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Specific Growth Rate (SGR) in Different Stages of Tilapia (*Oreochromis niloticus*) Production Cycle in Cemented Tank Based Semi-Intensive Aquaculture System

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Abstract:

Traditional assessment of specific growth rate (SGR) using the data of the beginning and the end of aquaculture production cycle, avoiding intermediary data, is criticized as misleading way by the scholars. However, by knowing SGR in different stages of fish growth, the utilization of feed by fish can be well known. The study was conducted with aim to assess SGR of Tilapia in six concrete tanks for 90 days from 8th May to 10th August, 2017. Tilapia (*Oreochromis niloticus*) fry was released at the rate of 4 fry per tank equivalent to the stocking density of 160 fishes/decimal as of the semi-intensive aquaculture system. Sinking and floating feeds were used for feeding the fish in T_1 and T_2, respectively with three replications for each treatment. During the experimental period, feed was given at the rate of 20%, 15% and 10% of the body weight in 1st, 2nd and 3rd month, respectively. Moreover, aeration facilities were installed for 24 hours using air stone aerator. The weight of fish was recorded using digital balance in 3 days interval to measure SGR. The water quality parameters i.e., temperature and dissolved oxygen (DO) were recorded twice daily. The weight gains of fish were 49.90±2.40 g and 63.12±4.97g for T_1 and T_2, respectively. The mean percent weight gain of Tilapia was higher in T_2 (747±0.00 g) than T_1 (253.51±0.00 g). Feed conversion ratio (FCR) in T_1 and T_2 were 1.70±0.07 and 1.90±0.20, respectively. Considering the data at the beginning and the end of the production cycle, the SGR (% per day) of Tilapia in T_1 and T_2 were 6.27±3.27 and 6.26±3.83, respectively. The SGR for floating feed was higher at the initial stage of production cycle and lower in the later stages. For sinking feed, SGR was almost static from the beginning to the end. The higher FCR in T_2 correlated with the lower SGR in the later stage of the culture period. Higher total production was obtained in T_2 (830.96 g) than T_1 (610 g) with 100% survival in both treatments. Therefore, determining SGR in a specific interval, at least 15 days interval, might be the efficient feeding practice of Tilapia farmers.

Keywords: *Specific Growth Rate, Tilapia, Semi-intensive aquaculture, floating feed, Sinking feed.*

Introduction

Aquaculture is experiencing rapid growth as a sector for producing animal-based food, especially in developing countries such as Bangladesh. Its production plays a crucial role in supporting livelihoods, creating employment opportunities, and meeting the increasing global demand for protein supply, food security, and income generation (Haque et al. 2016; Rahman and Islam, 2021). Aquaculture enterprise is very potential in terms of protein rich food production, food security and livelihood generation for the increasing number of people throughout the world especially for the developing countries like Bangladesh. In 2021-22, fisheries sector contributed 2.43% to total GDP, 22.14% to agricultural GDP (DoF, 2023). Nowadays, fish production is shifting to aquaculture from capture fisheries in terms of producing more fish by means of taking improved measures such as regular stocking, feeding, maintaining healthy conditions and implying the other modern aquaculture technologies. Among different categories of aquaculture technologies, semi-intensive system merely is the intermediate method of extensive and intensive system to produce fish (Rahman and Arifuzzaman, 2021a). The use of tank in semi-intensive system as a unit of fish farming is a modern method of aquaculture having several advantages. Rooftop or small space beside house shed may be used for installation of tank and this tank can be used as 'live fish freeze' for a household. Plastic tank or permanent concrete tank may be used in this regard and fish culturist can easily maintain this culture process. Moreover, water quality parameters and supply can also be managed easily and health observation of fish and disease treatment is relatively easy. Feeding and harvesting method require low cost and less energy. It is comparatively easy to adopt for the farmer because not so complicated as intensive system and the production is satisfactory as the culture process is managed properly. In the context of Bangladesh, semi-intensive aquaculture system is convenient as farmers, housewives even children can engage in fish farming. Homemade feed and household waste including poultry and livestock wastes can be used as input. As a result, the household pond can be made productive which may play a significant role in livelihood and family income. In this experiment the culture process is maintained more advanced manner and control way where the stocking density was adjusted to semi-intensive system (160 fish/decimal) to achieve the expected result more accurately.

Since commercial aquaculture largely depends on artificial feed and about 70% of total operational cost belongs to feed, so it is very crucial to optimize the usage of feed for expected growth (Karim et al., 2017; Rahman and Arifuzzaman, 2021b). The quality and amount of ingredients in feed determine the growth of fish, ultimately the production. The daily ration calculation and determination of the feeding frequency should be taken into consideration for the fish culturist. Feeding method and time also have remarkable impact on taking of feed by fish. Farmer needs to be careful whether the supplied feed was properly utilized or not. Unutilized feed affects the culture process negatively by deteriorating the water quality. As a result, fish become more susceptible to diseases outbreaks. Ultimately, wastage of feed makes aquaculture operation more costly. Therefore, it is necessary to detect the growth stage of fish in which stage feed should be supplied sufficiently to obtain proper growth of fish by maintaining good quality water which helps in minimizing feed cost as well. In this case, percentage increase in size and weight at a particular growth stage in relation to time (SGR) is very important to assess the amount of feed required for that stage for successful aquaculture operation. Commonly used SGR calculating 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. There are some models to describe the growth such as relative growth rate which describes absolute increase in relation to initial weight/length and expressed as percentage increase over time but it does not show result in the intermediary stages of a production cycle (Lugert *et al.* 2016). The commonly used SGR calculation equation is logarithm-based technique which is not convenient to understand the growth rate between the final and beginning of growth trial. Therefore, due to lack of the appropriate modeling to evaluate the growth of fish at different stage in relation to water quality parameter in semi-intensive farming, this study is effective to build a relationship between water quality parameters and SGR of *O. niloticus.* As fish lives in water, water quality parameters i.e., DO, temperature, pH, ammonia, nitrate, other dissolved gasses and organic metals have direct influence on growth, maintenance and survival of fish.

This study was carried out to assess the growth and production of Tilapia in semi-intensive aquaculture system in tanks feeding with sinking and floating feed; and to assess specific growth rate (SGR) of tilapia focusing on different intermediate sampling stages to have better understanding on growth trends. The objective of this study was to enhance Tilapia production by implementing an intensified culture technique in a limited timeframe. Thus, the use of this semi-intensive fish culture technology will enable marginal fish farmers to achieve their expected income from a small plot of land, while also ensuring a substantial fish yield.

Materials and Methods

Study Site

For conducting the study, twelve concrete constructed 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, Mymensingh (Fig. 1). Each tank diameter had of length 1m, width 1m and depth 1.2 m and water volume in each tank was 1 × 1 × 1 =1m^3. Among the twelve tanks, six tanks were used to study the growth and production, particularly specific growth rate (SGR) of tilapia (*Oreochromism niloticus*) in semi-intensive rearing in concrete tanks. The study was carried out for a period of 90 days from 10th May to 8th August, 2017. Besides, stocked Tilapia was fed with floating and sinking feed to have better understating on SGR in different types of feeding practices, because farmers used both types of feed depending on their economic affordability.

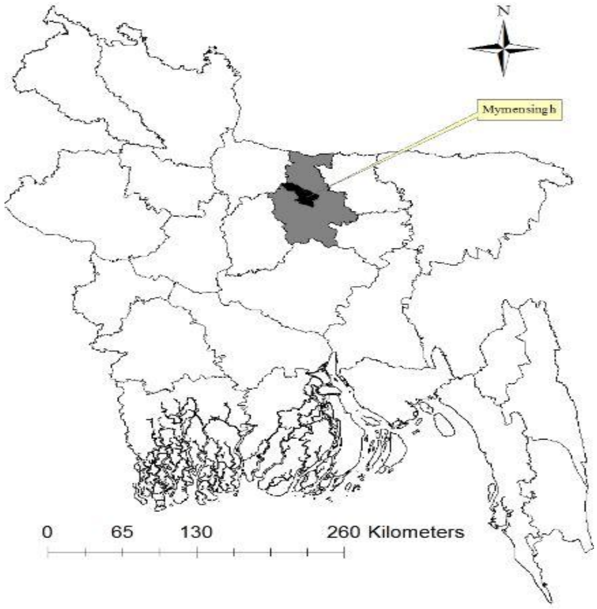

Figure 1. Map of Bangladesh showing the Study Site at BAU Campus in Mymensingh

Experimental Tanks

Six tanks were used for the experiment measuring each tank 1 m^3 made of bricks, sand and cement. The bottom was 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.

Experimental Design and Layout

Monosex male Tilapia *(O. niloticus)* fry was used as experimental species. For the experiment, two treatments were designed namely T_1 and T_2 with three replications for each treatment. First three tanks of T_1 were treated with sinking feed and the tanks of T_2 with floating feed. Fry was released at the rate of 4 fry per tank that equivalent to the stocking density of 160 fish per decimal with different average initial weight

(0.82, 0.89, 0.71, 0.93, 1.06 and 1.36 g) for six tanks individually.

Aerator Installation

Air stoned aerators were applied to provide sufficient oxygen powered by electricity. An 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 provided for 24 hours during the experimental period.

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.

$$\text{Weight gain (g)} = \text{Mean final weight (g)} - \text{Mean initial weight (g)} \quad (1)$$

$$\text{Percent (\%) weight gain} = \frac{\text{Mean final weight} - \text{Mean initial weight (g)}}{\text{Mean initial weight (g)}} \times 100 \quad (2)$$

$$\text{SGR (\%)per day} = \frac{\log W_2 - \log W_1}{T_2 - T_1} \times 100 \quad (3)$$

$$\text{Production} = \text{No. of fishes harvested} \times \text{average final weight increase of fishes} \quad (4)$$

Study of Water Quality Parameters

Water quality parameters of the experimental tanks were recorded very intensively two times daily throughout the entire study period. Water quality parameters especially temperature, DO, pH was measured in the morning (9:00 am) and afternoon (4:00 pm) daily and all the tests were performed in the experimental shed. Different physico-chemical parameters including DO was measured using digital DO meter (Model: CE 225908) in mg/l. Water temperature was measured by using digital thermometer (Model: CE 225908) in ºC and pH was recorded by using digital pH meter (Model: CE 224469).

Data Analysis

The data of sampled fish growth and water quality parameters data were entered in MS Excel 2019. Statistical analysis was done to evaluate the effect of the two treatments (sinking and floating feed) on the growth of fish. Independent sample T-Test was performed to test the significance of difference between two treatments. The entire statistical test was conducted by using SPSS (Statistical Package for Social science) version 24. The results were presented in both graphical and tabular form.

Results

Fish Growth Performance

Final Weight

The initial weights of individual Tilapia (0.80±0.07 g and 1.12±0.18 g) increased up to 50.70±2.40 g for T_1 and 69.24±4.97 g for T_2, respectively with no significant difference ($p>0.05$) between two treatments.

Weight Gain

Average weight gain of Tilapia in this study for T_1 was 49.90±2.40 g and for T_2 was 63.12±4.97 g. The frequent observation of weight gain of Tilapia in 3 days interval was done to find out where the maximum growth had taken place in the production cycle of 90 days in two different feeding systems. In terms of weight gain, in the most of the sampling stages, the performance in T_2 was significantly ($p<0.05$) higher than T_1. In term of growth trend, after about a month, the different trend of weight gain was observed (Fig. 1). The higher weight gain in T_2 was observed from the second sampling. However, it was a remarkable increment of growth observed after a month (Sampling stage 8, Fig. 2).

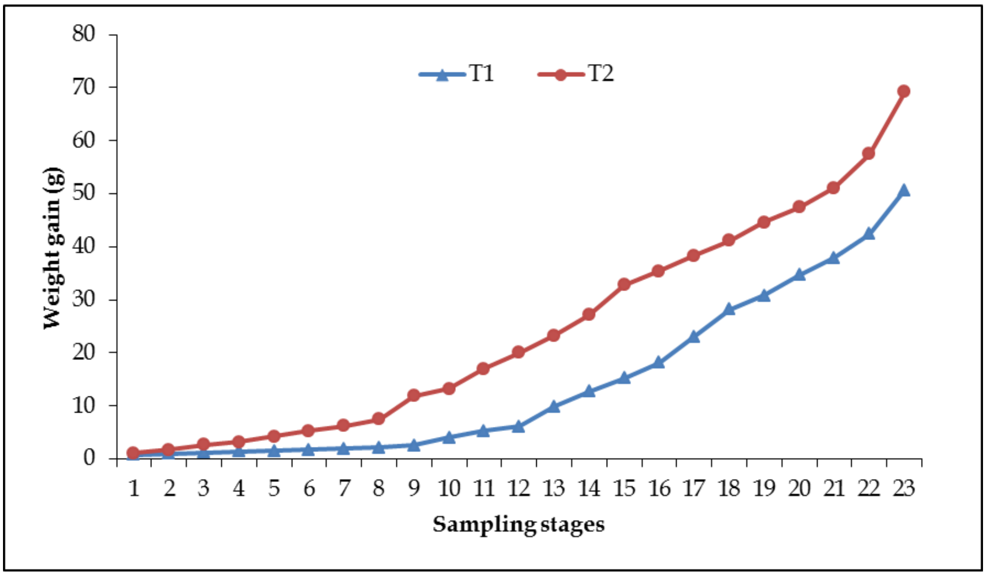

Figure 2. Variation of Weight Gain of Tilapia in Two Treatments

Percent Weight Gain (%)

The mean percent weight gains of fishes were 253.51±0.00 and 747±0.00 for the two treatments T_1 and T_2, respectively. The higher percent weight gain (747%) was found in T_2 where fish were fed floating feed.

Specific Growth Rate (SGR % per day)

The specific growth rates (SGR) of tilapia in T_1 and T_2 were found 6.27± 3.27 and 6.26 ±3.83, respectively with no significant difference ($p>0.05$) between the treatments. The important aim of the present study was to reveal the points of specific growth rate (SGR) in different stages of growth of Tilapia more frequently, which are generally determined considering the initial and harvesting weight data, and the intermediate data are excluded in calculation and the intermediate specific growth rate trend remains poorly understood. For this reason, the fish were sampled at 3 days interval to gain the weight of fish to determine the SGR at particular point of growth more specifically. In this regard, in first month of the production cycle, the SGR of T_2 was higher than that of T_1 (Table 1). However, the SGR of T_1 was shown decreasing gradually. After that, at the last sampling stage, higher trend of SGR was observed (Table 1). More specifically, the significant higher SGR were observed in later stage of the experiment particularly in case of (T_2) floating feed fed Tilapia.

The SGR at the initial stage started from the higher range in T_2 compared to T_1 that lasted for long period in T_2 as well (Fig. 3 and 4).

Table 1. Specific Growth Rate at 3 Days Interval

Sampling stage	Sampling day/stage	Average SGR in Treatment 1 (Mean ±SD)	Average SGR in Treatment 2 (Mean ±SD)	p value
01	14 May,17	7.07±4.47	15.43±5.26	0.110
02	18 May, 17	5.40±2.87	13.13±7.90	0.187
03	22 May, 17	6.29±3.39	6.65±7.25	0.956
04	26 May, 17	2.36±0.44	9.42±9.80	0.281
05	30 May, 17	3.16±0.78	7.33±4.40	0.182
06	03 Jun, 17	4.20±2.25	5.82±2.44	0.447
07	07 Jun, 17	2.99±2.31	5.87±0.61	0.106
08	11 Jun, 17	11.74±7.40	15.02±1.62	0.495

09	15 Jun, 17	9.89±6.67	4.05±3.05	0.285
10	19 Jun, 17	8.87±5.27	8.23±1.88	0.872
11	23 Jun, 17	5.38±7.09	5.25±1.41	0.978
12	27 Jun, 17	16.34±5.43	5.18±2.27	0.030
13	01 July, 17	8.45±0.26	5.18±3.62	0.194
14	05 July, 17	5.93±1.43	6.20±2.99	0.894
15	09 July, 17	5.78±o.667	2.53±1.57	0.030
16	13 July, 17	7.86±1.81	2.53±1.18	0.013
17	17 July, 17	6.71±0.76	2.38±0.92	0.003
18	21 July, 17	2.88±1.60	2.68±0.78	0.856
19	25 July, 17	3.95±3.41	2.07±1.40	0.308
20	29 July,17	2.92±0.17	2.34±1.60	0.566
21	01 August, 17	3.73±1.58	4.66±1.22	0.464
22	08 August, 17	6.18±2.56	5.80±2.64	0.864

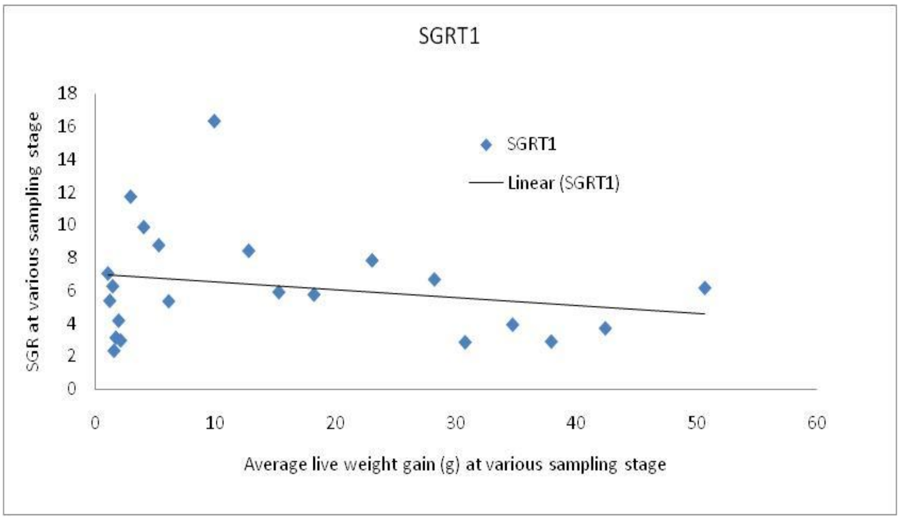

Figure 3. Specific Growth Rate of Tilapia in Sinking Feed (T_1)

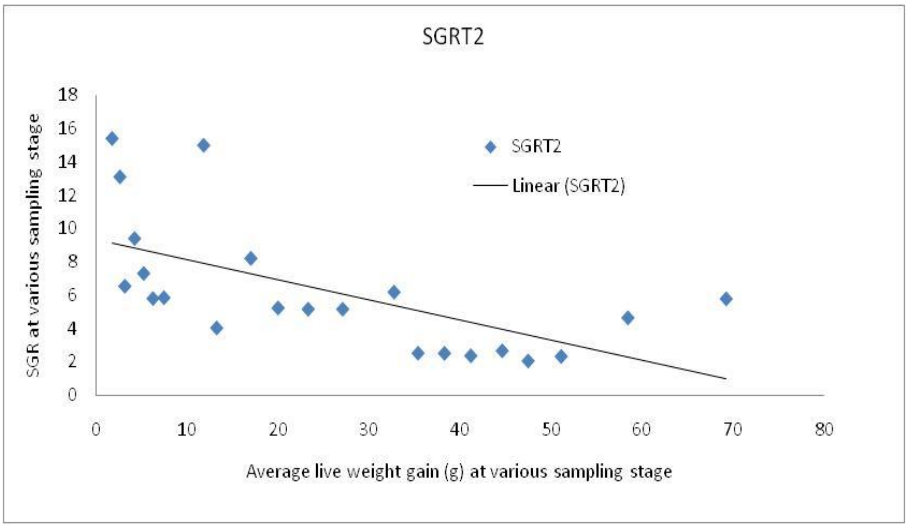

Figure 4. Specific Growth Rate of Tilapia in Floating Feed (T_2)

Feed Conversion Ratio (FCR)

The feed conversion ratio was calculated taking the total feed used into consideration in the experiment. FCR values of sinking and floating feed used for feeding the fish in T_1 and T_2 were 1.70±0.07 and 1.90±0.20, respectively.

Total Production (g)

Survival rate was 100% in both T_1 and T_2, respectively and total productions of Tilapia at the end of the study (after 90 days) were 610±0.00 g and 830.96 g ±0.00 g in T_1 and T_2. The production was higher in the tanks fed by floating feed than that of fed by sinking feed.

Water Quality Parameters of Water

The mean values of tested water quality parameters such as temperature and DO of the experimental ponds are presented in Table 2 where water temperatures and DO of both morning and evening were slightly higher in T_1 compared to T_2. There was a significant difference ($p<0.05$) in the temperature in morning and evening in both treatments. The average higher temperature (27.27±1.47) was recorded in T_1 and the minimum temperature (26.98±1.59) was found in T_2. Moreover, dissolved oxygen contents in both treatments were similar because aerators were installed in all the tanks (Table 2).

Table 2. Water quality parameters of experimental tanks

Water quality parameters	Treatments	Morning	Evening
Temperature (^{0}C)	T_1	27.06 ±1.44	27.27±1.47
	T_2	26.98±1.59	27.13±1.67
DO (mg/L)	T_1	6.94±0.87	6.64±0.78
	T_2	6.91±0.81	6.64±0.82

Discussion

The present study aimed to find out the crucial points in the growth of fish and to adjust the right amount of feed to reduce its wastage. If the wastage can be reduced, the water quality of culture systems will also be improved as well as the cost for feed will be minimized at the farmer level. In the present study, the fishes are fed by sinking and floating feed in T_1 and T_2. The difference in weight gain was found between the treatments which were lower than the findings of Hargreaves et al. (1991) and Saha (2004). The weight gain was higher in T_2 which might be due to the fact that fish had taken more amount of floating feed than sinking one in almost similar level of water quality. Specific growth rate of Tilapia in semi-intensive tank aquaculture system was the main fact of interest of the present study. Usually, specific growth rate is calculated using the data of initial and final weight but the intermediate data are not considered. Therefore, from that result, the important stage of the growth of fish is not possible to understand 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 6.27 ± 3.27 and 6.26 ±3.83, respectively which were higher than the result of Hossain *et al.* 2017. From these data, it was found that the specific growth rate of Tilapia in T_2 was higher than in T_1 in first 30 days (around) and in the middle stage it became lower than T_1, and about to end of the experiment the specific growth rate in T_2 was found in higher trend than T_1 in this study. 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 at the 4^{th} sampling stage when the mean weight was 1.56 g 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 15^{th} sampling stage when the mean weight of tilapia was 35.39 g. The trend line was also in downward direction at the end of the experiment. 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 paying energy rather preferred sinking feed from the bottom. However, it required further research for a long duration in different seasonality to unpack the subtle facts. Overall, it could be argued that use of floating feed in Tilapia farming is more effective in the early stage than sinking feed.

The FCR of Tilapia in present study were 1.70±0.07 and 1.90±0.20 in T_1 and T_2, respectively. The expected FCR for Tilapia ranged from 1.5 to 2.0 (Watanabe *et al.*, 2002). The FCR in T_1 was within expected range but in case of T_2, it was higher than the accepted value. In this experiment, feed was given considering body weight percentage, not considering the satiation level. For this, the supplied feed might remain unused. That is why the feed conversion ratio (FCR) of T_2 was higher than the expected level as the total amount of delivered feed was taken into consideration during calculating the FCR. This higher FCR in T_2 found in case of pre-determined feeding system (not satiation level) correlated with the findings of lower SGR in the later of the culture period. The study further confirmed that farmers using floating feed with pre-determined estimation of the required amount of ration derived from percent body weight, wasted 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 did 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 of Tilapia farmers. The survivability of Tilapia in the present study was 100%. Hussain *et al.* (1987) recorded survival rate ranged from 82 to 90%. 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 indicating that indoor tank-based aquaculture systems can be developed in Bangladesh where land is getting scarce natural resource. Moreover, the mean total production per tank in both T_1 and T_2 was lower than the finding of Rana (1998) 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 caused little disturbance in taking feed that may affect the growth of Tilapia. Moreover, the poor genetic at seed quality might be one of the reasons for lower growth.

The body temperature of fish is related to water temperature, and growth, reproduction and other biological activities are influenced by the temperature largely. Battes *et al.* (1979) reported that water temperature plays a vital role in regulating the metabolic process of fish. Therefore, it is very important to maintain the temperature of the culture unit. The suitable range of temperature for Tilapia culture ranges from 26 to 32^{0}C (Khan *et al.*, 2008). The water temperature of the experimental tanks was within the suitable range for Tilapia culture. Dissolved oxygen concentration is an important water quality parameter that affects the growth and survival process of fish. In the present study, the mean average oxygen content of both T_1 and T_2 were within the suitable range for Tilapia since the optimum DO for fish growth was 5.0 to 7.5 mg/L (Losordo *et al.,*1998). Higher level of DO concentration was recorded in the experimental tanks as a result of aerator installation.

Conclusion

Commercial aquaculture is getting enhanced day by day to meet the demand of increasing people. For producing higher amount of fish, it is important to maintain water quality parameters and selection of quality feed for feeding the fish. Aquaculture production largely depends on the amount of feed utilized by the fish. Therefore, fish should be delivered with required amount of feed in different growth stages. It reduces the feed cost and at the same time reduces the wastage. Thus, reduces the chances of water quality deterioration. By knowing SGR, the proper amount of feed needed for the fish in different stages of growth can be calculated. 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.

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