EFFECT OF FEEDING FREQUENCY ON GROWTH PERFORMANCE OF GIFT TILAPIA (*OREOCHROMIS NILOTICUS* LINNAEUS , 1758) IN DEEP WATER CULTURE AQUAPONICS SYSTEM*

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Abstract

Aquaponics integrates aquaculture and hydroponics into a common closed-loop eco-culture where a symbiotic relationship is created in which water and nutrients are recirculated and reused, concomitantly fully utilized and conserved. In this study, GIFT Tilapia (*Oerochromis niloticus*) (2.8 ± 0.5g) collected from Hlawga Hatchery Station; Yangon which was cultured with different feeding frequency in DWC aquaponics systems to investigate the appropriate feeding frequency for optimal growth of GIFT tilapia. These experiments were divided into three treatments on the basis of feeding frequency (2 times (2T), 3 times (3T) and 4 times (4T)) per day respectively, having three replications. Then 24 seedlings of lettuce were introduced aquaponic system. Fish were fed floating pellet for 5 % of body weight. Fish were cultured from July to November, 2022. The highest total mean weight was found in 4T (356 g), followed by 3T (326 g) and 2T (281.6 g) respectively. The highest final weight gains were recorded in 4T (219.6 g) while the lowest weight gain in 3T (186 g) followed by 2T (161 g) in the end of experiment. In November, the highest FCR was found in 2T (1.1) while the lowest FCR was recorded in 4T (0.9) followed by 3T (1). High specific growth rate (11) was found in 4T treatment in two production cycles. For plant quality index, the highest number of grade A plants were observed in 4T. However, 12 and 13, Grade B plants were found in 2T, 3T and 4T in first and second harvest times. According to this study, it is understood that feeding frequency has an important effect on growth rate: 4T system shows the most favorable outcome for tilapia and lettuce than other frequencies.

Keywords: Tilapia, feeding frequency, growth performance, lettuce

Introduction

Aquaculture is the culture of aquatic organisms in a designated water body. The water needs to be treated whenever toxicants in it have built up beyond animal's safe level. Toxicants such as ammonia and nitrite are derived from decomposition of unconsumed feed and metabolites or waste of the animals. Hydroponics is the culture of aquatic plants in soilless water where nutrients for plant's growth come entirely from a formulated fertilizer (Liang and Chien, 2013). Aquaponic systems are integrated recirculating aquaculture with hydroponics as fast emerging food production technology (Rakocy *et al.*, 2004). In aquaponic systems, the wastewater from aquaculture system that is rich in nutrients is circulated to vegetable grow beds (Rakocy *et al.*, 2006).

As the microbes break down fish waste metabolites into soluble nutrients. Thus, plants can uptake nutrients directly from water. Already treated, cleansed and safe water for the fish flows back to aquaculture system for reuse (Somerville *et al.*, 2014). Aquaponics productions are known to be natural, organic, eco-friendly and free of pesticides and herbicides (Blidariu and Grozea, 2011). Other advantages are: less usage of water through reuse, the recycling of nutrients and management of waste, and minimize adverse environmental impacts such as pollution (Al-Hafedh *et al.*, 2003; Rakocy *et al.*, 2004b). In addition to the ecological benefits, aquaponics systems are capable of offering several economic benefits such as: savings in the costs of the treatment of water in the aquaculture system (Adler *et al.*, 2000; Liang and Chien, 2013).

Tilapia is the most commonly used fish in aquaponics systems (Rakocy *et al.*, 2006) for their high availability, fast growing, stress and diseases resistant and easy adaptation to indoor environment (Hussain, 2004). The mostly grown plants in aquaponics include lettuce, water spinach, tomato, cucumber, pepper and herbs (Rakocy and Hargreaves, 1993; Adler *et al.*, 2000;

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Savidov *et al*., 2005). Among those, Lettuce (*Lactuca sativa*) is commonly used because it is well adapted to aquaponic systems. It can be harvested within 3 to 4 weeks, with relatively fewer pest problems and low to medium nutritional requirements (Diver, 2006; Rakocy *et al.*, 2006).

Feeding frequency is important to ensure a maximal food conversion ratio and weight of cultured organisms (De Silva and Anderson, 1995). Higher feeding frequencies decrease aggressive behavior may resulting the faster growth and uniformity in size (Zhou *et al*., 2003). Moreover, feeding frequency can affect growth performance, survival, body composition and water quality (Zakes *et al*., 2006). Furthermore, the feed cost is one of the largest operational costs in the aquaculture industry (De Silva and Anderson, 1995).

An important approach for reducing feed costs in commercial aquaculture is to develop proper feed management, husbandry strategies (Lovell, 1998). Hence, the act of feeding may be pointed as one of the most vital elements in the culture practice (Pouomogne and Ombredane, 2001). Several authors had already studied the influence of feeding frequency on growth performance for various species (Kasiri *et al*., 2011). However, the effect of feeding frequency on growth performance of GIFT tilapia reared in aquaponics system is yet quite limited.

Therefore, the present research work was carried out with an aim to find the more effective and a suitable feeding frequency for optimal growth and survival during rearing.

Materials and methods

The present study was conducted at the Laboratory of Aquatic Bioscience, Department of Zoology, University of Yangon.

The experiment was carried out from July to November 2022.

Experimental design

In this experiment, aquaponic systems included fish tanks, hydroponic tanks and biofilter. A fiber tank (0.85m x 0.61m x 0.43m) was used for the aquaponic system while fiber tank (1.2m ×1.2m×0.43m) was applied for hydroponic tanks. In the hydroponic tank, Styrofoam block(1.1m×1.1m) entirely covered the surface area of hydroponic tank. A water pump (75 Watt) was used in all systems. The running water system was set up between the hydroponic tank and the fish tank with the aid of a pump through a biofilter (Fig. 1 and Plate 1). The biofilter tank is one of the most important components in an aquaponics system as it reduces the toxicity of the nitrogenous waste for fish. In the present study, shells from bivalve were used as substrate in the biofilter to growth the nitrifying bacteria in large surface area. Large plastic bucket (0.39 m in diameter ×0.43 m in height) was filled with shell of bivalves until two-thirds of the bucket. This experiment system was set up for triplicate. The DWC unit, also called the float or raft system, set up a fish tank, filters, canals, and floating rafts (Plate 2).

Sample collection

A total of 400 fingerlings GIFT Tilapia (*Oreochromis niloticus* Linnaeus, 1758) was collected with oxygen filled plastic bags from Hlawga Hatchery Station to laboratory of Aquatic Bioscience, Department of Zoology, Yangon. Genetically Improved Farmed Tilapia (GIFT), a strain of tilapia, is one of the most-farmed aquaculture fish. Each fish tank is contained, 40 fingerlings GIFT tilapia (2.8 ± 0.5g) were put in each tank (0.85 x 0.61 x 0.43 m3).

Feeding regime

Three feeding frequencies were tested: two meals per day (9:00 and 16:00 hours; 2T), three meals per day (9:00, 12:00 and 16:00 hours; 3T), and four meals per day (8:00, 11:00, 14:00 and 17:00 hours; 4T). Three replications were allocated for each feeding frequency.

Preparation of vegetables

Seeds were put in seedling trays with coconut coir and soil. Seeds were germinating within four days.Seethings of lettuce (Lactuce sativa) were used as vegetable in this study.

Firstls, seeds were put in seelling trays with cocount coir soil . After two weeks, seedling of lettuce were transplanted in pot. Seedlings of lettuce were cultivated in the whole of styrofoam in DWC. The density of plant was 24 plants m^2. Plants were put to the pot together with substrate (coconut coir) which help the plants to stand vertical (Plate 3).

Growth parameters analysis of fish

Fish growth performance such as weight gain, specific growth rate and feed conversion ratio were evaluated in accordance with Cerozi and Fitzsimmons (2017).

$$\text{Weight gain (WG, g)} = \frac{Wf - Wi}{\text{number of fish per replicate}}$$

$$\text{Specific growth rate (SGR, \%)} = 100 \times \frac{\ln Wf - \ln Wi}{\text{days of feeding period}}$$

$$\text{Feed conversion ratio (FCR)} = \frac{\text{feed intake (g)}}{\text{weight gain (g)}}$$

wf = final weigth

wi= initial weigth

Growth parameters analysis of plants

Final plant parameters were: height of leaves (cm), weight of leaves and roots (g), number of leaves per plant, and specific growth rate (SGR = [(ln final leaves wet weight − ln initial leaves wet weight) × time$-^{1}$] × 100) (% day$-^{1}$).

Additionally, a plant quality index (PQI) was evaluated by grades attributed to visual aspect of the leaves. Visual parameters included abnormalities in the leaf surface such as yellowish color and/or imperfections (wrinkles and burns). The grades were from A to D as follows: (Pinho *et al*., 2017).

A = Excellent, up to 5% of the leaves surface with imperfections

B = Good, 33% imperfections

C = Average, 66% imperfections

D = Poor, 100% imperfections

Plants grades assessed using a “blind” approach where three valuators did not know which treatment the plants were grown.

Water quality analysis

The water quality parameters; pH, dissolved oxygen and temperature were monitored by probes (ID-1100, USA and ID-150, Iijima Electronics Corporation) every day in all tanks. Nitrate and ammonia equipment calibrated from the experimental tanks were measured twice a week using colorimetric test kits.

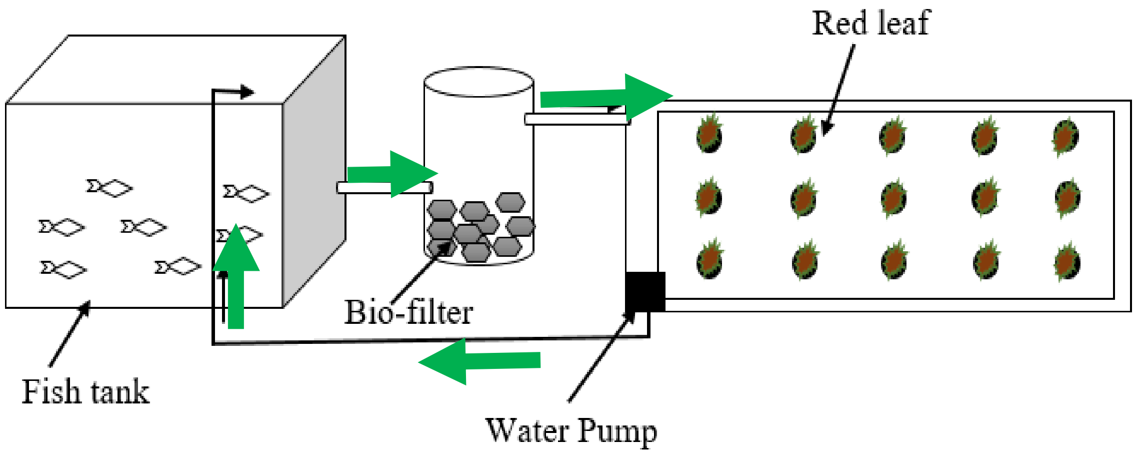


Figure. 1 Schematic diagram of Deep Water Culture (DWC) aquaponic system

Plate 1 Deep Water Culture (DWC) aquaponic system in experiment

Plate 2 Preparation the three different units in aquaponic system

Plate 3 Germination of Lettuce before introducing to aquaponic systems

Results

Growth of GIFT Tilapia

Growth of fish was studied during the period of five month culture in DWC aquaponic systems. In the beginning of experiment, mean weight of tilapia was 2.8g in all systems. Fish weight gradually increased during study period. At the end of experiment, the highest total mean weight was found in 4T (356 g), followed by 3T (326 g) and 2T (281.6 g) respectively (Fig. 2).

The highest final weight gains were recorded in 4T (219.6 g) while the lowest weight gain in 3T (186 g) followed by 2T (161 g) in the end of experiment (Fig. 3). Final specific growth rate of fish was (3.5) followed by 3T (3.2 g) and 2T (2.7 g) respectively (Fig. 4).

Food conversion ratio (FCR) in October, were 0.9, 1 and 1.1 in 2T, 3T and 4T respectively. In November, the highest FCR was found in 2T (1.1) while the lowest FCR was recorded in 4T (0.9) followed by 3T (1). Although the highest FCR was found in 4T, in the end of experiment in November, the lowest FCR was recorded (Fig. 5). The mortality of GIFT tilapia was found 98% in the beginning of experiment.

Lettuce production

During experimental period, the condition of plants was measured in all aquaponic systems. Plants were cultivated and harvested for two production cycles of lettuce during the study period. High specific growth rate (11) plants were found in 4T treatment in two production cycles (Fig. 6).

Plant quality index was assessed as A, B, C and D according to the quality of plant. For plant quality index, the highest number of grade A plants were observed in 4T. However, 12 and 13, Grade B plants were found in 2T, 3T and 4T in first and second harvest times. None of grade D lettuce was found in 4T while 1 grade D lettuce was found in 2T and 3T in September 15 - October 30, 2022 (Fig. 7).

Water quality

The water quality was recorded from July to November, 2022. In all experiments, at the end of experiment, ammonia and nitrite levels were 0.2 mg/L in all tanks. pH level of ranged between 6.8 to 7.5 in all tanks. Temperature ranged between 24 to 28 ºC in all systems. Dissolved oxygen ranged between 6 to 6.8 mg/L in all tanks (Table 1).

Table 1 Water Parameters during experimental period

Parameters	July			August			September			October			November		
	2T	3T	4T	2T	3T	4T	2T	3T	4T	2T	3T	4T	2T	3T	4T
Dissolved Oxygen (mg/L)	6	6	6	6.8	6.6	6.5	6.8	6.8	6.6	6.5	6.8	6.5	6.7	6.6	6.4
Temperature(°C)	24	24	24	25	25	25	27	27	27	27	27	27	28	28	28
pH	7.3	7.3	7.3	7.5	7.4	7.2	7.4	7.4	6.9	7.5	7.4	6.8	7.4	7.2	6.8
Ammonia (mg/L)	0	0	0	0	0	0	0	0	0	0.1	0.1	0.1	0.1	0.1	0.2
Nitrate (mg/L)	0	0	0	0	0	0	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2

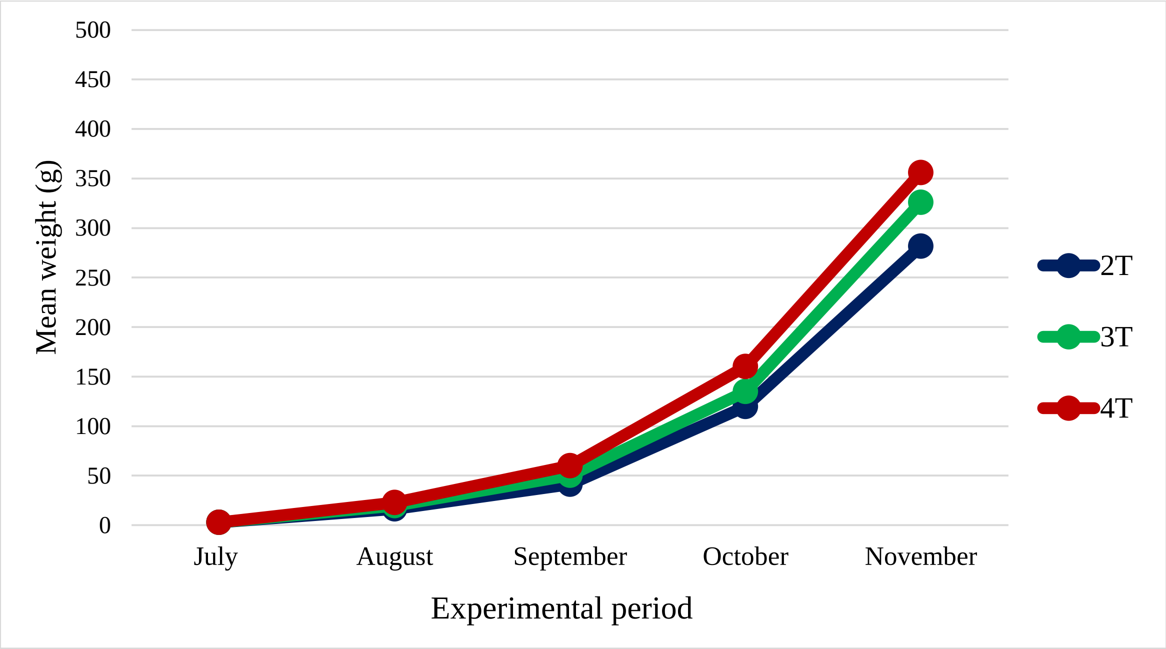


Figure. 2 Total Mean weight of GIFT Tilapia in all experiments

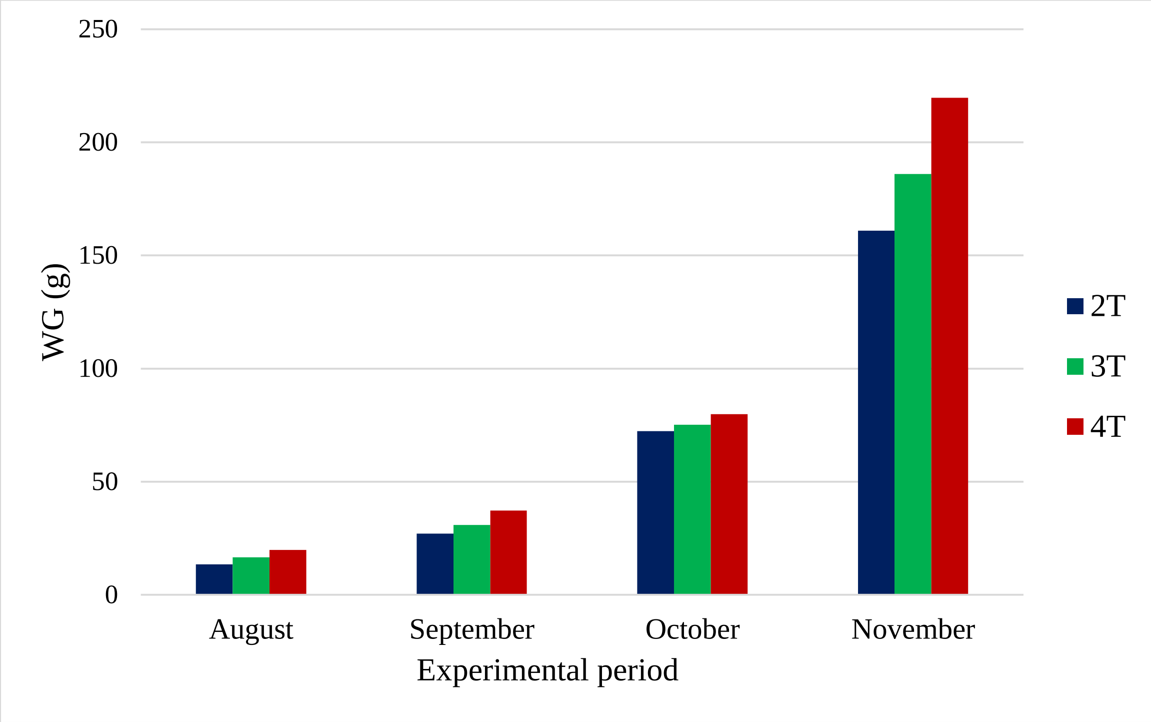


Figure. 3 Weight gain of GIFT Tilapia in all experiments

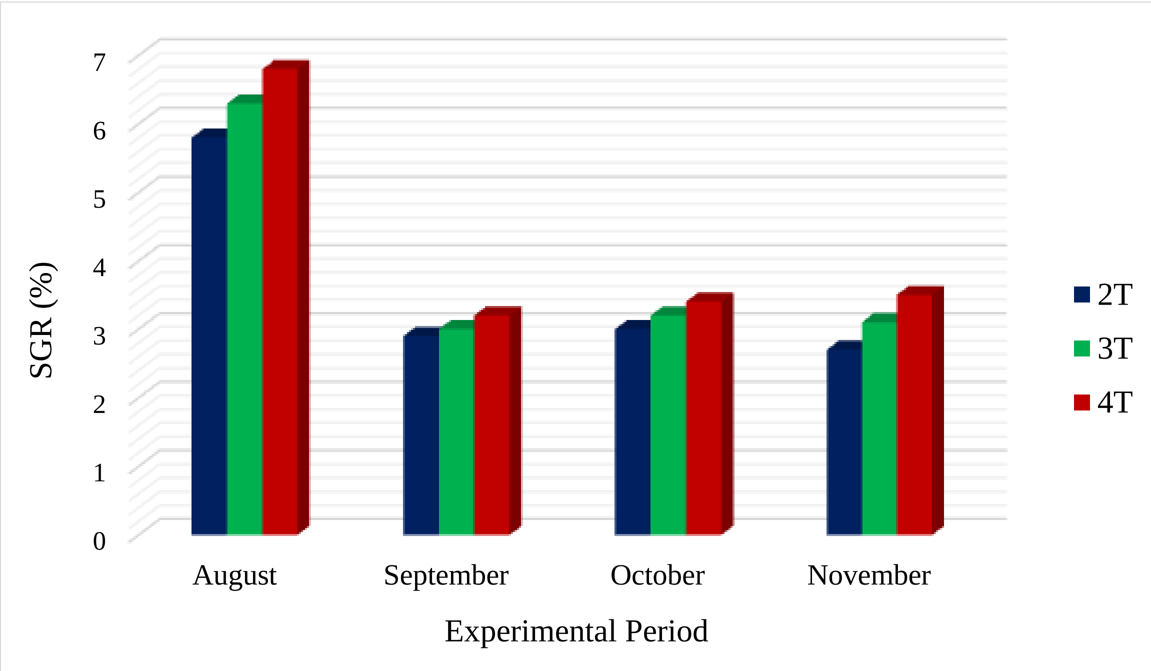


Figure. 4 Specific growth rate of GIFT Tilapia in all systems

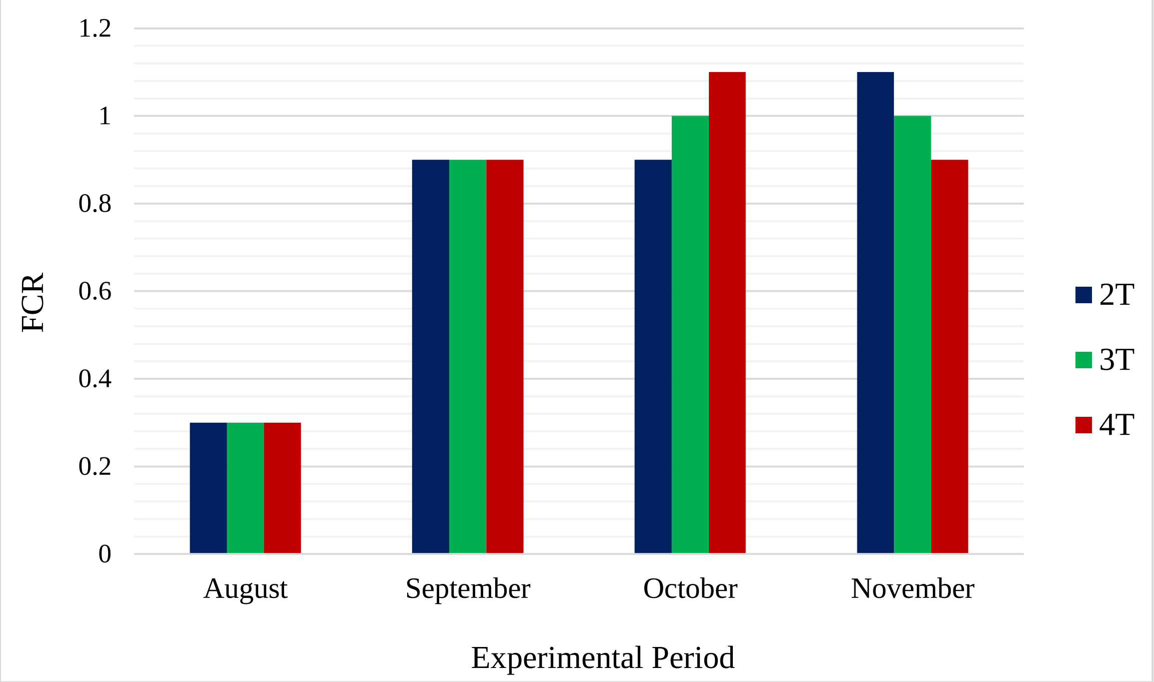


Figure. 5 Food conversion ratio in experimental tanks

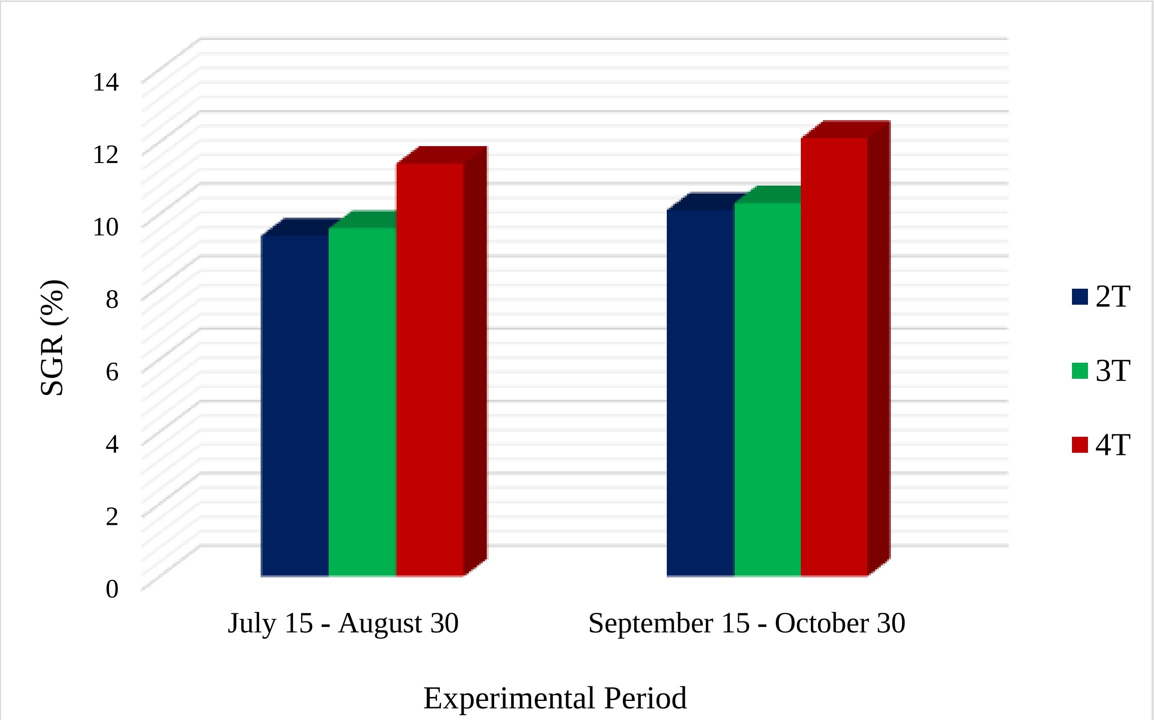
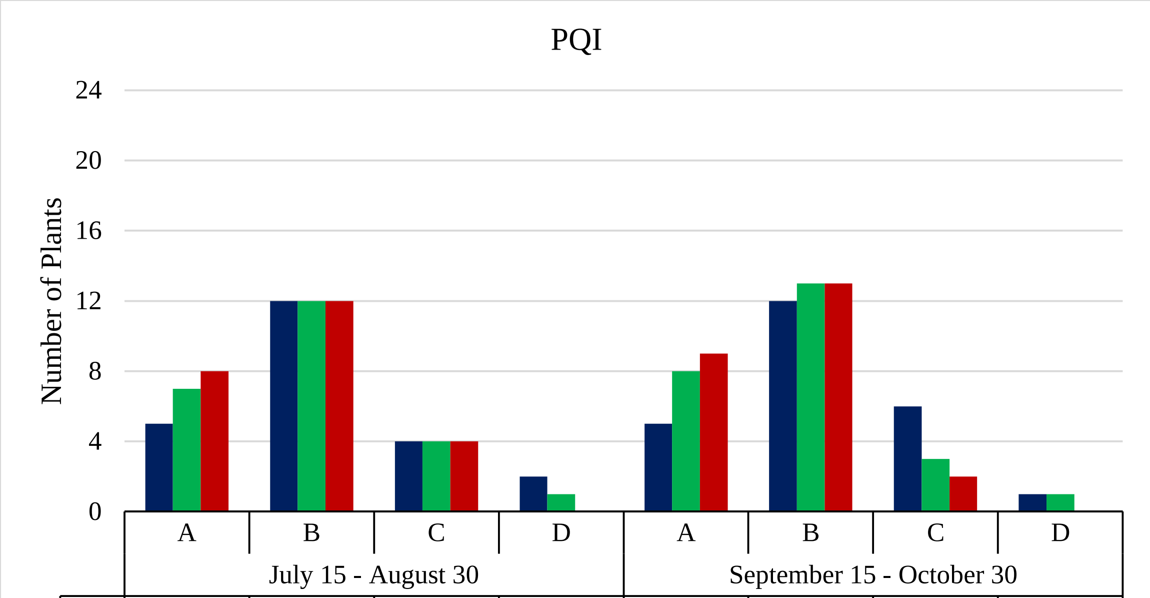


Figure. 6 Specific growth rate of lettuce in aquaponic systems



	A	B	C	D	A	B	C	D
	July 15 - August 30				September 15 - October 30			
2T	5	12	4	2	5	12	6	1
3T	7	12	4	1	8	13	3	1
4T	8	12	4	0	9	13	2	0

Figure. 7 Plant Quality Index of lettuce in all aquaponic systems

Discussion

Feeding frequency is one of the most important considerations in aquaculture practice that can affect overall growth, survival as well as habitat of fish. Again, the optimization of feeding frequency is considered as a significant factor as profit is the main motivating reason in fish culture. In the present study, Tilapia *Oreochromis* sp. growth and feed conversion values as related to feeding frequencies, initial weights and survival rate was similar in all treatments.

However, the final weight, weight gain, specific growth rate, feed intake and feed conversion ratio (FCR) significantly increased in all experimental tanks. Where fish were fed four times a day, followed by those tanks with fish fed thrice and twice a day. During the experimental period, three types of feeding frequency were conducted to observe the growth performance of tilapia. The mean final weight of tilapia was 356 g in 4T followed by 326 g in 3T and 281.6 g in 2T. Ali *et al*. (2017) studied that three-feeding frequency with four (T1), three (T2) and two times (T3) for four months. Their results were similar to the present findings that the highest mean final weight of tilapia was found in the tank treated with four times (4T).

The highest weight gain and SGR (%) were found in 4T which might be due to the effect of having four times feeding frequencies in a day. The lowest weight was found in 2T having feeding frequency two times a day. Yousif (2004) that had emphasized the effects of feeding frequency on growth performance of Nile tilapia juveniles. He reported that 3 meals/ day of feeding frequency was significantly better growth performance of tilapia. However, lower growth performance was observed in all groups of fish fed twice/day.

With regards to FCR, the lowest values (0.9) were recorded in *Oreochromis* sp. fed with four times (4T) per day followed by (1) three times (3T) and (1.1) two times (2T). According to Somerville *et al*., (2014), FCR for tilapia cultured in earthen pond is 1.4 to 1.8 which is higher than present study. Feeding frequency not only improved the growth indices, but also had a great impact on survival of tilapia. Liang & Chien (2013) reported that higher feeding frequency is well-effected tilapia survival and weight gain. The best plant quality index was recorded in 4T during the experiments. Plants indirectly used fish feed from fish waste (Rana *et al*., 2009).

In this study, the better production of lettuce (*Lactuca sativa*) was found in four times feeding frequency/day and also has better yield of tilapia production. The results indicated that the four times/day feeding frequency is more suitable for recirculation aquaponics of tilapia and lettuce production. The present findings are similar to the findings of Liang and Chien (2013) and Rakocy *et al*., (1997) who stated that higher feeding frequency would have an effect on plant growth, SGR and yield performance of tilapia and water spinach in raft aquaponics system.

Rakocy *et al*., (2006) indicated that water dissolved oxygen and pH plays a vital role in aquaponics system, tilapia culture and Lettuce *L. sativa* cultivation. In this study, the higher feed frequency experiment showed the slightly low level of Dissolved Oxygen (DO) and pH level; but it was within the acceptable level of tilapia growth. Lowest ammonia levels ranged 0 to 0.3 mg/L in all systems. Biofilter in aquaponic system convert fish waste ammonia into plant food nitrate (Rakocy, 2004a). Although, fish were feed with four times/day, water quality especially for ammonia in all tanks were acceptable levels.

Conclusions

The production of tilapia and lettuce using the DWC aquaponic system was studied in this experiment. The highest production of Tilapia and lettuce was observed in 4T (feed four times per day) during the study period. The water quality parameters are the favorable condition for the growth and survive for fish and lettuce in the study period. It was concluded that the maximum feeding frequency of four times per day (4T) is recommended to achieve maximum profitability. It is also recommended to use either of them with any selection of the other one, based on the business requirements of the system.

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