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Md. Hashibur Rahman
(1) Department of Aquaculture, Bangladesh Agricultural University, Mymensingh, Bangladesh
(2) Bangladesh Fisheries Research Institute, Headquarters, Mymensingh, Bangladesh

Mohammad Mahfujul Haque
Department of Aquaculture, Bangladesh Agricultural University, Mymensingh, Bangladesh

Md. Nasirul Islam
Department of Aquaculture, Bangladesh Agricultural University, Mymensingh, Bangladesh

Md. Arifuzzaman
Department of Aquaculture, Bangladesh Agricultural University, Mymensingh, Bangladesh

Corresponding Author:
Md. Hashibur Rahman
(1) Department of Aquaculture, Bangladesh Agricultural University, Mymensingh, Bangladesh
(2) Bangladesh Fisheries Research Institute, Headquarters, Mymensingh, Bangladesh

Growth and production performance of tilapia (*Oreochromis niloticus*) in intensive and semi-intensive tank based aquaculture system using floating feed

Md. Hashibur Rahman, Mohammad Mahfujul Haque, Md. Nasirul Islam and Md. Arifuzzaman

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Abstract
The stocking density is considered one of the most critical factors that affects the growth performance and production as well. The study was aimed to compare the growth parameters of tilapia at different stocking densities. The growth performance usually considered as the data of the beginning and the end of production cycle avoiding intermediary data for the measurement is highly criticized by the scholars due to the abjection of the accuracy. However, the utilization of floating feed by fish can be acquainted addressing the growth performance at different stages of fish growth. To evaluate the growth performance, the study was conducted in twelve concrete tanks under an outdoor laboratory shed from 10th May to 29th July, 2017. Tilapia (*Oreochromis niloticus*) fry was released at the rate of 8 fry per tank as per the recommended stocking density of 320 fishes/decimal and 4 fry per tank equivalent to the stocking density of 160 fishes/decimal in intensive semi-intensive aquaculture system, and respectively. To evaluate the growth performance floating feed and used for feeding the fish during the experimental period for T_1 (Intensive) and T_2 (Semi-intensive), respectively. Each with three replications at the rate of 20%, 15%, and 10% of the body weight feed was supplied in 1st, 2nd and 3rd month, respectively. The daily ration of feed was delivered to fish in the morning and at the evening dividing into two parts. Aeration facilities using air stone aerator were installed for 24 hours. The weight of fish was recorded using digital balance in 3 days interval to assume the trend of consecutive growth of fish while a customized scoop net was used to sample the fish. Water quality parameters i.e., temperature and dissolved oxygen (DO) were recorded two times (morning & evening) daily. The weight gains of fish were 132.23±1.29 and 63.12±4.97gm for T_1 and T_2, respectively. The mean percent weight gain of tilapia was higher in T_1 (1715.05±0.00) than T_2 (747±0.00 gm). Feed conversion ratio (FCR) in T_1 and T_2 were 2.53±0.18 and 2.13±0.20, respectively. The specific growth rates (SGR) of tilapia in T_1 6.26.98±2.28 and 4.78±3.83 considering the data at the beginning and the end of the production cycle, respectively. However, the growth performance and SGR was higher at the initial stage of production cycle and lower in the later stages. Higher total production was obtained in T_1 (1119.52 g) than T_2 (830.96 g) with 100% survival in both the treatments.

Keywords: stocking density, growth, production performance, specific growth rate (SGR)

1. Introduction
The contribution of fisheries sector in 2019-20 was 3.50% to the total GDP of the country and approximately 25.72% to agricultural GDP [5]. Aquaculture is the fastest-growing food-producing sector and plays an important role in enhancing global food security, alleviating poverty and human dependence on depleted natural fish stocks [2]. Tens of millions of people are engaged in aquaculture production with majority involved in small-scale production [16]. Tilapia is seen as one of the most significant fish species which can reduce the gap of increasing worldwide demand for protein sources [13]. Its production worldwide has been increased from 1,099,268 tons in 1999 to about 3,500,000 tons in 2010 [6]. Tilapia (*Oreochromis niloticus*) is a hardy fish that can survive in shallow and turbid water conditions and a good converter of organic matter into high quality protein [15]. Fish is the second most important agricultural produce in Bangladesh and today aquaculture is considered as one of the most promising resources of animal proteins and contributing a significant role in foreign

exchange earnings, nutrition supply and in our national economy. Now-a-days, fish production shifting to aquaculture as inland fisheries production has escalated over the years, but the productivity per hectare water area is not yet attained at its optimum [5]. Among various segments of the fisheries sub-sector, the inland aquaculture has generally experienced the fastest growth, with the establishment of new technologies, species, and intensification and improvement of farming, particularly in pond and tank-based aquaculture, entirely over the country. Aquaculture now provides around half the fish for direct human consumption in Bangladesh and is set to grow further.

In Bangladesh, conventional semi-intensive aquaculture system is generally followed in case of fish culture besides extensive system. However, with the increasing population land area is declining in Bangladesh. The competition between aquaculture and other agricultural sectors is increasing in the context of land and water use. Therefore, intensive aquaculture is growing to enhance national fish production in the context of population growth and declining land resource. Moreover, fish productions per unit area much higher in intensive and semi-intensive aquaculture system. To fulfill the animal protein demand for growing population in Bangladesh these culture systems may be alternative to enhance fish production since fish contributes about 60% of animal protein to our daily food [5]. Aquaculture ponds can be integrated into water conservation and management systems and tank culture can be an effective way of overcoming the problem of water shortages. These improved methods of tank-based aquaculture system can be an efficient way to utilize scare water resources effectively and farmers will get higher production in a small parcel of land.

In this experiment, the stocking density was adjusted to 320 fish/decimal and 160 fishes/decimal intensive and semi-intensive system to achieve the expected result more accurately. To assess the percentage increase in size and weight at a particular growth stage in relation to time is very important. Commonly used equation considers the initial and final weight over time but the intermediate data remain unused. Therefore, the result is not accurate enough to understand the growth of fish in the intermediary stages of a production cycle [11]. Therefore, due to lack of the appropriate modeling to evaluate the growth of fish at different stage in relation to feed supplement, this study is likely to be effective to develop a relationship between feed and stocking density having direct effect on growth, maintenance and survival of fish. The study was carried out to in intensive and semi-intensive aquaculture system in tanks feeding with s floating feed to assess the growth and production of tilapia; and to determine the specific growth rate (SGR) of tilapia focusing on different intermediate sampling stages to have better understanding on growth trends. As commercial fish feed is easily available at market the results can help the fish farmers to decide on the culture technology in accordance with their economic affordability.

2. Materials and Methods

2.1 Experimental site

Twelve concrete made squared shaped tanks under a properly constructed shed were established in the backyard (south of the wet laboratory complex) of the Faculty of Fisheries, Bangladesh Agricultural University (BAU), Mymensingh. The security measures were properly managed so that any external agents could not disturb or hamper the culture system. Water supply and exchange facility was also satisfactory there. Each tank is of length 1m, width 1m and depth 1.2 m and water volume in each tank was 1 X 1 X 1 $=1m^3$. Among the twelve tanks, six tanks were used to study the growth and production, particularly specific growth rate (SGR) of tilapia in intensive rearing and remaining six tanks were used for semi-intensive culture of fish. The study was carried out from 10th May to 29th July, 2017. Tilapia was fed with floating feed to have better understating on the growth performance in different stocking density.

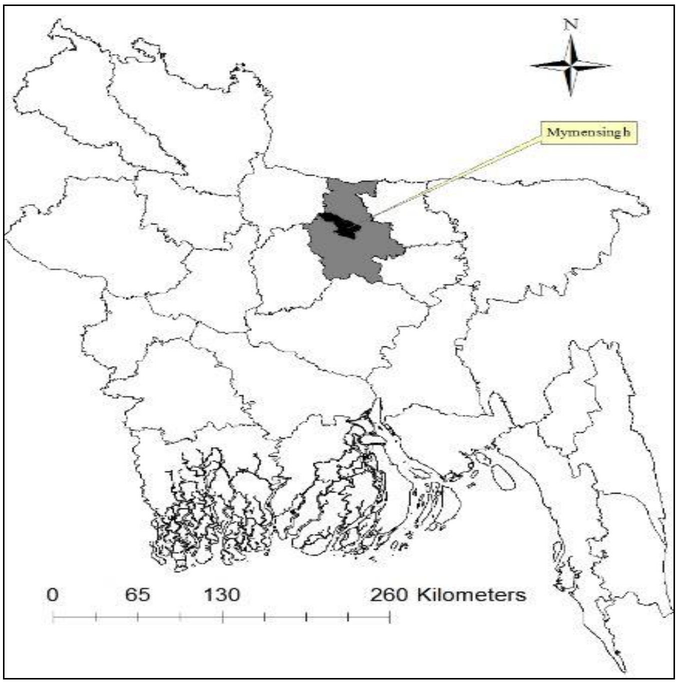

Fig 1: Map of Bangladesh showing the study site at BAU campus in Mymensingh.

2.2 Experimental tanks

For conducting the experiment, twelve concrete tanks were used. The bottom of the tank was made smooth and coated with white cement to make the bottom visible and facilitate the cleaning process easily. The outlet pipes of the tanks were closed to prevent water leakage. Siphoning process was followed to clean the tanks. Water was supplied from a deep tube well located near the experiment site.

2.3 Experimental design and layout

Mono sex male tilapia *(O. niloticus)* fry was used as experimental species. For the experiment, two treatments were designed namely T_1 and T_2 and there were three replications for each. Fry was released at the rate of 8 fry per tank that equivalent to the stocking density of 320 fish per decimal or about 80,000 per hectare and 4 fry per tank that equivalent to the stocking density of 160 fish per decimal.

2.4 Selection of feed and feeding frequency

Floating types of commercial pellet feed named as 'Quality Feed' were used. The proximate composition of feed is shown in Table-1. In first 30 days of the experiment, the size of floating feed used for feeding the fish was 0.25 mm. Then the pellets of 0.5 mm were used to fed the fish during the rest experimental period. During experimental period feed was given at the rate of 20%, 15%, and 10% of the body weight in 1st, 2nd and 3rd month, respectively.

Table 1: Proximate composition of floating feed as per labeling on the feed bag

Proximate composition	Floating feed (%)
Moisture	10
Protein	28
Fat	6
Starch	22
Fiber	3
Ash	12
Calcium	2
Phosphorus	1

2.5 Aeration Installation
Air stone aerators were applied to provide sufficient oxygen powered by electricity. A single air stone was allocated for each tank. The aerator motors were attached with the main structure of the roof of the shed. The aeration was operated for 24 hours during the experimental period.

2.5 Study of growth parameters of fish
For evaluating the growth of fish, different growth parameters such as length gain (cm), weight gain (g), percent (%) weight gain, specific growth rate (SGR% per day) and production (kg/ha/100 days) were taken into consideration and were measured using the following formula. The length and weight of fish were measured using centimeter scale and electric balance (Model; HKD-620AS-Led) in grams.

Weight gain (gm) =Mean final weight (gm) – Mean initial weight (gm)

$$\text{Percent (\%) weight gain} = \frac{\text{Mean final weight} - \text{Mean initial weight (gm)}}{\text{Mean initial weight (gm)}} \times 100$$

$$\text{SGR (\%) per day} = \frac{\log W2 - \log W1}{T2 - T1} \times 100$$

Production = No. of fishes harvested × average final weight increase of fishes

2.6 Study of water quality parameters
Water quality parameters (i.e., temperature, DO, pH) of the experimental tanks were recorded very intensively two times daily. Different physio-chemical parameters were measured using digital DO meter (Model: CE 225908) in mg/l. Water temperature was measured by using digital thermometer in ºC and pH was recorded by digital pH meter.

2.7 Data analysis
Statistical analysis was done to evaluate the effect of the two treatments on the growth of fish were significant or not. Independent sample T-Test was performed to test the significance of difference among different water quality parameters. The entire statistical test was conducted by using SPSS (Statistical Package for Social science) version 16. The graph was prepared by using both MS Excel and SPSS.

3. Results
3.1 Fish Growth performance
3.1.1 Final weight
The initial weight of individual tilapia was 7.71±0.19g and 1.12±0.18 g for T_1 and T_2, respectively. The final mean weight of each fish was for T_1 139.94±1.29 and 69.24±4.97 g for T_2, respectively with having significant difference ($p<0.05$) between the treatments.

3.1.2 Weight gain
The average weight gain of tilapia for T_1 was 132.23±1.29 g and for T_2 was 63.12±4.97 g, respectively. The difference in weight gain is notably remarkable between two treatments. The weight gain of tilapia was higher in T_1 than T_2. This frequent observation was performed to find out where the maximum growth was taken place in the production cycle of two different feeding systems. In term of weight gain, in the most sampling stages, the performance in T_1 was significantly ($p<0.05$) higher than T_2. In term of growth trend, after about a month, the different trend of weight gain was observed. The higher weight gain in T_1 was observed from the 5th sampling. However, it was remarkable increment growth after about a month (Sampling stage 7, Table-1).

3.1.3 Percent weight gain (%)
The mean percent weight gains of fishes were 1715.05±0.00 and 747±0.00 for the treatments T_1 and T_2, respectively. The higher percent weight (1715.05%) was found in T_1 where lower (747±0.00%) was in T_2 fed with floating feed.

3.1.4 Specific growth rate (SGR% per day)
The specific growth rates (SGR) of tilapia in T_1 and T_2 were found 6.26 ±3.83and 4.98±2.28, respectively. There was significant difference ($p>0.05$) in term of SGR between the treatments. The present study determined the percentage growth rate in different sampling stages of tilapia more frequently which are generally not determined considering the initial and harvesting weight data, and the intermediate data are excluded. For this reason, the fishes were sampled at 3 days interval to gain the weight of fish to determine the actual growth performance at particular sampling stages. In this regard, in first month of the production cycle the growth of T_1 was higher than that of T_2. The SGR of T_1 was shown increasing gradually. After that, at the last sampling stage, average trend of SGR was observed (Figure-3 and 4). More specifically, the significant higher specific growth rates were observed at the middle stage (In between 4th June and 11th June) of the experiment and also in later stages in case of floating feed fed tilapia (Table-2 and Figure-2).

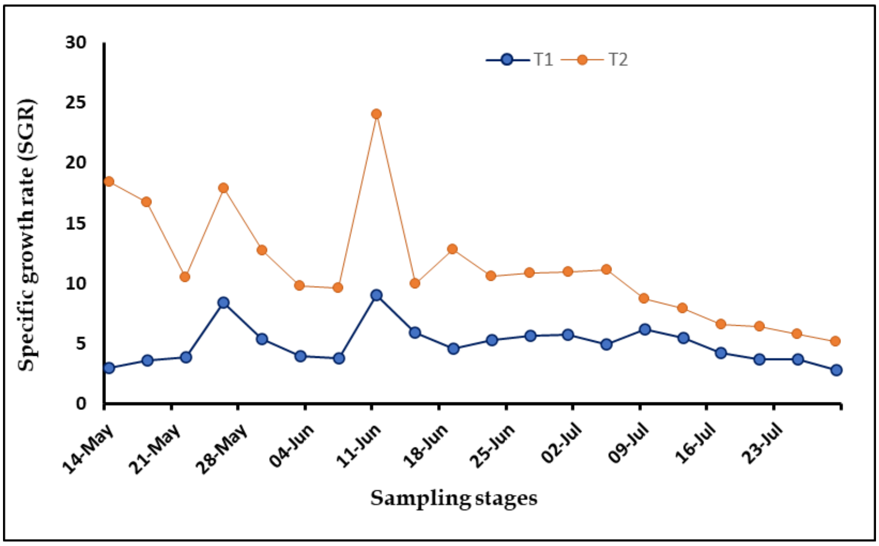

Fig 2: Specific growth rate at various sampling stages.

Table 2: Specific growth rate (SGR) at 3 days interval

Sampling No.	Sampling day/stage	Average SGR in Treatment 1 (Mean ±SD)	Average SGR in Treatment 2 (Mean ±SD)
01	14 May,17	3.00±0.562	15.43±5.26
02	18 May,17	3.63±1.204	13.13±7.90
03	22 May,17	3.89±2.784	6.65±7.25
04	26 May,17	8.46±2.099	9.42±9.80
05	30 May,17	5.44±0.479	7.33±4.40
06	03 Jun, 17	3.96±1.335	5.82±2.44
07	07 Jun, 17	3.78±1.781	5.87±0.61
08	11 Jun, 17	9.01±3.120	15.02±1.62
09	15 Jun, 17	5.89±2.173	4.05±3.05
10	19 Jun, 17	4.63±0.297	8.23±1.88
11	23 Jun, 17	5.32±1.109	5.25±1.41
12	27 Jun, 17	5.66±0.706	5.18±2.27
13	01 July, 17	5.76±5.729	5.18±3.62
14	05 July, 17	4.97±1.786	6.20±2.99
15	09 July, 17	6.23±1.299	2.53±1.57
16	13 July, 17	5.52±1.251	2.53±1.18
17	17 July, 17	4.24±0.667	2.38±0.92
18	21 July, 17	3.74±1.623	2.68±0.78
19	25 July, 17	3.69±0.610	2.07±1.40
20	29 July,17	2.86±0.595	2.34±1.60

The SGR at the initial stage started from the higher range in T_1 compared to T_2 (Figure-3 and Figure-4)

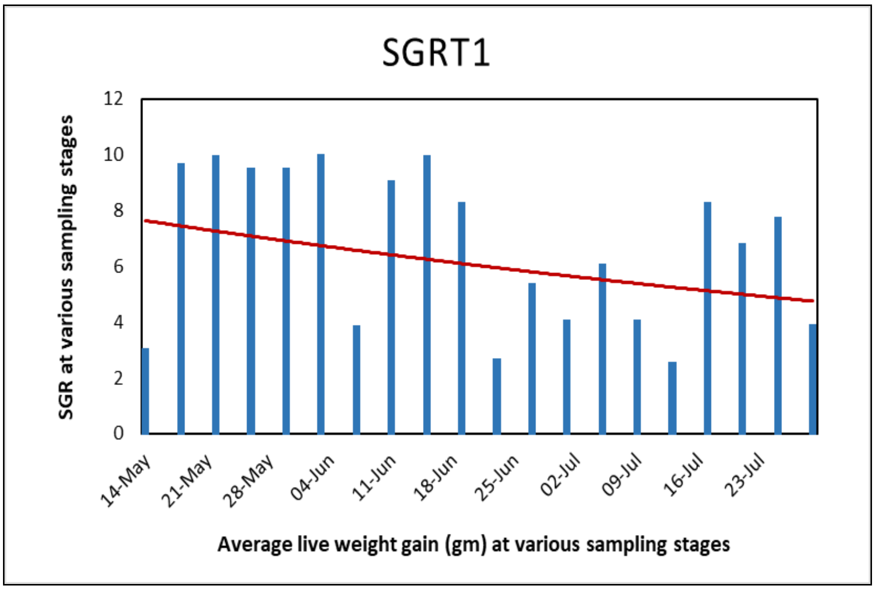

Fig 3: Specific growth rate of tilapia in intensive culture system (T_1).

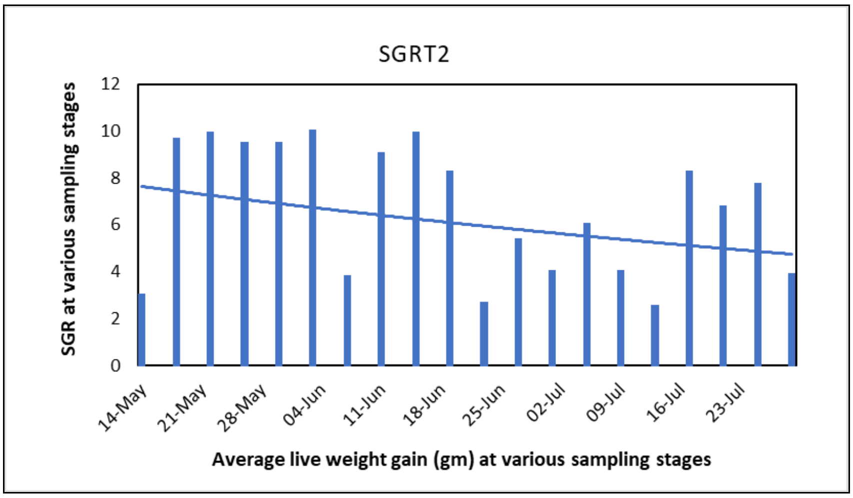

Fig 4: Specific growth rate of tilapia in semi-intensive culture system (T_2).

3.1.5 Feed conversion ratio (FCR)

The feed conversion ratio was calculated taking the total feed used into consideration in the experiment. Feed conversion ratio values of sinking and floating feed used for feeding the fish in T_1 and T_2, respectively were 2.43±0.18 and 2.13±0.20 (Figure-5).

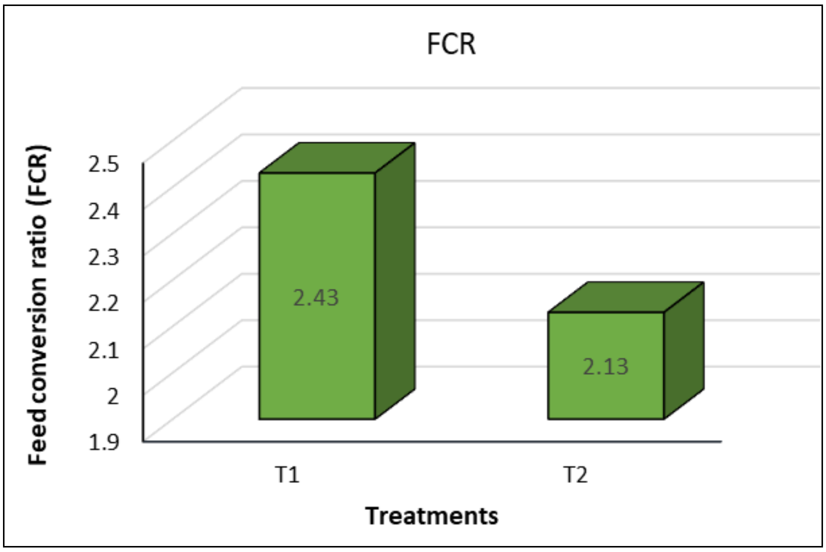

Fig 5: Feed conversion ration in T_1 and T_2

3.1.6 Total production (g/cm^3)

The total productions of tilapia at the end of the study were 1119.52±0.00g and 830.96 g ±0.00 g per cm^3 in T_1 and T_2, respectively. The production was higher in the T_1 than that of T_2 (Figure-6).

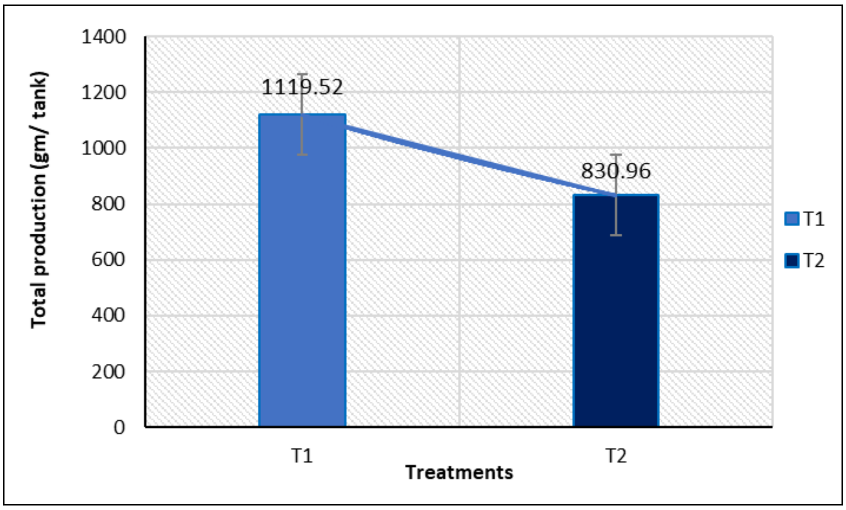

Fig 6: Total production of tilapia in the two treatments (T_1 and T_2)

3.1.7 Water quality parameters

The mean values of tested water quality parameters such as temperature and DO of the experimental ponds are presented in Table-3. There was no significant difference ($p<0.05$) in the temperature in morning and evening in both treatments. The difference of dissolved oxygen content was very low between two treatments. The dissolved oxygen contents in both treatments were similar because aerators were installed in all the tanks.

Table 3: Water temperature of experimental tanks

	Intensive			Semi-intensive		
Water quality parameters	**Treatments**	**Morning**	**Evening**	**Treatments**	**Morning**	**Evening**
Temperature (^{0}C)	T_1	27.31±1.45	27.41±1.57	T_2	26.98±1.59	27.13±1.67
DO (mg/l)	T_1	6.76±0.83	6.57±0.79	T_2	6.91±0.81	6.64±0.82

4. Discussion

In this present study, the difference in weight gain was found between the treatments. The mean initial weight of the tilapia in the 6 tanks of T_1 was 7.71±0.19g and in the other 6 tanks of T_2 was 1.12±0.18 g. At the end of the experiment, the mean weight of the fish in T_1 was 139.94±1.29 and 69.24 in T_2. The weight gain was higher in T_1 which might be due to the fact that fish had taken more amount of feed than almost similar level of water quality [1].

Growth rate and production performance of tilapia in tank-based aquaculture system was the main fact of interest of the present study. Usually, intermediate growth data are not considered to assess the specific growth rate and calculated using the data of initial and final weight only. Therefore, the important stages of the growth of fish are not feasible to understand the trends properly. To avoid this gap, the weight of fish was taken after 3 days interval in this experiment. The mean value of SGR in T_1 and T_2 were 6.26 ±3.83and 4.98±2.28, respectively. From these data, the specific growth rate of tilapia in T_1 was higher than in T_2 in first 30 days (around) and in the middle stage both SGR increased simultaneously. The SGR of tilapia in T_1 was initially lower than T_2 and the value decreased with the culture period in a regular fashion. The lowest value of SGR in T_1 was recorded in between 4th and 11th June (Figure-2) and at the end of the experiment the trend line of SGR was observed about to elevate. On the other hand, the value of SGR in T_2 was higher at the first stages of the growth than T_1 . Then it was decreasing in trend and started falling rapidly from the 3rd sampling stage. The trend line of both SGR was also in downward direction at the end of the experiment (Figure-3 and 4). It might be due to that after particular stages of weight gain, the fish did not like to take floating feed from the surface layer of water by expending energy rather preferred sinking feed from the bottom. However, it required further research for a long duration in different seasonality to unpack the fact. Overall, it could be argued that use of floating feed in tilapia farming is more effective in the early stage than sinking feed.

Feed conversion ratio (FCR) was calculated to evaluate the utilization of feed that was given to the fish. The expected FCR for tilapia ranges from 1.5 to 2.0 [17]. The FCRs of tilapia in present study were 2.43±0.18 and 2.13±0.20 in T_1 and T_2, respectively. The FCR in T_2 was within expected range but in case of T_1, it was higher than the accepted value (Figure-5). In this experiment, feed was given following general method of body weight percentage consideration, not considering the satiation level. For this, the supplied feed might remain unused. That is why the feed conversion ratio (FCR) of T_1 was higher than expected level as the total amount of delivered feed was taken into consideration during calculating the FCR. This higher FCR in T_1 found in case of pre-determined feeding system (not satiation level) correlates with the findings of lower SGR in the later of the culture period. This further confirms that farmers using floating feed with pre-determined estimation of the required amount of ration derived from percent body weight, waste the high-cost feed and money. Therefore, calculation of SGR at a certain interval in a production cycle is very critical issue. Calculation of traditional SGR using the data at the beginning and end of the culture period, weight gain and FCR do not indicate the efficient and economic use of feed and production of fish. Therefore, determining SGR in a specific interval at least 15 days interval might be the practice for tilapia farmers.

The survivability of tilapia in the present study was 100%. The survival rate of tilapia ranged from 82 to 90% [8]. In this study, the highest survivability might be the cumulative result of good water quality parameters due to weekly water exchange, quality feed uses and proper maintenance during culture. This result of 100% survival in both the treatments confirms that indoor tank-based aquaculture systems can be developed in Bangladesh where land is getting scarce natural resource.

In the present study, the production was lower than the finding of [12] if the culture area of tank were corresponded to hectare. The fact of lower production might that the fish were sampled at frequently at 3 days interval that causes little disturbance in taking feed that may affect the growth of tilapia. The mean total production per cm^3 was 1119.52±0.00g and 830.96 g ±0.00 g in T_1 and T_2, respectively. The production was higher in T_1 than T_2 (Figure-6). The production of tilapia (*O. niloticus*) recorded at the rate of 28MT/ha/100 days in pond [12].

The suitable range of tilapia culture is 26 to 32^{0}C [9]. It was reported that water temperature plays a vital role in regulating the metabolic process of fish [4]. Therefore, it is very important to maintain the temperature of the culture unit. The body temperature of fish is related to water temperature, and growth, reproduction and other biological activities are influenced by the temperature largely. The water temperature of the experimental tanks was within the suitable range of tilapia culture.

Tilapia can tolerate dissolved oxygen concentration as low as 0.1 mg/l [3]. Dissolved oxygen concentration is an important water quality parameter that affects the growth and survival process of fish. Reduction in dissolved oxygen content has negative effects on growth, reproduction and other biological activities of fish and very low dissolved oxygen content is lethal to fish. In the present study, the mean average oxygen content of T_1 was 6.57±0.79 and 6.64±0.82 during morning and evening, respectively. Higher level of dissolved oxygen concentration was recorded in the experimental tanks as a result of aerator installation.

The present study aimed to find out the crucial points in the growth performance of fish and production performance in accordance with the different stocking densities to have better understanding the on-growth trends at various sampling stages. These results may help the fish farmers to decide on the culture technology in accordance with their economic affordability.

5. Conclusion

Under the experimental, it was found that total production was increased with the increase of stocking density. The proper amount of feed needed for the fish in different stages of growth can be calculated by knowing the specific growth rate (SGR). Overall, this study suggests that tank-based aquaculture can be developed in the indoor system that can ensure 100% survival. This study also indicates that tilapia farmers in Bangladesh practicing inefficient feeding systems wasting high-cost floating feed due to lack of proper knowledge on specific growth rate at different stages of fish growth and production. This study reveals an outstanding clarification on the growth performance of fish in different sampling stages and thus the wastage of feed at the final stages of the culture period can be retarded due to the proper demonstration of feed. From the experiment, it might be suggested that the stocking density (320 fish per decimal) performed the better results and further study is needed to explore the cost-benefit analysis of tilapia farming in tank-based aquaculture system.

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