Abstract: The present study was aimed to evaluate the growth performance and subsequent survival rate of the rohu (Labeo rohita) and tilapia (Oreochromis niloticus). The experiment was conducted in six concrete tanks under an outdoor laboratory shed from 10th May to 29th July, 2019. There were three replications for each treatment and feed was supplied at the rate of 12%, 8%, and 4% of the body weight of rohu and 20%, 15%, and 10% of the body weight of tilapia in 1st, 2nd, and 3rd month for rohu (T1) and tilapia (T2) respectively to assess the comparative growth performance. The initial weight of individual tilapia was 7.52±1.81 g and 14.75±0.19 g for T1 and T2 respectively. The final mean weight of each fish was 44.01±5.65 g for T1 and 139.94±1.29 g for T2. The weight gains of fish were 36.49±4.09 g and 125.19±1.29 g for T1 and T2 respectively. The mean percent weight gain of tilapia was higher in T2 (1715.05±0.00) than T1 (485.23±0.00). Feed conversion ratio (FCR) in T1 and T2 were 2.86±0.14 and 2.23±0.18, respectively. Higher total production was obtained in T2 (1119.52 g) than T1 (278.19 g) with 100% survival in both the treatments. The water quality parameters for both of the species were within the suitable range. The study reveals that growth performance was higher in T2 than T1, having 100% survival rate in the concrete tanks.

Keywords: Floating feed, FCR, Growth performance, Intensive aquaculture, Yield.
contributes to the livelihoods, employment and also meet the demand in terms of protein supply, food security and income generation of the increasing number of people throughout the world.

To fulfill the animal protein demand for growing population in Bangladesh intensive fish culture system may be an alternative to enhance fish production since fish contributes about 60% of animal protein to our daily food (DoF, 2020). The competition between aquaculture and other agricultural sectors is increasing in the context of land and water use. Therefore, to replenish the existing gap intensive aquaculture is growing to ameliorate the national fish production in the context of immense growth of population and declining land resource. 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 hence adoption of new farming technology in the plain land is need of the hour (Islam et al., 2020). Moreover, fish production per unit area much higher in intensive aquaculture system compared to semi-intensive and extensive system. Aquaculture ponds are often integrated into conservation and management systems while tank culture is often an efficient way of overcoming the matter of water shortages.

In this experiment, the stocking density for both of the species was adjusted to intensive (320 fish/decimal) system to achieve the expected result more accurately. To assess the amount of feed required in percentage increase of size and weight at a particular growth stage in relation to time (SGR) is very important. The initial and final weight data over time remain unaccustomed to calculate the growth performance. Therefore, the result is not accurate enough to understand the growth of fish in the intermediary stages of a production cycle (Lugert et al., 2016). Therefore, due to lack of the appropriate modeling to evaluate the growth of fish at different stage in relation to water quality parameter in intensive farming, this study is likely to be effective to develop a relationship between water quality parameters i.e., DO (dissolved oxygen), temperature, pH, ammonia, nitrate, other dissolved gases and organic metals having direct effect on growth, maintenance and survival of fish.

The present study has taken rohu and tilapia as experimental species to explore the growth of fish in intensive culture system in concrete tanks by using floating feed. The intensive aquaculture increases the production of fish rearing exotic species. Intensive aquaculture of indigenous species can enhance the indigenous fish production in a particular/limited time. The aquaculture development and increase in per unit volume of water depends after all artificial feed (Shaheen et al., 2000). Fishes are rich in nutrients and among cyprinids, rohu (Labeo rohita) is the most popular fish species which is cultivated in Indian subcontinent (Ashok, 2020, 2021; Kumar et al., 2020). Rohu is considered as the delicious and prestigious fish species among other Indian major carps for its uniqueness and attributes (FAO, 2000). Tilapia (Oreochromis niloticus) regarded as an honest converter of organic matter into top quality which will survive in shallow and turbid water conditions (Stickney et al., 1979). Tilapia is very resilient species which may reduce the gap of accelerating worldwide demand for its protein sources and market demand (Romano and Ng, 2013). The use of commercial feed has become a time demanded initiative for the success of cyprinid and tilapia culture under intensive culture conditions particularly rohu along with other carps (Abid and Ahmed, 2009) and tilapia monosex culture. Chakraborty et al. (2020) and Chakraborty (2021) conducted research on rearing, spawning and nursing of Pangas in Bangladesh.

The study was conducted to specify the comparative growth performance, yield and FCR to optimize feed supplementation during the culture period and to make a rational decision for get better outcomes from tank-based intensive aquaculture system with the economic affordability of fish farmers. The study was carried out to assess the growth and production of rohu and tilapia focusing on different intermediate sampling stages to have better understanding on growth trends.

MATERIALS AND METHOD

1. Experimental site
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. Water supply and exchange facility was also satisfactory there. Each tank is of 1 m length, 1 m width and 1.2 m depth and water volume in each tank was $1 \times 1 \times 1 = 1\text{m}^3$. Among the six tanks, three tanks were used to study the growth, yield and survival of rohu (*Labeo rohita*) and remaining three tanks used to observe the consecutive growth performance of tilapia (*O. niloticus*) in intensive rearing system. Both the fish species were fed with floating to have better understating on various sampling stages.

![Fig.1: Intensive Aquaculture System Lab, BAU, Mymensingh.](image1)

2. Experimental tanks
For conducting the experiment, six 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.

3. Experimental design and layout
Rohu (*Labeo rohita*) and Monosex male tilapia (*O. niloticus*) fry was used as experimental species. For the experiment, two treatments were designed namely T₁, and T₂ and there were three replications for each. For both of the species, 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 with different average initial weight for six tanks individually.

![Fig.2: Experimental concrete made tank.](image2)

Table 1: Design and layout of the experimental tank.

| Replication | Stocking density (fry/tank) | Average initial weight (g) | Replication | Stocking density (fry/tank) | Average initial weight (g) |
|-------------|-----------------------------|---------------------------|-------------|-----------------------------|---------------------------|
| T₁ (*Labeo rohita*) | R₁ (tn₁) | 6.52 | R₁ (tn₁) | 15.92 |
| | R₂ (tn₂) | 8 | 9.62 | R₂ (tn₂) | 8 | 14.61 |
| | R₃ (tn₃) | 6.42 | R₃ (tn₃) | 8 | 14.61 |

Note: The table shows the stocking density and average initial weight for each replication.
Table 2: Experimental layout with six tanks.

| Treatment 1 | Treatment 2 |
|-------------|-------------|
| T₁R₁ (Tank No. 1) | T₂R₁ (Tank No. 4) |
| T₂R₁ (Tank No. 2) | T₂R₂ (Tank No. 5) |
| T₃R₁ (Tank No. 3) | T₃R₂ (Tank No. 6) |

4. Selection of feed and feeding frequency
The fishes were fed commercial floating feed named as 'Mega Feed' and 'Quality Feed' for T₁ and T₂, respectively. 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 feed the fish during the rest experimental period. During experiment, feed was given at the rate of 20%, 15%, and 10% of the body weight in 1ˢᵗ, 2ⁿᵈ and 3ʳᵈ month, respectively.

Table 3: Proximate composition of floating feed as per labeling on the feed bag.

| Proximate composition | T₁ Floating feed (%) | T₂ Floating feed (%) |
|-----------------------|----------------------|----------------------|
| Moisture              | 12                   | 10                   |
| Protein               | 32                   | 28                   |
| Fat                   | 5                    | 6                    |
| Starch                | 27                   | 22                   |
| Fiber                 | 9                    | 3                    |
| Ash                   | 12                   | 12                   |
| Calcium               | 2                    | 2                    |
| Phosphorus            | 1                    | 1                    |

5. Feeding strategy
The daily ration of fish was adjusted with the body weight. The total amount of ration was divided into two parts and half was supplied to the fish in the morning (9:30 am) and the remaining half was delivered in the afternoon (4:30 pm). During experimental period, there were three replications for each treatment and feed was supplied at the rate of 12%, 8%, and 4% and 20%, 15%, and 10% of the body weight in 1ˢᵗ, 2ⁿᵈ and 3ʳᵈ month for T₁ and T₂, respectively. The daily ration was calculated as the following rate in the Table-4.

Table 4: Feeding chart for the experimental fish.

| Days      | Amount of feed (% of the total body weight of fish) |
|-----------|----------------------------------------------------|
|           | T₁ | T₂ |
| 1ˢᵗ 30 days | 12% | 20% |
| 2ⁿᵈ 30 days | 8% | 15% |
| Final 30 days | 4% | 10% |
6. Sampling of fish
Fish sampling was done by catching all fishes of individual tanks at three days interval. Fishes were caught by using small triangle shaped push net (Fig. 3). The weighing process was done by an electric balance (MODEL: HKD-620AS-LEDE) in gram. The length was recorded by measuring scale in cm (Fig. 3). Sampling was performed in the morning at around 9:00 am prior to delivering feed to observe growth and health conditions.

7. 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.

8. 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 formula given below. The length and weight of fish were measured using centimeter scale and electric balance (Model; HKD-620AS-Led) in grams.

\[
\text{Weight gain (g)} = \frac{\text{Mean final weight (g)}}{-\text{Mean initial weight (g)}}
\]

9. Study of water quality parameters
During the experiment, water quality parameters of the experimental tanks were recorded very intensively two times daily. Water quality parameters especially temperature, DO, pH were measured in the morning and afternoon 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; Fig. 4) in mg/l. Water temperature was measured by using digital thermometer (model: CE 225908) in °C and pH was recorded by digital pH meter (Model: CE 224469).
1. Weight gain
This controlled experiment was conducted to assess the growth of rohu and tilapia frequently in 3 days interval. In this study, the average weight gain of $T_1$ was $36.49\pm 4.09$ g and for $T_2$ was $125.19\pm 1.29$ g, respectively. The difference in weight gain is notably remarkable between two treatments. The weight gain was found higher in $T_2$ than $T_1$ (Table 5). In term of weight gain, in the most 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 trends of weight gain were observed. The higher weight gain in $T_2$ was observed from the 5th sampling. However, it was remarkable increment growth after about a month.

3. Percent weight gain (%)
The mean percent weight gain was higher in $T_2$ ($1715.05\pm 0.00$) than $T_1$ ($485.23\pm 0.00$). The higher percent weight (1715.05%) was found in $T_2$ where fishes were fed at the rate of 20%, 15%, and 10% of the body weight in 1st, 2nd and 3rd month with average individual weight of $14.75\pm 0.19$ g (Fig. 5).

Table 5: Weight gain performances (mean ± SD) of individual tilapia in experimental tank.

| Growth parameters | $T_1$          | $T_2$          |
|-------------------|----------------|----------------|
| Initial weight (g)| $7.52\pm 1.81$ | $14.75\pm 0.19$|
| Final weight (g)  | $44.01\pm 4.03$| $139.94\pm 1.29$|
| Weight gain (g)   | $36.49\pm 4.09$| $125.19\pm 1.29$|
| % Weight gain      | $485.23\pm 0.00$| $1715.05\pm 0.00$|
4. Feed conversion ratio (FCR)
The feed conversion ratio was calculated by taking into consideration the total amount feed used in the experiment. Feed conversion ratio values of floating feed used for feeding the fish in \(T_1\) and \(T_2\), respectively were 2.86±0.14 and 2.23±0.18 (Fig. 6).

5. Total production \((g/cm^3)\)
The total productions at the end of the study were 278.19±0.00g and 1119.52±0.00g per \(cm^3\) in \(T_1\) and \(T_2\), respectively (Fig. 7). The production was higher in the tanks fed with 20%, 15%, and 10% of the body weight.

6. Water quality parameters
The mean values of tested water quality parameters such as temperature and DO of the experimental ponds are presented in Table 6. 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 6: Water temperature of experimental tanks.

| Water quality parameters | Treatments | Morning  | Evening  |
|--------------------------|------------|----------|----------|
| Temperature \((^{0}\Celsius)\) | \(T_1\) | 27.19±1.46 | 28.23±1.58 |
|                          | \(T_2\) | 27.54±1.43 | 28.65±1.67 |
| DO (mg/l)                | \(T_1\) | 5.58±0.82  | 6.15±0.65  |
|                          | \(T_2\) | 5.85±0.85  | 6.58±0.82  |

DISCUSSION
In the present study, the fishes are fed with floating feed in treatment 1 and treatment 2. The difference in weight gain was found between these two treatments. The mean initial weight of the rohu in the 3 tanks of \(T_1\) was 7.52±1.81 and in the other 3 tanks of \(T_2\) was 14.75±0.19. At the end of the experiment, the mean final weight of the fish in \(T_1\) was 44.01±7.77 and 139.94±1.29 in \(T_2\). The mean weight gain was 36.49±4.09 and 125.19±1.29 in \(T_1\) and \(T_2\), respectively. The weight gain was higher in \(T_1\) which might be due to the fact that fish had taken more amount of feed in almost similar level of water quality.

To evaluate the utilization of feed, feed conversion ratio (FCR) was calculated that was given to the fish as feed supplement. The expected FCR for tilapia ranges from 1.5 to 2.0 (Watanabe et al., 2002). The FCRs of tilapia in present study were 2.86±0.14 and 2.23±0.18 in \(T_1\) and \(T_2\), respectively. The FCR in \(T_1\) was within expected range but in case of \(T_2\), it was higher than the accepted value. 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 survivability of rohu and tilapia in the present study was 100%. Hussain et al. (1987) recorded survival rate of tilapia 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. 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 as a natural resource.

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 tilapia culture is 26 to 32°C (Khan et al., 2008). 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. The average value of temperature in T1 was 27.19 ±1.46 and 28.23±1.58 during morning and evening, respectively. In T2, the mean temperature was 28.54±1.43 and 28.65±1.67 in morning and evening, respectively.

Balarin and Hatton (1979) reported that tilapia can tolerate dissolved oxygen concentration as low as 0.1 mg/l. Higher level of DO concentration was recorded in the experimental tanks as a result of aerator installation. In the present study, the mean average oxygen content of T1 was 5.58±0.82 and 6.15±0.65 during morning and evening, respectively. In T2, the mean dissolved oxygen content was 5.85±0.85 and 6.58±0.82 in morning and evening, respectively. Tilapia can survive at very low dissolved oxygen content.

CONCLUSION
This study suggests that tank-based aquaculture can be developed in the indoor system that can ensure almost 100% survivals. This study also had an introspective observation to detect consecutive growth performance and yield in relation to FCR. 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 wastage of feed at the final stages of the culture period can be limited due to the proper demonstration of feed to reduce the FCR. From the experiment, it is possible to produce a higher number of fish in such an improved way from a small parcel of land.

However, further study is needed to explore the relative cost-effectiveness of the culture of rohu and tilapia fish in higher stocking density in tank-based aquaculture system. For producing high number of fish, it is important to maintain water quality parameters and selection of right quality feed for feeding the fish. This study also indicates that farmers in Bangladesh practicing inefficient feeding systems wasting high-cost floating feed due to lack of proper knowledge on growth and production at different stages. This study reveals an outstanding clarification and will assist the researchers and academicians who want to culture rohu and tilapia in intensive aquaculture system by using floating feed and contribute to modify the research in near future.

CONFLICT OF INTEREST
There is no conflict of interest regarding the submitted manuscript.

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