

Performance evaluation of different bedding media in aquaponic system for growth and production of okra and tilapia

Kamrun Naher Azad¹, M. A. Salam², Md. Zakir Hossain³

¹Department of Fisheries and Marine Bioscience, Jessore University of Science and Technology, Jessore

²Department of Aquaculture, Bangladesh Agricultural University, Mymensingh

³Department of Biomedical Engineering, Jessore University of Science and Technology, Jessore, Bangladesh

Abstract— Aquaponics is the marriage of aquaculture and hydroponic technologies. Present research was accomplished to evaluate the relative performance of only gravels (T_1), only coconut husk (T_2) and mixture of gravels and coconut husk (1:1 in volume) (T_3) as media in aquaponic system to grow okra (*Abelmoschus esculentus*) and tilapia (*Oreochromis niloticus*). Each treatment had three replications of similar bedding media. Nine food grade plastic containers filled with media and a 180 liter plastic water tank were used to construct the aquaponic system for growing okra and tilapia, respectively. In each bedding container, 4 okra seeds were sown and tilapia with initial length of 13.65 ± 1.88 cm and weight of 46.04 ± 20.93 g were stocked at the rate of 144 fish/m³ in the fish tank. Tilapia were fed twice a day at the rate of 3% for premier month, 2% for next month and 1.5% of body weight for the remaining time. Fish and plants were sampled biweekly during the whole study period. Data analysis revealed that the treatment T_3 performed best followed by T_1 and T_2 , respectively in terms of okra plant growth performances with respect to duration of plant growth in different growth stages, plant height, leaf number per plant, leaf area and branch number per plant. Okra production was shown significantly greater ($P \leq 0.05$) in the treatment T_3 (9.08 ± 1.25 kg/m²/157 days) pursued by T_1 (7.5 ± 1.83 kg/m²/157 days) and T_2 (3.83 ± 2.33 kg/m²/157 days), respectively. At the termination of the study, the length gain and weight gain of tilapia were 6.64 ± 0.1 cm and 104.76 ± 20.78 g, respectively. Total tilapia yield was recorded 138.80 tons/ha/157 days with 92.3% survival and FCR of 1.96. The water quality parameters and the nutrient concentrations in influent and effluent water remained within suitable ranges for tilapia production as well as the growth of okra. Therefore, the mixture of gravels and coconut husk media showed incentive performance in plant growth and production of okra compared to the individual media and at the same time the tilapia production was also satisfactory.

Keywords— Aquaponics, bedding media, coconut husk, gravels, okra, tilapia.

I. INTRODUCTION

Fish is one of the utmost-traded food stuffs worldwide. More than half of fish exports by worth generate in developing states. The dietary contribution of fish is more momentous regarding animal proteins. A volume of 150 g of fish supplies about 50–60 percent of the routine protein demand for a full-aged person (FAO, 2016). Fruit and vegetables are also necessary components of a salubrious diet. Their adequate daily consumption could help avert serious non-communicable maladies (Lock et al., 2005).

In a small developing country with extensive population growth, aquaculture is intensified to meet the demand of fish protein for increasing population. This creates water pollution and depletes the ground water level day by day. Agricultural land is also used for other purposes which cause pressure on natural resources. To keep pace with the growing food demand, farmers use various chemicals to boost up cereal production. These chemicals strike out human health hazards as well as other environmental problems around the world. All of these obstacles can be defeated to an innovative technology like aquaponics. Aquaponics is a viable food growing technology which connects consecutive aquaculture with hydroponics in a symbiotic condition (Azad et al., 2016). The basic principle of aquaponics is that the wastages of the biological system serve as nutrients to the other system and the water is reused through biological filtration (Bethe et al., 2017).

Diversified leafy vegetables and plants are grown in aquaponics. Among them, okra, radish, lettuce, water spinach, Indian spinach, tomato, capsicum, cucumber, cabbage, carrots, mints, Lettuce, herbs etc. are remarkable (Azad et al., 2016). Several thermal water and non-thermal water fish species like tilapia, trout, perch and bass (Diver, 2006) are cultured in the same system. Among different types of aquaponic systems, media based system is the most common style in the world because it requires less management practices and the fewest components. This system is easy to set in the backyard, rooftop or balcony of the houses. In media based system, miscellaneous inorganic media like gravels, bricklets, saw-dust (Salam et al., 2014) etc. or diverse organic media like coconut fiber, husk and dust, discarded tea leaves, water hyacinth roots etc. (Azad et al.,

2016) are used. Okra (*Abelmoschus esculentus*) is an amazing food item having its nutritional, culinary and medicinal values for growing in aquaponics because of its adaptability to expansive range of climatic status. On the other hand, tilapia (*Oreochromis niloticus*) is an ideal candidate to culture in aquaponics as they are habituated in high density and poor water quality. Considering the importance's of okra and tilapia as routine food commodities, they were selected as culturable species in the aquaponic system. Furthermore, both of inorganic and organic media were considered as bedding media in this media based system to evaluate their performance by comparing how they contribute higher to food production- individually or combined. Hence, the present study investigated three different bedding media for okra production in aquaponic system as well as ascertained the suitable media through comparison of their performances and also evaluated their effects on tilapia production of the technique.

II. MATERIALS AND METHODS

2.1 Experimental site and set up

The experiment was conducted at the roof top of a building. The roof was well protected from stealth. The empirical set up was in well exposed to sunshine.

Among different types of aquaponic system, the media based aquaponic system was selected to conduct the experiment. Three different media, gravels (gravels size was 1-2 cm) (T1), coconut husk (T2) and mixture of gravels and coconut husk (1:1 in volume) (T3) as three treatments, each having three replications were used in this experiment for okra production. The experimental model comprises of a fish holding tank of 180 liter (0.77m x 0.57m x 0.41m) and nine food grade plastic containers (each size 0.42m x 0.29m x 0.20m) for holding the media. Completely randomized design (CRD) was followed during placing the vegetable plastic containers side by side (Fig. 1).

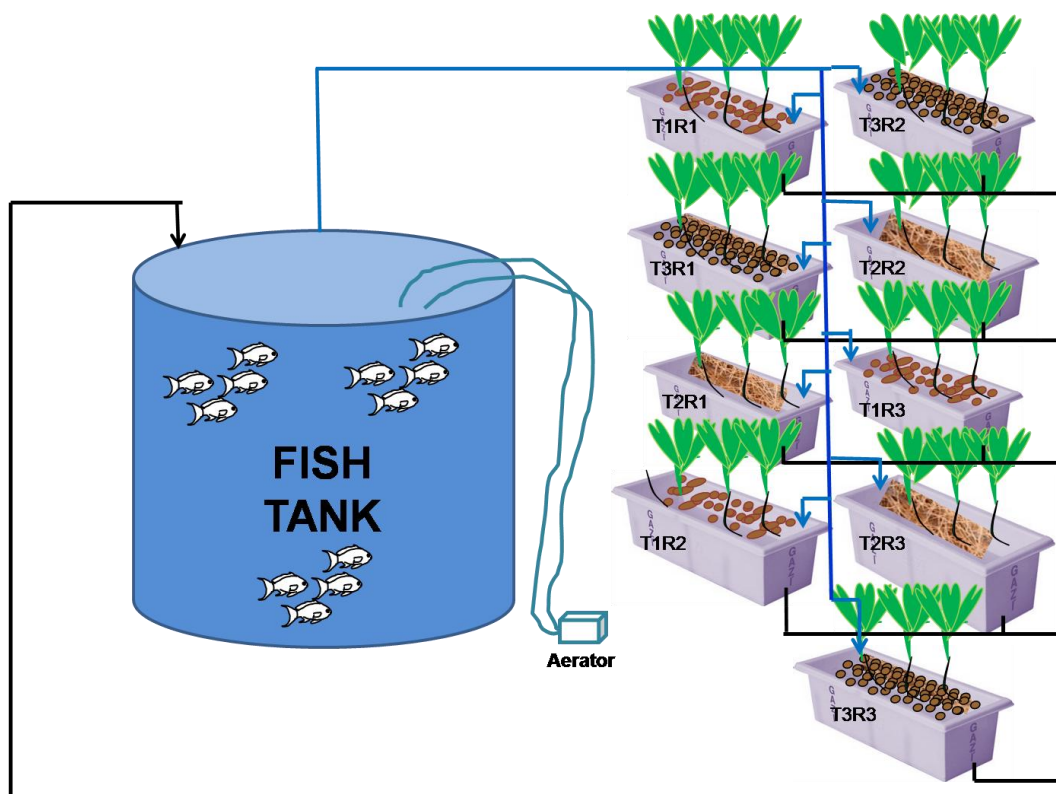


FIG. 1. Experimental design of the study

An inlet and outlet pipe was set to the fish tank. A 10-watt air pump installed with two air stones was set to aerate the tank water. A 12-watt submersible water pump irrigated the vegetable beds with the waste water of tank through the inlet pipe and then the clean water returned to the fish tank through the outlet pipe. The vegetable containers filled with different bedding media were placed side by side on the balcony of the roof keeping some space (total 20% area) between the containers for maintenance. Another plastic PVC pipe (length 3.5 m and diameter 1.5 cm) with nine holes over the containers was also attached to the inlet pipe for watering the vegetable beds (Fig. 1).

2.2 Stocking and feeding of fish

The fish with initial length of 13.65 ± 1.88 cm and weight of 46.04 ± 20.93 g were released at the rate of 144 fish per m^3 after acclimatization. Traded floating feed having 30% protein was fed to fish twice a day. Feed was supplied at 3% of body weight of fish for premier month, 2% for next month and 1.5% for the remaining time of the experiment.

2.3 Sowing rooted seeds and watering vegetable beds

The okra seeds after collection were soaked overnight and placed on a damp tissue paper for another two days to sprout. Then small roots emerged from the seeds and were sown in each four corners of the containers. The fish tank water was irrigated by submersible water pump to the okra beds through inlet pipe. The pump was run from 9 AM to 5 PM during day time.

2.4 Fish and plant sampling

Fish and plants were randomly sampled biweekly. During each sampling, individual length and weight of ten fishes were measured carefully with a wooden fish length measuring scale and an electric weighing balance (KD-S/F-en), respectively. During plant sampling, plant height, branch number, leaf number, leaf length and width were measured with a measuring scale. After harvesting, okra pod was weighed with an electronic balance. Okra was harvested and measured the weight till the completion of experiment. After collection, all data were recorded.

2.5 Assessment of physico-chemical parameters of water in fish tank

The physical and chemical parameters of water in fish tank were measured for water quality assessment. pH, Temperature (T) and Dissolved oxygen (DO) were recorded every 15 days interval. In addition, Electric conductivity (EC), total-nitrogen (N), Carbonate (CO_3), Bicarbonate (HCO_3), Sulphur (S), Potassium (K) and Sodium (Na) were measured thrice at two months interval during the study period at the Humboldt Soil Testing Laboratory.

2.6 Data analysis

Data related to fish and okra production, fish and plant growth parameters were explored by one way and two-way ANOVA with MSTAT-C software. Duncan's multiple range tests (DMRT), Tukey's HSD (Honestly Significant Difference) and Fisher's LSD (Least Significant difference) tests were conducted to compare the averages to exhibit significant distinctions among the treatments at significant level of 0.05 and 0.01.

III. RESULTS AND DISCUSSION

3.1 Plant growth and production performances

During the study period, the growth and yield performances of plants in three treatments (T1 - gravels, T2 - coconut husk and T3 - mixture of gravels and coconut husk media) were recorded.

3.1.1 Duration of plant growth in different growth stages

The okra seeds were recorded to germinate after 4 days of sowing in all the treatments. Okra seed germination in aquaponic system was faster than that in the conventional agricultural system. Because Das (2011) and Patwary (2001) reported that okra seedlings emerged from the seeds in 4-6 and 11 days of sowing respectively who cultured okra in soil.

First flower bloomed 37 days later of sowing seeds in T3, but more 7 days were needed to show flowers in the treatments T1 and T2. Patwary (2001) reported that the okra plants took 37-39 days in soil media for first flowering, indicating that vegetable production in aquaponics was faster than conventional agriculture.

About 42 days later of sowing seeds, first okra pod was seen in T3, although other treatments delayed 7 days to show first okra pods. However, the okra pod was started to harvest after 46 days of sowing Plants. Olsantan and Bello (2004) reported that the time from planting to first pod harvest ranged from 55-62 days, confirming the faster growth rate of plant in soil-less media compared to soil media. Salam *et al.* (2013) and Rakocy *et al.* (2004) also cultured okra in aquaponic system and supported its rapid outgrowth.

Therefore, okra plant growth in the soil-less media didn't take longer duration than that of the soil media. It was also observed that in almost every growth stage, T₃ (mixed media) showed better performances than the other treatments. This might be due to higher aeration and having sufficient nutrients for plants in the mixed media than the individual media.

3.1.2 Plant growth performances in terms of vegetative parameters

After emerging of okra saplings from the seeds, the height, leaf number, leaf areas and branch number of the okra plants were measured every 15 days interval.

3.1.2.1 Plant height (cm)

The significantly highest mean height of the plants ($P \leq 0.05$) was 98.75 ± 2.38 cm found in T_3 followed by T_1 of 89.42 ± 12.20 and T_2 of 71.17 ± 17.90 cm, respectively at 8th sampling stage. No significant differences among the treatments were observed in the mean heights of plants in all sampling dates except 1st sampling ($P \leq 0.01$) and 8th sampling ($P \leq 0.05$) (Fig. 2). Olasantan and Bello (2004) reported plant height ranging from 94-104 cm for early season of okra and 51-56 cm for late season of okra which were analogous and little inferior, respectively to the heights observed in present trial. The differences in plant growth among different treatments occurred due to the effect of different bedding media (Roosta and Afsharipour, 2012). The wastewater could provide the leafy plants with nitrogen, but the plants' growth could be weakened due to inadequate nitrogen supply (Chen *et al.*, 2004). Huge surface ground for bacterial survival and sufficient pores in inorganic natural gravel media could provide air to the plant roots (McCauley *et al.*, 2005) as well as some nutrients (Rakocy *et al.*, 2006) also. On the other hand, naturally available organic coconut husk media having neutral pH (Connolly and Trebic, 2010), suitable electrical conductivity and other chemical attributes for plants growth (Awang *et al.*, 2009) contributed to enhance microbial abundance in the grow bed (Connolly and Trebic, 2010). The husks were high in nutrient retention capacity and poor in nutritional value (Vidhanaarachchi and Somasiri, 1997), although contained high levels of Cl, K and Na (Konduru and Evans, 1999). But high water holding capacity of husk media caused imperfect relationship of air and water. This led to less aeration into the medium, which ultimately affects the oxygen pervasion towards the roots. Corporation of coarser components with coco-peat could enhance the aeration condition of the media (Awang *et al.*, 2009). Moreover, due to having high nutrient and water retention capacity, the husks gradually clogged the system with the progress of time. That's why the solid waste from fish tank couldn't reach the plant roots.

The mixed media performed best in terms of plant height due to higher aeration within the media (McCauley *et al.*, 2005) and supply of more nutrients to the plant roots (Rakocy *et al.*, 2006) through the faster nitrification process as both of gravels and coconut husk media acted symbiotically. On the other hand, at the preliminary stage, the plant height in coconut husk was better than gavel. But with the progress of time, the result turned into opposite. The main cause of this might be- the husks clogged the system gradually because of their higher nutrient and water retention capacity and thereby could not supply sufficient nutrient to the plants. At the young stage, plants didn't require higher amount of nutrients for their growth. Hence, the plant growth seemed to be better. But with the advancement of time, nutrient requirement for plant increased, but the coconut husk could not provide that. So plant growth in husk media started to show poor performances and gravel media took the position.

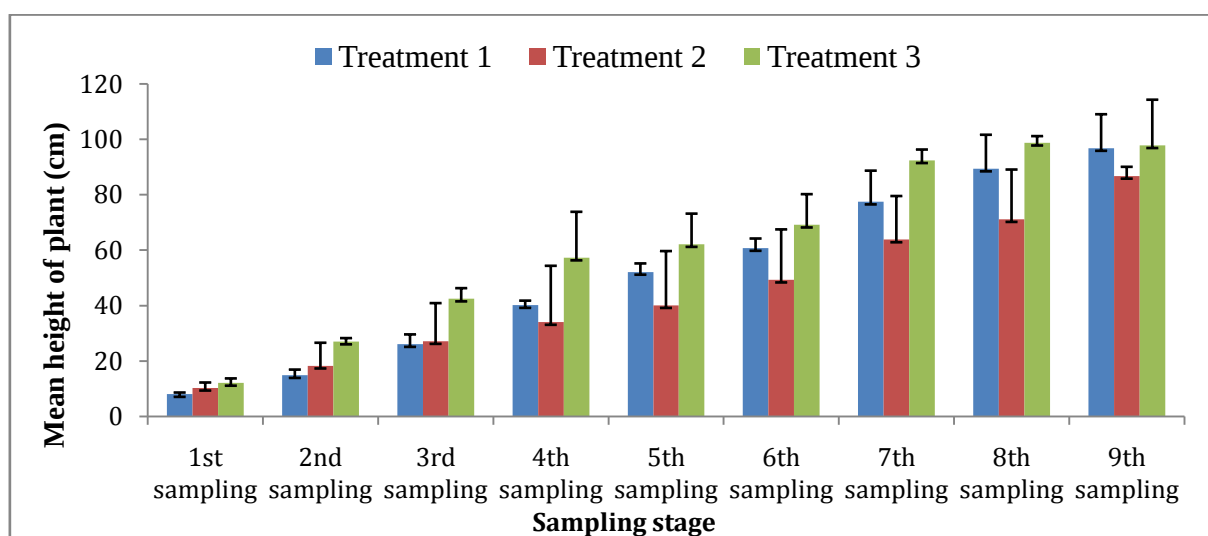


FIG. 2. Plant heights in different treatments in the experimental term ($P \leq 0.05$ and $P \leq 0.01$). In every sampling date, the highest mean height of plants was found in T_3 , whereas T_2 showed better performances than T_1 up to 3rd sampling. However, with the progress of time, the result was just opposite where T_1 showed better performances than the T_2 .

3.1.2.2 Count of leaves per plant

The highest mean leaf number was found in T₃ on 9th sampling date and the lowest mean number of leaves (except initial number) was observed in T₂ on 3rd sampling date. The media showed no significant effects on mean number of leaves of each plant in every sampling stage but 1st sampling ($P \leq 0.01$) and 8th sampling dates ($P \leq 0.05$). In all sampling dates, T₃ showed the highest mean leaf number. On the contrary, T₁ showed higher mean leaf number than T₂ up to 6th sampling. But later the result was just opposite where T₂ exhibited better performances than the T₁ (Fig. 3). That means, the mixed media displayed better performance than the individual media in case of leaf number also. Up to certain time, the gravels media could provide the plants with enough nutrients particularly required for leaf emergence. But later due to faster drainage capacity of gravels, necessary nutrients were not absorbed by the plants. By contrast, at that time the plants grown in the husk media could receive the required nutrients due to higher nutrient retention capacity of the media (Vidhanaarachchi and Somasiri, 1997). Patwary (2001) also supported the leaf number in the experiment. Das (2011) recorded maximum leaf number of 22 for okra production in soil media which appreciated the present outcome.

3.1.2.3 Leaf area

No significant distinctions in mean leaf area of plants were reported among the three treatments in all sampling stages except the initial one ($P \leq 0.05$). In the present study, the mixed media exposed larger leaf area than other media up to particular lifetime of the plant (up to 6th sampling). But later, the leaf area in the mixed media started to fall and the husk media took the space (Fig. 3). This might be due to higher-availability of nutrients essential for increasing leaf size in the mixed media up to particular time (up to 6th sampling) and then lower availability of the particular nutrients in the media. At that time the nutrients for leaves were higher in coconut husk rather than the mixed media and thereby higher leaf area was found in the coconut husk media.

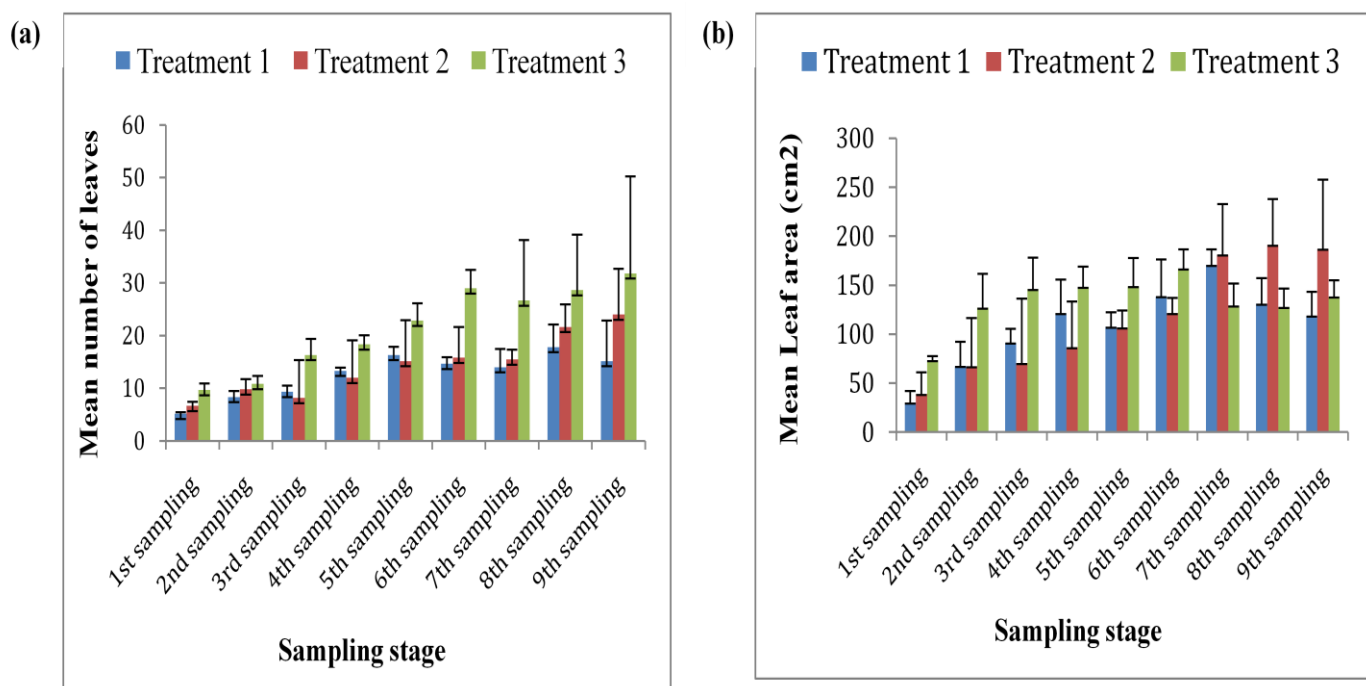


FIG. 3. Mean number (a) and mean area (b) of leaves in different treatments in the experimental term ($P \leq 0.05$ and $P \leq 0.01$).

3.1.2.4 Number of branch per plant

About three months later of sowing seeds, plant of T₃ showed first branching. The other treatments delayed about 7 days to show branching. During the study period, the highest mean number of branch was 3 ± 0.5 per plant found in T₃ followed by T₂ of 1.52 ± 0.78 and T₁ of 1.06 ± 0.72 , respectively (Fig. 4). Patwary (2001) and Das (2011) supported the results as they reported the number of branch ranging from 2.0 to 2.62 and 1.96 to 2.97 respectively during okra production in soil. The combined media showed faster and more branching than other media. This might be due to supply of higher amount of essential nutrients to the plant roots through the faster nitrification process by the mixed media.

3.1.3 Production performances of okra plant

Significant ($P \leq 0.05$) variations in mean okra production were found among three treatments. During the study period, the significantly highest mean production of okra was $9.08 \pm 1.25 \text{ kg/m}^2$ found in T_3 whereas T_1 produced $7.5 \pm 1.83 \text{ kg/m}^2$ and T_2 produced $3.83 \pm 2.33 \text{ kg/m}^2$ of okra (Fig. 4). If the production was converted to land area, it would be 75, 38.3 and 90.8 tons/ ha/ 157 days in T_1 , T_2 and T_3 respectively. Das (2011) and Patwary (2001) cultured okra for 120 days in soil media and reported maximum okra production of 10.19 tons/ha and 13.09 tons/ha respectively in their experiments which applauded the present production. Similarly, Rakocy *et al.* (2004) reported that total field okra production was only 5% of the aquaponic okra production. They also reported okra production of $3.04 \text{ kg/m}^2/80 \text{ days}$ ($5.97 \text{ kg/m}^2/157 \text{ days}$) in UVI aquaponic system, confirming that the mixed media could be preferred over individual media. The outstanding performances of combined media in okra production compared to single medium might be due to having suitable growing condition and higher availability of nutrients for plants in the mixed media compared to the individual media.

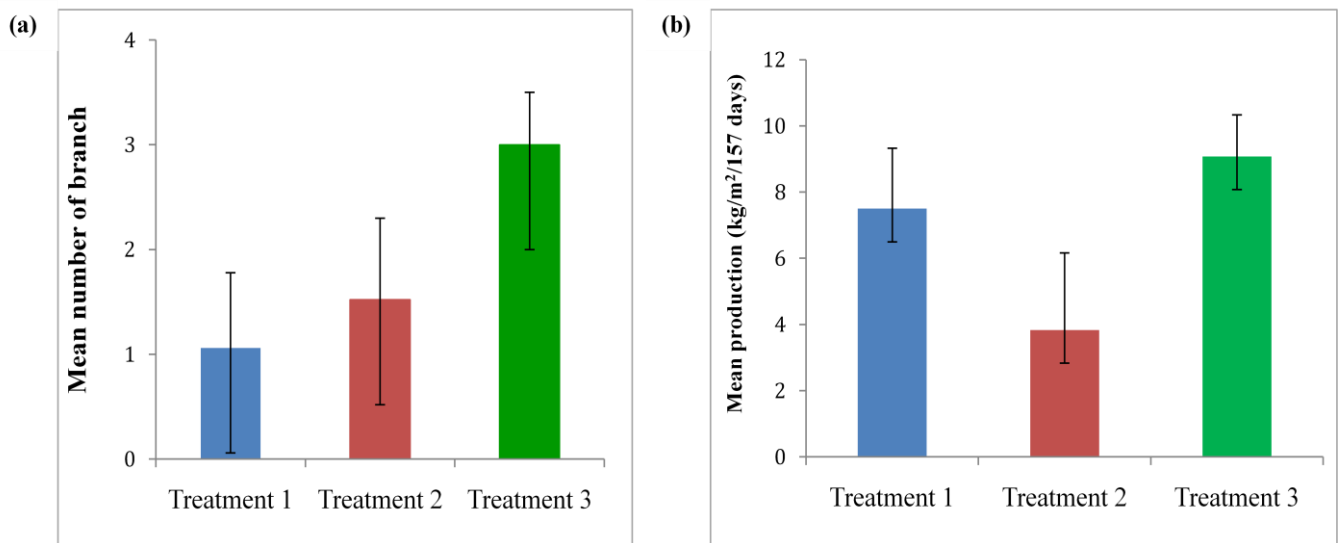


FIG. 4. Number of branch (a) and Mean okra production (b) of different treatments in the experimental term ($P \leq 0.05$).

3.2 Growth and yield performances of Tilapia

3.2.1 Growth performances of fish

The growth performances of tilapia regarding length (cm) and weight (g) gain were presented in Table 1.

TABLE 1
GROWTH PERFORMANCES OF TILAPIA OBSERVED IN THE EXPERIMENTAL TERM

Growth measuring parameters	Value
Mean initial length (cm)	13.65 ± 1.88
Mean final length (cm)	20.29 ± 1.98
Mean length gain (cm)	6.64 ± 0.1
% Length gain	48.64 ± 5.32
Mean initial weight (g)	46.04 ± 20.92
Mean final weight (g)	150.8 ± 41.70
Mean weight gain (g)	104.76 ± 20.78
% Weight gain	227.54 ± 99.33
Specific growth rate (% per day)	0.75
FCR	1.96
Survival rate (%)	92.30
Fish production (tons/ha/157 days)	138.80

Rana *et al.* (2015) cultured tilapia and found similar mean length gain of the present experiment. Sarkar (1998) recorded mean length gain of tilapia of 11 cm in 180 days which was slightly higher than the present findings and might be due to the differences in culture period, system, density and feed used. Hosen (2014); Salam *et al.* (2014) appreciated and Bethe *et al.* (2017) slightly depreciated the present mean weight gain who cultured tilapia in aquaponic system for 152, 116 and 180 days, respectively and obtained mean weight gain of 58, 116 and 170 g respectively. The differences might be due to various climatic conditions and stocking densities. Specific Growth Rate (SGR) of tilapia in the study was found satisfactory. More or less analogous findings were testified by Salam *et al.* (2013) and Salam *et al.* (2014) who recorded SGR value for tilapia in aquaponic system 0.79 and 0.74 respectively.

The FCR in the experiment was within the expected tilapia FCR ranging from 1.5 to 2.0 (Watanabe *et al.*, 2002). Rakocy *et al.* (2004) and Bethe *et al.* (2017) reported FCR value for tilapia in aquaponics 1.8 and 2.33 respectively, which more or less supported the present finding. Elsewhere, Khan *et al.* (2008) recorded FCR value of 1.7 for Nile tilapia culture from August to October and Salam *et al.* (2014) reported 2.67 from March to June. It was also noted that higher water temperatures ($> 28^{\circ}\text{C}$) within the suitable ranges could lead to higher FCR for tilapia (Midmore *et al.*, 2011). The survival rate in the current experiment was favored by the pronouncements of Salam *et al.* (2013) and Rahman (2000) who recorded 93 and 94% survival respectively but slightly devaluated the results of Salam *et al.* (2014) and Bethe *et al.* (2017) who reported 83.34 and 85% survival respectively. Satisfactory survival rate obtained in the current research might be owing to favorable environmental conditions, regular monitoring of water quality, and supply of adequate amount of feed.

Extensive tilapia production in the present trial was more appreciable compared to the production of Salam *et al.* (2014) and Bethe *et al.* (2017) who also cultured tilapia in aquaponic system for 116 and 180 days and found tilapia yield of 95.85 and 134.30 tons/ha respectively. Moreover, the present finding also showed superiority over the output of Rana *et al.* (2015) who obtained tilapia production of 28 tons per hectare for 90 days of rearing in ponds and feeding with experimental diets, meaning that the tilapia production in aquaponics was much higher than that in the conventional semi intensive culture system.

3.2.2 Growth pattern of Tilapia

There were significant ($P \leq 0.01$) differences of mean lengths and mean weights of fish within varied sampling dates over the culture time. The length increment as well as weight enhancement of the present trial (Fig. 5) was analogous with the pronouncements of Salam *et al.* (2014) and Bethe *et al.* (2017).

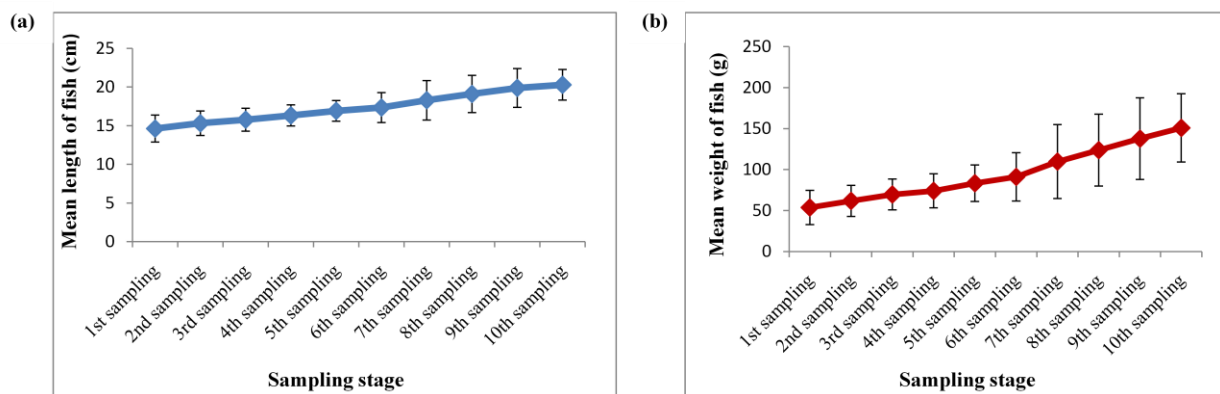


FIG. 5. Growth pattern of fish in respect of length increment (a) and weight enhancement (b) in the experimental term ($P < 0.01$).

3.2.3 Length–Weight relationship of Tilapia

The Correlation Coefficient (r) was 0.99 and Coefficient of Determination (R^2) was 0.98 for Tilapia. In this study, for 1 cm length increase of tilapia, the weight increase was 15.97 g (Fig. 6). The Correlation Coefficient in the present experiment of 0.99 revealed that a very high positive relationship existed between the length and the weight of tilapia and it was proximate to 1, which indicated the increasing slope. Coefficient of Determination of 0.98 suggested that 98% variation of the dependent variable (Weight) could be explained by the independent variable (Length) but the rest could not be explained due to some experimental errors. Salam *et al.* (2014) recorded the correlation coefficient 0.95, Coefficient of Determination 0.95 and the weight increment of tilapia in aquaponic system 8.19g for 1 cm length increase which were lower than the present findings.

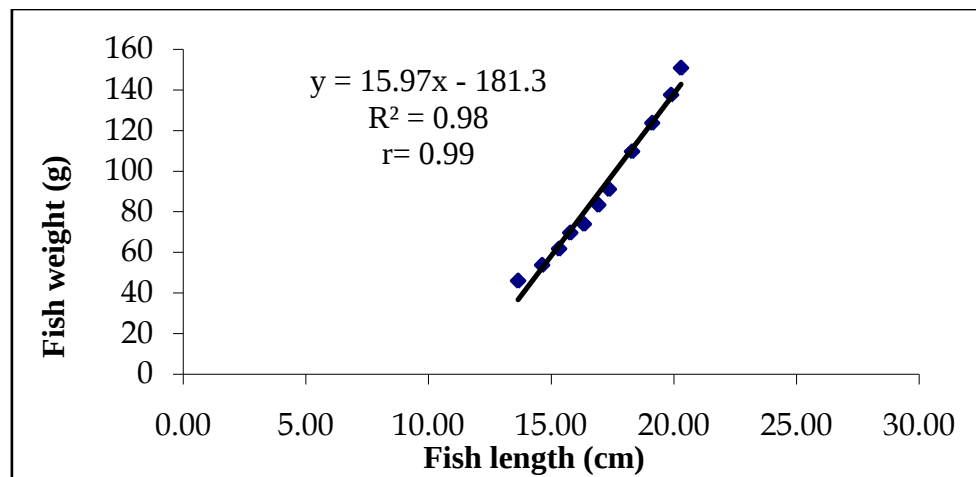


FIG. 6. Regression analysis of length-weight relevance for tilapia in aquaponics

It was observed that tilapia performed well in the system, although the stocking density was higher and they had to tolerate higher water temperature in summer as fish tank was exposed to the direct sunlight at the roof top.

3.3 Water quality parameters

The water quality parameters remained within the suitable limits for tilapia production as well as the growth of okra throughout the experiment. The averages of pH, temperature and DO values were 7.87 ± 0.41 , $29.25 \pm 1.17^\circ\text{C}$ and 4.18 ± 0.27 ppm, respectively (Fig. 7). There were significant ($P < 0.01$) dissimilarities of pH, temperature and Dissolve oxygen among different sampling dates during the study period. pH between 6.5 and 9.0 was desirable for tilapia culture (Swingle, 1968; Huet, 1972). Tyson and Simonne (2014) reported that optimum pH for nitrifying bacteria ranges from 7.0-8.0, whereas their growth is averted underneath pH of 6.5 where 7.8 is the most favorable pH (Antoniou *et al.*, 1990). So, the range of pH value in the present study was also good for okra production and nitrification.

On the other hand, temperature of water also plays a diametrical role, not only in reining fish's metabolic process (Battes *et al.*, 1979), but also for vegetable production and nitrification process. Tyson and Simonne (2014) reported that optimum temperature for tilapia culture ranged from $28 - 32^\circ\text{C}$. The low and high lethal temperature threshold for Nile tilapia was 11 and 42°C respectively (Balarin and Hatton, 1979). Okra plant showed better performances at $29 - 35^\circ\text{C}$ temperature (Salam *et al.*, 2013). The optimum temperature for nitrifying bacteria was $25 - 30^\circ\text{C}$ (Tyson and Simonne, 2014) and nitrification could be accomplished between 7 and 35°C with an optimum temperature of 15 to 25°C (Wortman and Wheaton, 1991). In the current experiment, temperature of fish tank water during the study period varied from 27.4 to 31°C with an average value of $29.25 \pm 1.17^\circ\text{C}$ which remained within optimum level for tilapia, okra and even for nitrification too.

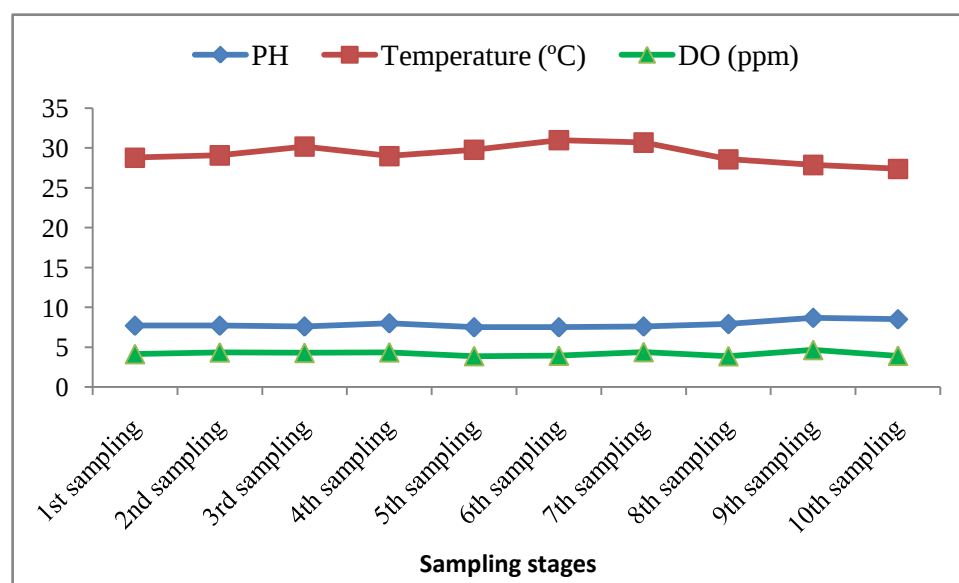


FIG. 7. Biweekly variations of water quality parameters during study period ($P < 0.01$).

Dissolved oxygen (DO) is another considerable factor in fish culture although tilapia is a hardy fish that can survive in a low DO content. The least endurance limit of dissolved oxygen for Nile tilapia is as low as 0.1 mg/l (Ahmed and Magid, 1968; Magid and Babiker, 1975; Balarin and Hatton, 1979) owing to its capability to survive by using ambient oxygen. In the current study, the DO in tank water ranged from 3.88 to 4.65 ppm, where the average value was 4.18 ± 0.27 ppm. More or less similar results were reported by Kohinoor (2000) and Hossain (2000) who observed DO values in fish culture ponds of 3.8 - 6.9 ppm and 2.04 - 7.5 ppm, respectively. Bethe *et al.* (2017) and Salam *et al.* (2014) also recorded DO values from 1.8 to 5.37 and 2.07 to 4.69 ppm respectively for tilapia in aquaponic system. Rakocy *et al.* (2004) observed DO values from 3.7 to 4.6 while producing okra in aquaponic system. The nitrifying bacteria growing on the root systems also participated in oxygen uptake (Sutton *et al.*, 2006). Therefore, the present finding of DO value was suitable for okra, tilapia and nitrifying bacteria in aquaponic system.

3.4 Chemical analysis of influent and effluent water in laboratory

Nitrogen (N), potassium (K), phosphorous (P), sodium (Na), sulphur (S) are important macronutrients for plant growth. Here, the inner water of fish tank was considered as influent water and the water returning again to the fish tank after recycling was figured out as effluent water. In the present trial, the largest amount of Total-N was 22.4 ± 2.4 ppm in influent in 1st sampling when it was 16.8 ± 1.6 ppm in the effluent (Fig. 8), where the Total-N removal was 25%. Highest Total-N removal was 66.6% found in 2nd sampling. Ghaly and Snow (2008) experimented the usage of barley for nourishment dismissal from re-circulating aquaculture equipped with Arctic charr (*Salvelinus alpinus*) and observed 76% of total-N shortening. Salam *et al.* (2014) and Bethe *et al.* (2017) reported 16% and 42% total-N utilized by plants cultured in aquaponic system which supported the present finding. In the present study, the Phosphorus (P) value in the effluent was higher than that in the influent. This might occur because the growing media- coconut husk or cocopeat contains several macro- and micro-plant nutrients (Evans *et al.*, 1996). In 3rd sampling, the influent and effluent water contained 0.08 ± 0.01 and 0.98 ± 0.06 ppm P values respectively (Fig. 8) which coincided with the recognition of Salam *et al.* (2013) who recorded average $\text{PO}_4\text{-P}$ of 0.05 to 1.0 ppm in research ponds of BAU, Bangladesh

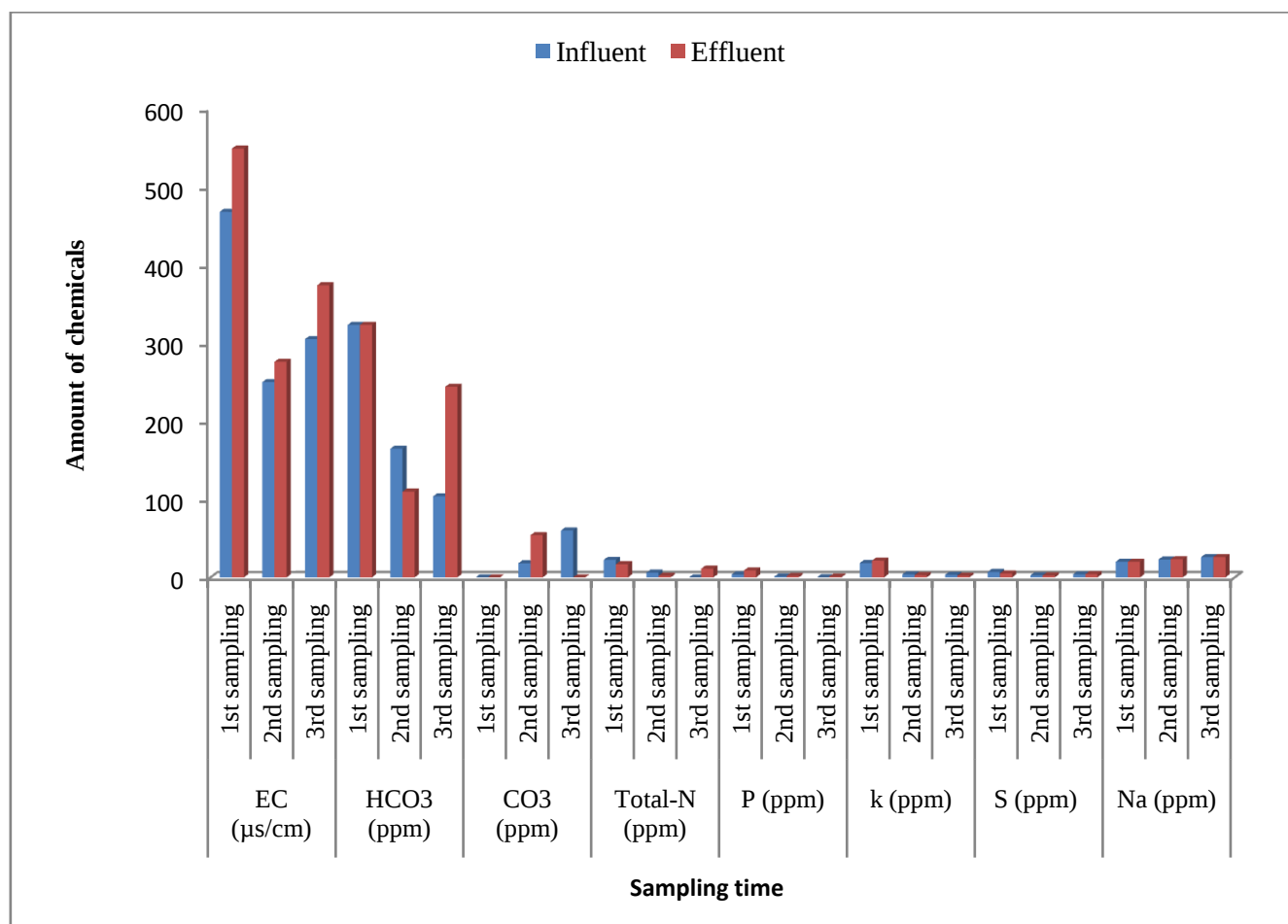


FIG. 8. Chemical properties of influent and effluent water in the experimental term

The higher value of Potassium (K) in effluent (21.38 ± 4.3 ppm) than the influent (18.33 ± 3.5 ppm) in 1st sampling indicated that plants didn't uptake K at the preliminary stage which was supported by the findings of Rakocy *et al.* (2004). Moreover, coconut husk itself contains high level of potassium from 19 to 948 ppm (Evans *et al.*, 1996). But with the maturity, plants required K and up took them as their nutrients (Fig. 8). In 1st sampling, 27.8% sulphur (S) was utilized by plants. But at the final stage of experiment (3rd sampling), plants might stop to uptake S, so the influent might be lower than the effluent (Fig. 8) due to reaction with the media which was supported by the findings of Rakocy *et al.* (2004) who also produced okra in the aquaponics.

The greatest average value of sodium (Na) was 26 ± 4.1 ppm found both in the influent and effluent water in 3rd sampling. Contrariwise, the least mean value of Na was 20 ± 3.6 ppm found both in the influent and effluent water in 1st sampling (Fig. 8). In the present research, Na utilization by plants remained undetectable which was supported by Rakocy *et al.* (2004). This might be due to having higher level of Na (23 to 88 ppm) in the coconut husk media (Konduru and Evans, 1999). The highest mean value of EC was 549 ± 1.2 $\mu\text{S}/\text{cm}$ that was found in the effluent water in 1st sampling and the lowest mean value of EC was 250 ± 0.6 $\mu\text{S}/\text{cm}$ found in the influent in 2nd sampling (Fig. 8). The EC ranging from 2.00-4.00 milliSiemen/cm contained in a typical hydroponic nutrient solution (Resh, 1995). Rakocy *et al.* (2004) recorded EC value of 0.5 mS/cm (500 $\mu\text{S}/\text{cm}$) in okra production experiment which was approximately analogous to the current pronouncement.

The largest amount of HCO_3 (323.3 ± 4.2 ppm) was found both in the influent and effluent water in 1st sampling. On the contrary, the lowest mean value of HCO_3 was 103.7 ± 0.29 ppm found in the influent in 3rd sampling, while the value was 244 ± 4.4 ppm in the effluent water (Fig. 8). At the preliminary stage of culture, plants didn't uptake HCO_3 from the fish waste water, but at the middle stage HCO_3 was utilized by plants as the effluent was lower than the influent. At the final stage, plants further might stop to uptake HCO_3 due to reaction with the growing media. The highest mean value of CO_3 was 60 ± 1.3 ppm that was found in the influent water in 3rd sampling, while in the effluent no CO_3 was found. Moreover, CO_3 content was nil both in influent and effluent water in 1st sampling (Fig. 8). Plants didn't require CO_3 at first 3 months of culture, but later they utilized CO_3 from the system extensively.

Therefore, the nutrient concentrations and other water quality parameters were favorable for aquaponic system as both of fish and vegetable grew well in the system.

IV. CONCLUSION

The present experiment has proved that the mixture of gravels and coconut husk media is more suitable for vegetable growth and production than the individual media. The fish growth and production performances are also favorable in the same aquaponics. The system can be used for fish and vegetable production in urban and peri-urban areas. Thus nutrition and food security will be enhanced with minimum environmental pollution. Moreover, the availability and low-cost of bedding materials and suitability of this system provide better opportunities to fulfill the nutritional demand and maximize the use of land and water.

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