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ASSESSMENT OF THE COMPARATIVE GROWTH PERFORMANCE OF TILAPIA (*OREOCHROMIS NILOTICUS*) AT DIFFERENT STOCKING DENSITIES

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Abstract: This study was intended to assess the comparative growth and production performance in relation to different stocking densities to have better understanding on the consecutive growth trends. Tilapia (*Oreochromis niloticus*) fry was released at the rate of 8 fry per tank ($1m^3$) 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 (T_1) and semi-intensive (T_2) aquaculture system, respectively. Floating feed was used to evaluate the growth performance during the experimental period for T_1 and T_2, respectively. There were six replications for each treatment. The feed was supplied at the rate of 20%, 15%, and 10% of the body weight during the study period of 90 days. The weight gains of fish were 132.23±1.29 and 63.12±4.97g for T_1 and T_2, respectively. Feed conversion ratio (FCR) in T_1 and T_2 were 2.43±0.18 and 2.13±0.20, respectively. Higher total production was obtained in T_1 (1119.52 g) than T_2 (830.96 g) with 100% survival in both the treatments. The present study indicates that, the production performance acquired higher in T_1 having significant difference compared to T_2 and the intensive culture of Tilapia is more rational for getting more production in relation to semi-intensive culture.

Keywords: Feed Conversion Ratio (FCR), Production performance, SGR, Stocking density, Tilapia.

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INTRODUCTION

Aquaculture is a great revolution in fisheries sectors, which has introduced many effective technologies to rear fish and other aquatic animals and has contribution to escalate the total fish production worldwide. 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.

Aquaculture is the fastest growing animal-based food-producing sector particularly in developing countries like Bangladesh and its production contributes to the livelihoods, employment and also meets the demand in terms of protein supply, food security and income generation of the increasing number of people throughout the world (Haque *et al.,* 2016; Chakraborty *et al.,* 2019). 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 (Chakraborty, 2020; Chakraborty *et al.,* 2021; Chakraborty and Mome, 2022). Now people are getting involved in small scale aquaculture to attain more production (Subasinghe *et al.,* 2012). However, climate change exerts huge impact on aquatic ecosystem and sustainable development (Ashok, 2019; Prakash, 2021; Verma, 2021).

Tilapia is seen together of the foremost significant fish species which may reduce the gap of accelerating worldwide demand for protein sources (Romano and Ng, 2013). 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 (DoF, 2020). 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 (DoF, 2020). Among various segments of the fisheries sub-sector, the inland aquaculture has generally experienced the fastest growth, with the establishment of latest 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 about 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 reinforce national fish production within the context of increase 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 (DoF, 2020). Aquaculture ponds are often integrated into conservation and management systems and tank culture are often an efficient way of overcoming the matter 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.

Since commercial aquaculture largely depends on artificial feed and about 70% of total operational cost goes for feed, so it is very important to select right feed for expected growth (Karim *et al.,* 2017). In this experiment, the stocking density was adjusted to 320 fish/decimal and 160 fishes/decimal in intensive and semi-intensive system to achieve the expected result more accurately. To evaluate the growth of fish at different stages 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 floating feed to assess the feed conversion ratio and production performance of tilapia in different sampling stages to have better understanding on the FCR in relation to supplied feed.

MATERIALS AND METHODS

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. Each tank continuing with supply water was of length 1m, width 1m and 0.8 m of depth. Among the twelve tanks, six tanks were used to study the growth and subsequent production in relation to FCR in intensive rearing and remaining six tanks were used for semi-intensive culture of fish. The study was carried out for a period of 90 days. Tilapia was fed with floating feed to have better understating on the FCR and growth performance in different stocking density.

2. Experimental tanks
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 bottom faeces of the tanks. Water was supplied from a deep tube well located near the experiment site.

3. 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 and there were six replications for each. Fry was released at the rate of 8 fry per tank ($1m^3$) that equivalent to the stocking density of 320 fish per decimal or about 80,000 per hectare in intensive and 4 fry per tank that equivalent to the stocking density of 160 fish per decimal in semi-intensive aquaculture system.

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 size of 0.5 mm was 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.

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

5. Aeration installation
Air stone aerators were applied to provide sufficient oxygen 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.

6. Study of growth parameters of fish

$$FCR = \frac{\text{Weight of fish (dry weight)}}{\text{Live weight gain}} \times 100$$

$$\text{Weight gain (g)} = A - B$$

$$\text{Percent (\%) weight gain} = \frac{A - B}{B} \times 100$$

where 'A' is mean final weight and 'B' is mean initial weight in gram.

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

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

Note: Weight of fishes was measured in gram.

7. 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 °C and pH was recorded by digital pH meter.

8. 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 20. The graph was prepared by using both MS Excel and SPSS.

RESULTS

1. Fish growth performance

1.1 Final weight
The final mean weight of each fish was

139.94±1.29 and 69.24±4.97 g in treatment T_1 and $T_2$where the initial weight of individual tilapia was 7.71±0.19g and 6.12±0.18 g in T_1 and T_2, respectively with having significant difference ($p<0.05$) between the treatments.

1.2 Weight gain

The difference in weight gain is notably remarkable between two treatments. 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 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.

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.

1.4 Specific growth rate (SGR % per day)

The fishes were sampled at 3 days interval to gain the weight of fish to determine the actual growth performance at particular sampling stages. The specific growth rates (SGR) of tilapia in T_1 and T_2 were found 5.38 ±3.83and 4.98±2.28, respectively. There was significant difference ($p>0.05$) in term of SGR between the treatments. 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

Table 2: Specific growth rate (SGR) during the experimental period.

Sampling No.	Sampling day/stage	Average SGR in Treatment 1 (Mean ±SD)	Average SGR in Treatment 2 (Mean ±SD)
01	14 May,17	5.43±5.26	3.00±0.562
02	18 May,17	6.08.13±7.90	3.63±1.204
03	22 May,17	6.65±7.25	3.89±2.784
04	26 May,17	9.42±9.80	8.46±2.099
05	30 May,17	7.33±4.40	5.44±0.479
06	03 Jun, 17	5.82±2.44	3.96±1.335
07	07 Jun, 17	5.87±0.61	3.78±1.781
08	11 Jun, 17	15.02±1.62	9.01±3.120
09	15 Jun, 17	4.05±3.05	5.89±2.173
10	19 Jun, 17	8.23±1.88	4.63±0.297
11	23 Jun, 17	5.25±1.41	5.32±1.109
12	27 Jun, 17	5.18±2.27	5.66±0.706
13	01 July, 17	5.18±3.62	5.76±5.729
14	05 July, 17	6.20±2.99	4.97±1.786
15	09 July, 17	2.53±1.57	6.23±1.299
16	13 July, 17	2.53±1.18	5.52±1.251
17	17 July, 17	2.38±0.92	4.24±0.667
18	21 July, 17	2.68±0.78	3.74±1.623
19	25 July, 17	2.07±1.40	3.69±0.610
20	29 July,17	2.34±1.60	2.86±0.595

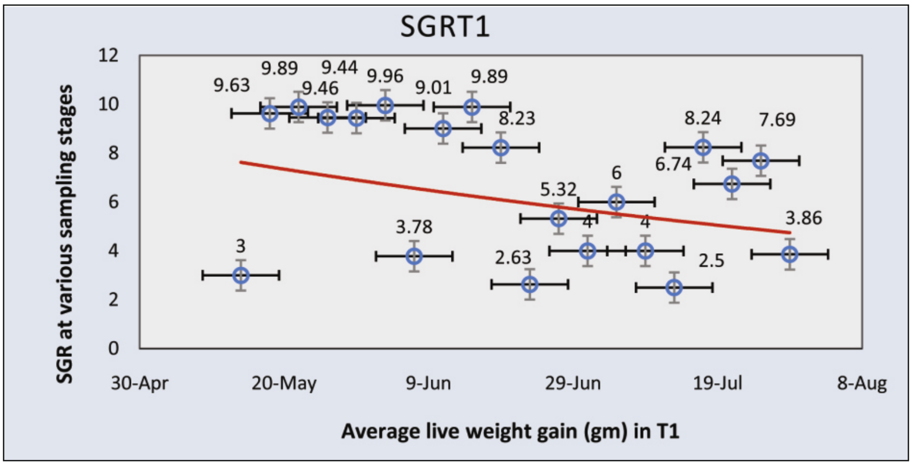

Fig.1: Specific growth rate of tilapia in intensive culture system (T1).

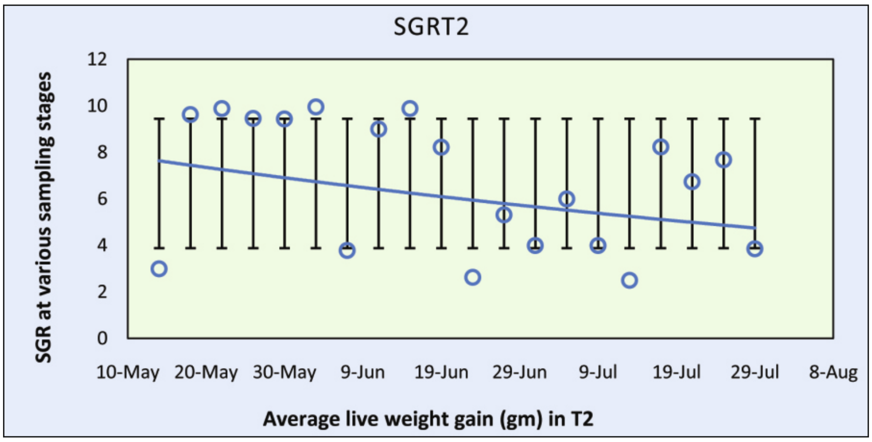

Fig.2: Specific growth rate of tilapia in semi-intensive culture system (T2).

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 (Fig.3).

1.6 Total production (g/m^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 m^3 in T_1 and T_2, respectively. The production was higher in the T_1 than that of T_2 (Fig.4).

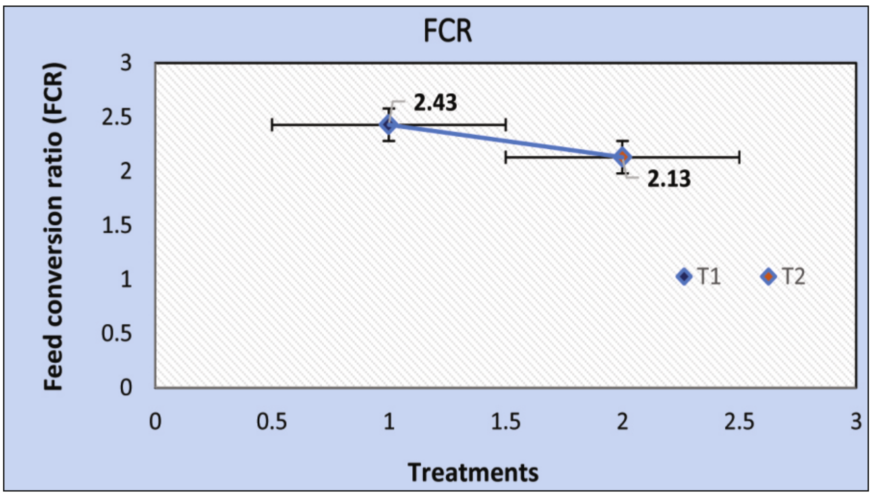

Fig.3: Feed conversion ratio in T_1 and T_2.

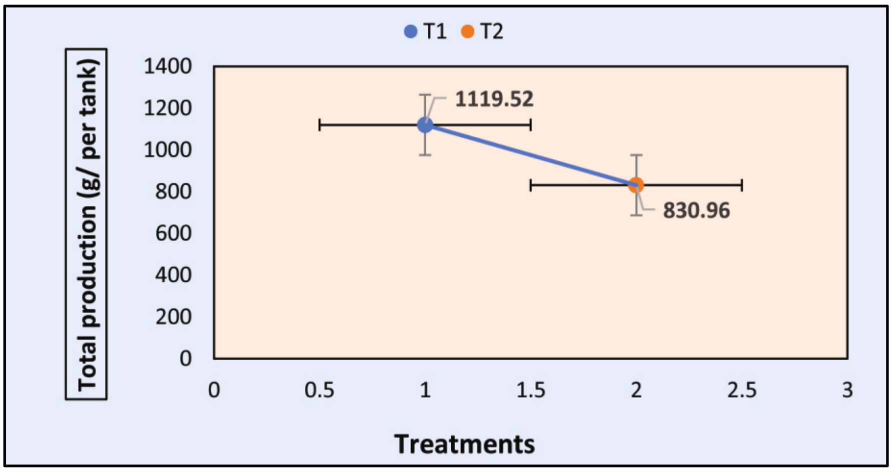

Fig.4: Total production of tilapia in the two treatments (T_1 and T_2).

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 and oxygen 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

DISCUSSION

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 6.12±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 (Alam, 2009-).

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 (Watanabe *et al.*, 2002). 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 (fig.3). 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.

The mean value of SGR in T_1 and T_2 were 5.38 ±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. Growth rate and production performance of tilapia in tank-based aquaculture system in relation to FCR was the main fact of interest of the present 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 between 4th and 11th June and at the end of the experiment the trend line of SGR was observed about to elevate (Table-2). 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. 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 (Rahman and Islam, 2021).

Hussain *et al*. (1987) recorded survival rate of tilapia ranged from 82 to 90%. The survivability of tilapia in the present study was 100%. 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.

The mean total production per cm^3 was 1119.52±0.00g and 830.96±0.00 g in T_1 and T_2, respectively. The production was higher in T_1 than T_2. Rana (2014) recorded the production of tilapia (*O. niloticus*) at the rate of 28MT/ha/100 days in pond. In the present study, the production was lower than the finding of Rana (2014) 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 (Rahman and Arifuzzaman, 2021).

Khater *et al*. (2017) reported that water temperature plays a vital role in regulating the metabolic process of fish. The suitable range of tilapia culture is 26 to 32^{0}C (Khan *et al*., 2008). Therefore, it is very important to maintain the temperature of the culture unit. The water temperature of the experimental tanks was within the suitable range of tilapia culture.

The growth and survival process of fish might be obstructed due to the unusual fluctuation of dissolved oxygen concentration. It is an important water quality parameter that affects the normal physiological state. Low dissolved oxygen content is lethal to fish and reduction in dissolved oxygen content has negative effects on growth, reproduction and other biological activities of fish. Rahman *et al.* (2021) reported that tilapia can tolerate dissolved oxygen concentration as low as 0.1 mg/l. 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 reveal the growth performance of fish in relation to FCR and production performance in accordance with the different stocking densities to have better understanding on the growth trends at various sampling stages. This finding may be helpful to the fish farmers to assemble immense information on the suitable culture technology specially for producing fish tank-based aquaculture system at different stocking densities.

CONCLUSION

The total production was enhanced and found a promising growth performance with the increase of stocking density. This study suggests that tank-based aquaculture can be developed in the indoor system that can ensure 100% survival. This study reveals an outstanding clarification on the growth performance of fish in different sampling stages in relation to supplied feed at various stages of fish growth and thus the culture period can be retarded. From the experiment, it might be suggested that the higher stocking density performed better in comparison with the semi-intensive aquaculture system in tank-based aquaculture. It is possible to produce a higher number of fish in such a improved way from a small parcel of land. However, further study needed to explore the relative cost effectiveness of the culture of tilapia fish in higher stocking density in tank-based aquaculture system.

CONFLICT OF INTEREST

There is no conflict of interest.

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