the experiment. (Jhingran, 1991) mentioned that the appropriate temperature assortment for the production of phytoplankton in tropical ponds was between 18.3 to 37.9°C. Water temperature is the greatest significant physical variable moving the metabolic rate of fish and is therefore one of the most important water quality features in aquaculture (Kane et al., 2015). According to (De, 2005) the best temperature of water for fish culture ranges from 20 to 30 ºC. The pH values of water were varied from 6.83±0.57 to 7.67±0.76. The highest pH value of water was recorded in April in T_1 and the lowest value recorded in June in T_2. Aquatic animals are exaggerated by pH because most of their metabolic activities are dependent on the value of pH (Wang, Wang, Chen, & Liu, 2002). (Directorate of Fisheries, 1996) distinguished that suitable pH the range for fish production is 6.5 to 8.5. In the case of tilapia production pH ranges from 6.0 to 8.5 (Tyson RV, 2014) is appropriate. The values of dissolved oxygen under different ponds were varied from 3.37±0.55 to 5.37±0.15 during the experiment. According to (Bhatnagar, Jana, Garg, Patra, & Singh, 2004.) and (Singh, 2010.) DO level more than 5 mg L^{-1} is essential to support good fish production. DO of all pond of treatment T_1 was more or less similar to (Sing 2010), (Santhosh, 2007). The NH_3 values of water were varied from 0.017±0.01 to 1.33±0.29. The highest NH_3 value of water was recorded in June in T_2 and the lowest value recorded in March in T_2. Ammonia is a vital factor of water that controls the existence of organisms in the water. The maximum limit of ammonia concentration for aquatic organisms is 0.1 mg L^{-1} (Santhosh, 2007). In aquaponics batch and staggered basil production system (Rakocy, 2004) reported that total ammonia content ranges from 1.1-2.9 mg L^{-1} is suitable for better tilapia production. The NO_2 values of water were varied from 0.320±0.00 to 1.53±0.38. The highest NO_2 value of water was recorded in June in T_2 and the lowest value recorded in March in T_1. Nitrite nitrogen is a form of nitrogen and a vital nutrient for growth, reproduction, and survival of organisms. Santhosh (2007) stated the promising range of nitrate content is 0.1 to 4.0 mg L^{-1} for fish culture. In aquaponics batch and staggered basil production system (Rakocy, 2004) stated that nitrite nitrogen ranges from 0.4-1.1 mg L^{-1} is suitable for better tilapia production. The NO_3 values of water were varied from 44.30±0.00 to 103.37±25.58. Where ammonia and nitrite were toxic to the fish, nitrate is safe and is formed by the autotrophic. Nitrate levels are normally alleviated in the 50-100 ppm range. (Meck, 1996) recommended that its concentrations from 0 to 200 ppm are acceptable in a fish pond and is generally low toxic. The TDS value was varied from 130.33±2.52 to 177.67±8.74, the highest value recorded in June in T_2 and lowest value recorded in March T_2. TDS of water generally indicates the occurrence of several minerals and the typical level of TDS for fisheries is about 165 mg L^{-1} and suitable range is 160 to 200 mg L^{-1} for growth and production (Huq and Alam, 2005); (Rahman et al., 2015). The water transparency value was varied from 10.67±1.15 to 31.00±1.00, highest value recorded in March in T_1 and the lowest value recorded in June in T_2. According to (Bhatnagar et al., 2004) turbidity assortment from 30-80 cm is decent for fish wellbeing; 15-40 cm is good for intensive culture system and <12 cm triggers stress on the fishes.

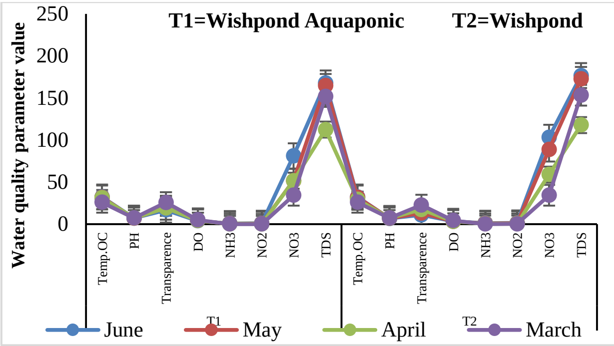

Figure 1. Water quality parameters of Wish pond and Wish pond-aquaponics system recorded during the experiment.

Nutrient loads of pond water in both the systems

Among water nutrient HCO_3 (Hydrogen by carbonate), total nitrogen, EC (Electrical conductivity), P (Phosphorus), K (Potassium), S (Sulphur), Na (Sodium) and Ca (Calcium) were considered during the period of the experiment which were presented in Table: 02. There were no significant differences in HCO_3, S, Na, and Ca water nutrient load between the two treatments. Total-N and K were significantly ($P \leq 0.05$) differences observed in wish pond aquaponics vs. wish pond treatments. Total-N, P and K were greater in wish pond Table-2. The values of HCO_3 under different ponds were varied from 222.65±10.17 to 385.66±3.55 during the experiment. The highest value was recorded in June in T_2 and the lowest value was recorded in March in T_1. A more or less similar result was obtained by (Salam, 2012), (Fatema, 2017). The Total-N values of water were varied from 3.73±0.71 to 6.04±0.26. According to (Midmore, 2011) the suitable range of total-N was 3.5-5, whereas (Swan, 2009) found it 3.0 mg L^{-1} in his experiment. The values of P under different ponds were varied from 0.279±0.12 to 1.02±0.14 during the experiment. The highest value was recorded in June in T_2 and the lowest value was recorded in March in T_1. The K values of water were varied from 4.19±0.94 to 10.30±0.91. The highest K value of water was recorded in June in T_2 and the lowest value recorded in March in T_1. The S values of water were varied from 3.49±0.72 to 6.25±1.00. The highest S value of water was recorded in June in T_2 and the lowest value recorded in March in T_1. The Na values of water were varied from 32.40±9.30 to 52.66±2.47. The highest Na value of water was recorded in June in T_2 and the lowest value recorded in March in T_1. The Ca value ware varied from 28.15±9.12 to 48.70±4.49, the highest value recorded in June in T_2 and lowest value recorded in March T_1. It designated the application of nutrients by the plants (Rakocy, 2004). So that present results are within the range mentioned by other scientists. Na was significantly higher in wish pond system (46.66±5.39) than the wish pond aquaponics system (36.55±8.04) mgL^{-1}. A more or less comparable result was found by (Fatema, 2017). The EC value ware varied from 160.33±3.79 to 272.33±11.68, the highest value recorded in June in T_2 and lowest value recorded in March T_2. EC is the amount of electrical drive through the water. Though EC cannot move through pure water, it may occur when any salt is melted in water since of its (+) charged cations and (-) charged an ion. Concerning (Argo, 2004) the EC will be higher when a greater amount of salt will melt in water. According to (Rakocy, 2004) the value of EC was 500 µs/cm during okra production in the aquaponics system. According to (Stone, 2004) the desirable range of EC is 100 to 2,000 µS cm^{-1} and the acceptable range is 30-5,000 µS cm^{-1} for fish culture. Therefore, the present values of EC are suitable for fish production.

Growth of Fish and production

The mean total initial weight (g), total final weight (g), weight gain(g), % weight gain, length gain (cm), % length gain, total final weight (g), feed intake/30 days, survival rate% and the yield of fish production (ton/ha/ 120 days) during the study period were recorded and presented in Table: 03. There was no significant difference in total initial weight (g), % length gain, length gain (cm) and feed intake/30 days of experimental fish species under both treatments. Treatment-1 showed significantly higher ($P \leq 0.05$) total final weight (g) and % Weight gain than treatment-2. On the other hand, treatment 1 showed significantly higher ($P \leq 0.01$) weight gain (g), survival rate% and yield of fish production (tons/ha/120 days) than treatment-2. The mean SGR (%), weight gain (g) and FCR (Food conversion ratio) during the study, the period was recorded and presented in Figure 2. There was no significant ($P \leq 0.05$) difference in the initial weight of fish under both treatments. In the study period the significantly higher ($P \leq 0.05$) mean weight gained by Tilapia was recorded in treatment-1 in month June and lowest mean weight recorded in treatment -2 in April. Hossain (2004) reported a similar result in his experiment, (Islam, 2018) also observe more or less similar results 37.37±0.36 wish pond and 37.22±3.08 g wish pond aquaponics in his study. The %weight gain of fish was 1775.34±139.72 and 1474.55±50.90% for T_1 and T_2, respectively. The significantly ($P \leq 0.05$) highest weight gain 1775.34±139.72 % was found in the wish pond aquaponics system and the lowest weight gain 1474.55±50.90% was found in the wish pond system. The finding of (Islam, 2018) was more or less similar in the present study. In the present study, the length gain of tilapia was 8.31±0.43 and 8.02±0.21 cm for T_1 and T_2 during the study period respectively. Recorded length gain of tilapia was 5.15±0.2 cm in 90 days in an Aquaponics system where water spinach was cultured (Akter, 2018) and it more or less similar to the present finding. The mean specific growth rate of Tilapia in different treatments ranged between 0.56±0.06 and 2.33±0.16. The significantly ($P \leq 0.05$) highest SGR values (2.33±0.16) were recorded in treatment T_1 in month April while the lowest (0.56±0.06) was obtained also in treatment T_2 in the month of June. Finding of (Islam, 2018) 1.26 ± 0.07 wish pond system 1.30 ± 0.07 cm in wish pond aquaponics system were observe that is more or less similar to the present result. The specific growth rate (% day^{-1}) was a bit higher in the current study than the result of Endut (2009) and Kamal (2006). A comparable result was found (Salam, 2014), (Islam, 2018) finding. The food conversion ratio (FCR) values among the treatments were varied from 0.75 to 3.19±0.39. The significantly lowest the best FCR (0.75) was found with treatment T_1 in month April while the highest (3.19±0.39) FCR the poorest was found with treatment T_2 in the month of June. The FCR for tilapia in the present experiment was a bit higher (2.73) from the expected FCR for tilapia 1.5-2.0 (Watanabe, 2002) in wish pond system and wish pond system was similar to it. A more or less similar result was found (Salam, 2014) finding. The survival rate ware 89.17±3.82 and 76.67±2.08 % for treatments T_1 and T_2 in the experiment there was significant differences were found between two treatments when compared using ANOVA ($P \leq 0.01$). Which more or less similar to findings of (Kamal, 2006) and (Rakibullah, 2004) who have piloted research in the Fisheries Field Laboratory of the BAU campus and discover that survival rate of tilapia was 83.54–93.75% in the ponds. The finding of (Islam, 2018) also support this result. Significantly higher production (34.88±2.22 tons ha^{-1}120 day^{-1}) was found in wish pond-aquaponics system than the wish pond system alone 26.33±0.87 tons ha^{-1}120 day^{-1} when compared using ANOVA ($P \leq 0.01$). Total production of tilapia (Rana KMS, 2015) obtained tilapia production of 28 tons ha^{-1}120 day^{-1} in ponds. This production is higher than T_2 and less than T_1 respectively. The result indicated that the highest growth, production, and survivability was found when there were biological filters initiated in the wish pond aquaponics system.

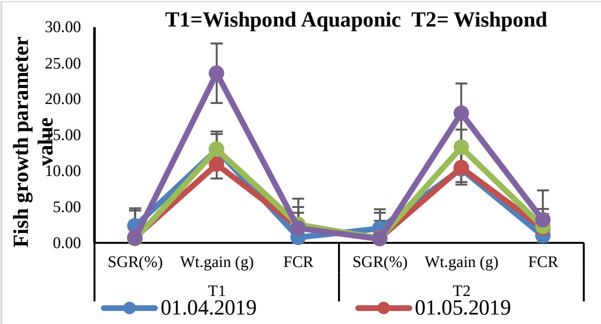

Figure 2. Growth performances of fish in both the systems during the current study.

Vegetable Production

Among the two production systems, vegetables of wish pond-aquaponics system got continuous nutrition from fish water. Here, fish waste was used as fertilizer to the plants. Another system the wish pond system did not have such fertilizer from the water.

Effect of bio-filter on the growth parameters of Brinjal

Through the research mean plant height (cm), branch number, leaves number/plant, leaves area (cm^2) were recorded and presented in Fig: 03 and Table: 04, 05. During the study period wish pond aquaponics noted maximum plant height (75.88±2.28 cm), branch number (6.61±0.42), leaves numbers/plant (62.72±1.68) and leaves the area (17817.32±2118.16 cm^2) compared to wish pond which recorded minimum height (22.33±0.65 cm), branch number

(2.78±0.09), leaves number/plant (14.44±1.39) and leaves the area (1861.24±284.36cm^2). This outcome is in understanding with those of Hasan (2012), Ahmad (2016), Lawal and Ilupeju (2015), Muoneke and Ndukwe (2016), and Rahul (2017).

Effect of fish waste as fertilizer on reproductive and yield characteristics of Brinjal

During the study period number of flower/plants, number of fruit/plant and fruit length (cm), fruit weight (g) and fruit diameter (cm) were recorded and presented in Fig: 03, 04 respectively. Throughout the study period wish pond aquaponics observed maximum flower/plant (24.17±0.93), number of fruit/plant (14.22±1.17), fruit length (22.65±1.24 cm), fruit weight (111.55±6.57 g) and fruit diameter (6.19±0.41cm) compared to wish pond which recorded minimum flower/plant (12.50±0.76), number of fruit/plant (9.22±0.58), fruit length 18.67±0.38 (cm), fruit weight 70.35±1.78 (g), fruit diameter 4.20±0.21 (cm). A similar result was observed during the study period of Ahmad (2016), Hasan (2012), and Laila (2017).

Effect of bio-filter on yield of Brinjal

A significant difference was noted between the treatments in case of brinjal yield per hectare. The maximum yield of 49.60±6.69 tons per hectare was observed in T_1 and minimum yield per hectare was 18.67±0.38 tons observed in T_2 (Figure 5). The results of present study are in conformity with the findings reported by Laila (2017). Variation in yield per hectare in the case of different lines was also shown by (Rahul, 2017).

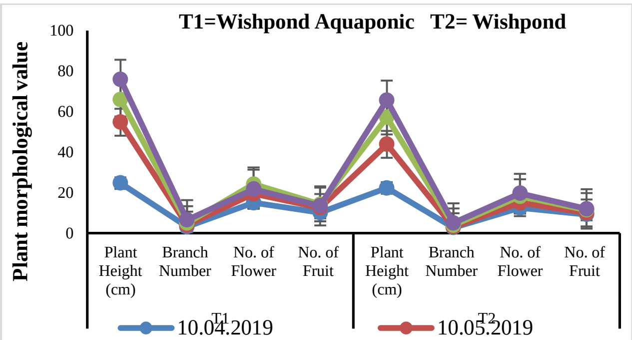

Figure 3. Growth performances of Brinjal at different sampling days after transplanting in both the systems in the study.

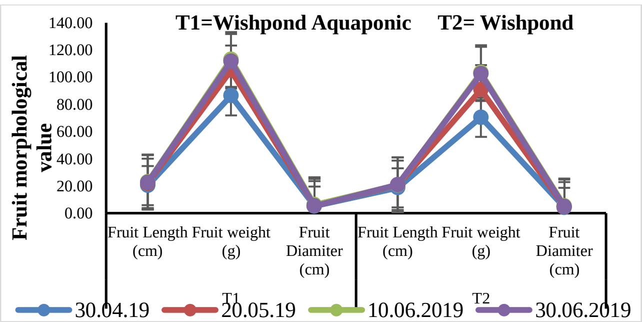

Figure 4. Effect of filtration on fruit morphological characteristic of Brinjal at different sampling days after transplanting in wish pond-aquaponics system.

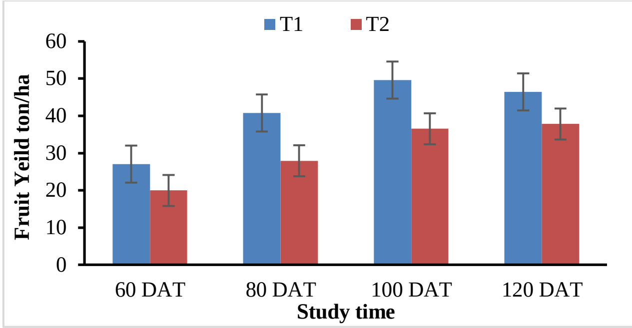

Figure 5. Effect of filtration on fruit yield tons/ha of Brinjal at different sampling days after transplanting in wish pond-aquaponics system.

Chilli growth parameters

Vegetative Growth of Chilli

Throughout the trial period the mean plant height (cm), branch number/plant were recorded and presented in Figure 6, and data in Table 4 and 5 expressed the plant height, branch numbers/plant, number of leaves/ plant and leaf area of Chilli was statistically significant on different dates of both the treatments. The height of Chilli was varied from 84±2.66 to 19.22±0.37 cm, branch numbers/plant 21.61±1.39 to 4.22±0.25, number of leaves/ plant 21.61±1.39 to 4.22±0.25, leaf area/plant 4220.06±569.17 to 320.38±66.72 cm^2. The results are to some degree in agreement with Islam (2018), Akram (2017), Suresh (2013), Harjoko (2018), and Mishra (2018).

Reproductive and yield attributing characters:

During the study period the number of flowers/plant, number of fruits/plant and fruit length (cm), fruit weight (g), fruit diameter (cm), seeds/fruit, were recorded and presented in Figures 6 and 7. Through the research phase wish pond-aquaponics system observed maximum flowers/plant (169.78±6.11), number of fruits/plant (109.61±5.07), fruit length (7.38±0.46 cm), fruit weight (2.08±0.16 g), fruit diameter (0.64±0.01cm) and seeds/fruit (46.67±2.10) compared to the wish pond which recorded the minimum flowers/plant (88.50±2.49), number of fruits/plant (70.56±2.67), fruit length (6.58±0.3cm), fruit weight (1.64±0.10 g), fruit diameter (0.57±0.03 cm) and seeds/fruit (36.40±1.49). The above results are supported by Akram (2017), Farzana (2015), Mishra (2018), Islam, (2018), Ramgiry (2019), and Chowdhury (2015).

Yield Performances of Vegetables

The fresh fruit yield/ha presented in Figure 8. The treatment T_1 provided the highest fruit yield of 12.28±1.43 tons/ha/120 days. The lowest fruit yield 6.67±0.51 tons/ha/120 days was attained in T_2 Figure 6. The maximum (12.83 tons/ha) yield was obtained in T_1 treatment and minimum (8.88 ton/ha) was found in soil grown system as treatment T_2. Nitrogen fertilization improved plant growth but did not influence the fruiting time reported by Islam (2018). The result is similar to the above findings.

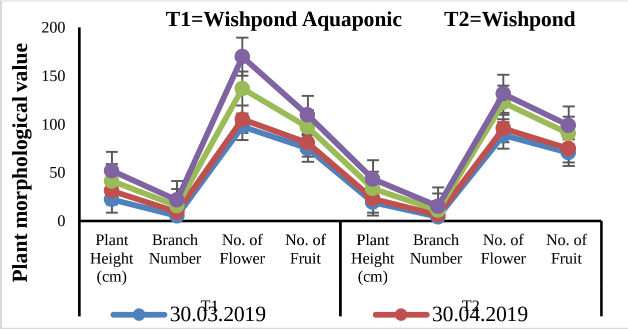

Figure 6. Growth parameter of Chilli (*Capsicum frutescens*) at different sampling days after transplanting in both the systems in the study.

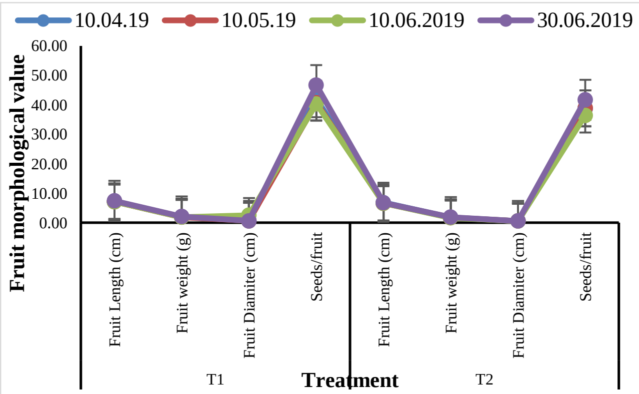

Figure 7. Effect of filtration on fruit morphological characteristic of Chilli (*Capsicum frutescens*) at different sampling days after transplanting in wish pond-aquaponics system.

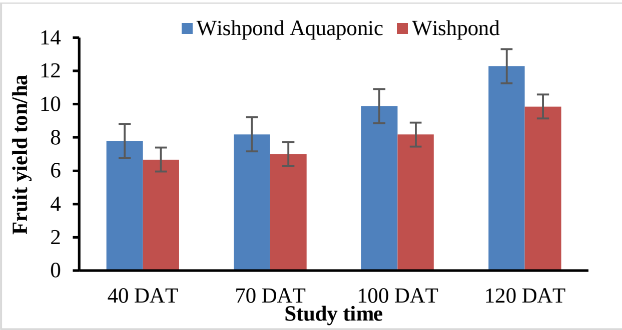

Figure 8. Effect of filtration on fruit yield tons/ha of Chilli (*C. frutescens*) at different sampling days after transplanting in wish pond-aquaponics system.

Mint growth performances

Growth parameters of mint pants

The growth parameters of Mint were significantly inclined by nutrient supply at harvest. The wish pond-aquaponics recorded the maximum plant height (24.24±0.34 cm), plant spread (11.16±0.36 cm) and number of branches (10.89±0.35) compared to the wish pond system which recorded the minimum height (16.77±0.27 cm), plant spread (5.44±0.23 cm) and branches (6.00±0.29) (Figure 9). The results are in line with the findings of the increase in plant height as a response to the application of organic manures and bio-fertilizers is probably due to enhancing the availability of nutrients which emphasized by Arafa (2017). Moreover, Mahantesh (2017) observed plant height varied from 41.33 to 46.33 cm. The results noted by Kaur (2019), Tanjia (1970), Zarandi (2010) and Mahantesh (2017) are more or less similar to current study. Similar results were reported by Shwetha (2018) and Kaur (2019).

Plants physiological parameters

The physiological parameters varied significantly with the sampling, planting, and harvest dates. The plants of T_1 treatment recorded the maximum leaf numbers (217.78±6.94/plant) and leaf area (1894.96±152.64 cm^2/plant) compared to T_2 which recorded minimum leaf numbers (96.00±4.62/plant) and leaf area (660.72±168.55$cm^{2/}$plant) in Tables 4 and 5. The results are in conformity with the findings of Kaur (2019), Mahantesh (2017). In the experiment carried out by Shwetha (2018) reported the maximum leaf area 3913.15 cm^2/plant and minimum leaf area 2356.55 cm^2/plant.

Yield and quality parameters

The Japanese mint in T_1 was significantly superior in terms of total fresh yield (120.79±24.82 g/plant) and herbage yield (7.43±1.47 /ha), while minimum total fresh yield (23.94±1.41 g/plant) and herbage yield (5.21±0.24 ton/ha) was recorded by T_2 in Figure 10, 15. This might be due to increased plant growth in terms of plant height, spread, branches, leaf area, and fresh yield /plant. These findings of total fresh yield/plant are in agreement with those reported by Mahantesh (2017), Tanjia (1970). Similar results were found in reported by Shwetha (2018) and Kaur (2019).

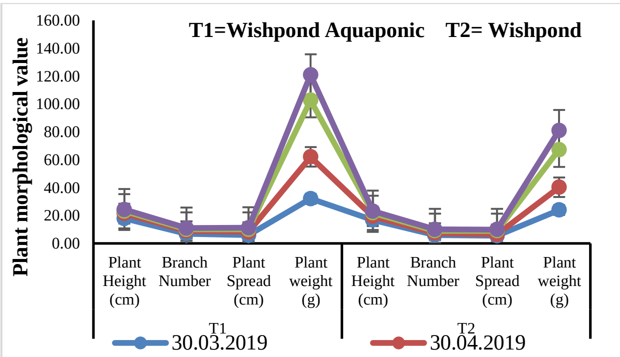

Figure 9. The growth parameters of Mint (*Mentha japanica*) at different sampling days after transplanting in both the systems in the study.

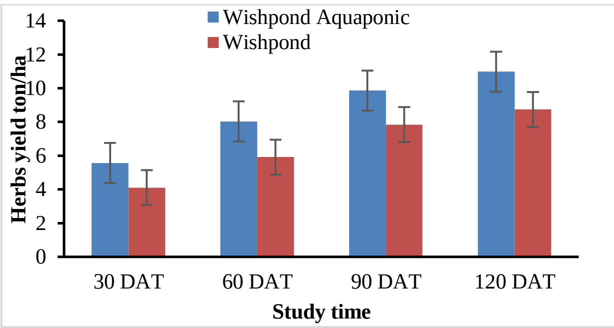

Figure 10. Effect of filtration on herbs (*M. japanica*) yield tons/haat different harvesting days after transplanting in wish pond-aquaponics system.

Table 1. Water quality parameters (Mean ±SD) in both the wish pond and wish pond-aquaponics systems.

Treatments	Water quality parameters							
	Temperature (°C)	pH	DO (mg/l)	NH_3 (mg/l)	NO_2 (mg/l)	NO_3 (mg/l)	TDS (mg/l)	Transparence (cm)
T_1	29.89±0.05^a	7.29±0.20^a	4.58±0.26^a	0.46±0.19^a	0.58±0.18^a	52.50±15.04^a	160.56±4.46^a	21.04±1.24^a
T_2	29.89±0.03^a	7.15±0.28^a	3.77±0.32^b	0.75±0.18^a	0.87±0.22^a	67.27±18.64^a	166.04±6.05^a	16.48±1.33^b
Significance	NS	NS	**	NS	NS	NS	NS	*
$LSD_{(0.05)}$	0.11	0.64	0.31	0.38	0.51	61.14	10.51	3.22
CV (%)	0.10	2.50	2.20	18.22	19.80	29.06	1.83	4.90
P-value	-- -- --	-- -- --	0.0085	0.0830	0.1318	0.4078	0.1543	0.0261

Note: ** = Significant at 1% level of probability,* = Significant at 5% level of probability, NS = Not significant

Table 2. Water quality parameters (Mean ±SD) in both the wish pond and wish pond-aquaponics systems.

Treatments	Water quality parameters							
	HCO_3 (mg/l)	Total-N(mg/l)	EC (µs/cm)	P(mg/l)	K(mg/l)	S(mg/l)	Na(mg/l)	Ca(mg/l)
T_1	265.49±15.36^a	4.35±0.53^b	229.63±6.43^a	0.50±0.07^b	5.37±0.60^b	4.34±0.56^a	36.55±8.04^a	34.19±7.94^a
T_2	293.53±5.07^a	5.53±0.25^a	237.63±7.54^a	0.73±0.11^a	9.08±0.68^a	5.34±0.83^a	46.66±5.39^a	43.36±5.97^a
Significance	NS	*	NS	*	**	NS	NS	NS
$LSD_{(0.05)}$	33.16	1.02	17.64	0.22	0.83	2.45	14.02	16.32
CV (%)	3.38	5.86	2.15	10.43	3.28	14.38	9.59	11.98
P-value	0.0679	0.0377	0.1901	0.0509	0.0027	0.2216	0.0900	0.1368

Note: ** = Significant at 1% level of probability,* = Significant at 5% level of probability, NS = Not significant

Table 3. Growth performances (mean ±SD) of Tilapia observed during the present study.

Treatments	Growth performances							
	Weight gain (g)	% Weight gain	Length gain (cm)	% Length gain	Total initial weight (g)	Total final weight (g)	Survival rate %	Yield (tons/ha)
T_1	60.48±1.14^a	1775.34±139.72^a	8.31±0.43^a	60.62±5.05^a	648.00±59.97^a	8965.05±627.47^a	89.17±3.82^a	34.88±2.22^a
T_2	52.64±0.36^b	1474.55±50.90^b	8.02±0.21^a	55.76±1.24^a	669.13±25.27^a	8059.10±266.30^b	76.67±2.08^b	26.33±0.87^b
Significance	**	*	NS	NS	NS	*	**	**
$LSD_{(0.05)}$	2.52	221.75	0.66	13.77	91.10	914.18	5.41	3.37
CV (%)	1.27	3.88	2.30	6.73	3.94	3.06	1.86	3.13
P-value	0.0055	0.0281	0.1987	0.2679	-- -- --	0.0508	0.0100	0.0083

Note: ** = Significant at 1% level of probability,* = Significant at 5% level of probability, NS = Not significant

Table 4. Number of leaves /plant (Mean ±SD) observed in treatment 1 and treatment 2 during the present study.

Treatments	Number of Brinjal leaves/plant				Number of Chilli leaves/plant				Number of Mint leaves/plant			
	40	70	100	120	30	60	90	120	30	60	90	120
T_1	19.44^a	36.61^a	55.22^a	62.72^a	31.17^a	64.72^a	148.11^a	170.72^a	111.11±5.50^a	159.00^a	201.11^a	217.78^a
T_2	14.44^b	30.33^b	45.39^b	52.94^b	28.61^b	52.83^b	140.33^a	148.33^b	96.00±4.62^b	134.00^b	180.00^b	200.00^b
Significance	**	**	**	**	**	**	NS	**	**	**	**	*
$LSD_{(0.05)}$	0.416	1.563	1.805	2.055	0.648	4.426	21.763	11.000	3.815	11.385	9.553	12.648
CV (%)	0.71	1.33	1.02	1.01	0.61	2.14	4.30	1.96	1.05	2.21	1.43	1.72
P-value	0.0004	0.0033	0.0018	0.0024	0.0034	0.0074	0.2640	0.0128	0.0034	0.0110	0.0109	0.0263

Note:** represent that the values in the same rows are significantly different at 1% (P≤0.01) significant level respectively.

Table 5. Leaf area (cm^2)/plant (Mean ±SD) observed in treatment 1 and treatment 2 during the present study.

Treatments	Brinjal leaves area (cm^2)/plant				Chilli leaves area (cm^2)/plant				Mint leaves area (cm^2)/plant			
	40	70	100	120	30	60	90	120	30	60	90	120
T_1	3176.28^a	7894.04^a	13803.47^a	17817.32^a	391.63^a	1245.68^a	3289.73^a	4220.06^a	792.28^a	1344.26^a	1894.96^a	2230.93^a
T_2	1861.24^b	4730.48^b	8353.67^b	10902.04^b	320.38^a	666.96^a	2638.79^a	3230.81^b	660.72^a	1027.78^b	1518.44^b	1929.51^b
Significance	**	**	**	**	NS	**	NS	**	NS	**	**	**
$LSD_{(0.05)}$	772.092	603.150	733.532	1957.57	163.18	701.53	1179.68	587.38	614.64	135.75	39.39	71.68
CV (%)	8.72	2.72	1.88	3.88	13.05	20.88	11.33	4.49	24.08	3.26	0.66	0.98
P-value	0.0181	0.0020	0.0010	0.0043	0.2010	0.0710	0.1408	0.0185	---	0.0098	0.0006	0.0030

Note: ** represent that the values in the same rows are significantly different at 1% (P≤0.01) significant level respectively.

Conclusion

The present study determined that the wish pond system water quality was bad as it developed toxic matters over time; hence, partial water replaced three times throughout the 120 days of trial. By contrast, incorporation of water clarification arrangement in wish pond-aquaponics system enhanced the good water quality and fish and vegetable yield than the wish pond system. The system produced enough vegetables without adding manure and ensured clean water for fish rearing. The vegetable production in all contexts in wish pond-aquaponics has shown better performance than the wish pond system. The wish pond-aquaponics system performed water filtration continuously with the help of nitrifying bacteria and mimics as a natural ecosystem and the system became eco-friendly for both the fish and vegetables which have reflected in the final outcomes. On the other hand, the wish pond system did not filter the water, hence, the water turned into toxic for fish and that reflected in the outcome. Therefore, the wish pond-aquaponics system proved to be eco-friendly and sustainable.

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