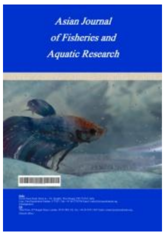

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# Sinking Feed Efficiency in Growth Performance, Feed Conversion Ratio (FCR) and Yield of Tilapia (*Oreochromis niloticus*) at Different Stocking Densities

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***Authors' contributions***

*This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.*

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## ABSTRACT

The efficiency of feed is considered as one of the most crucial factors that affects the growth performance, feed conversion ratio and yield as well. The study was aimed to compare the growth parameters of tilapia at different stocking densities to detect the efficiency of sinking feed assessing the growth trends at various sampling stages. To evaluate the comparative yield, the study was carried out in twelve concrete tanks under an outdoor laboratory shed. 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 and semi-intensive aquaculture system, respectively. To evaluate the growth trends sinking feed was used for feeding the fish during the experimental period for $T_1$ (Intensive) and $T_2$ (Semi-intensive), respectively. The feed was supplied in each with three replications at the rate of 20%, 15%, and 10% of the body weight of fish, respectively. The daily ration of feed was delivered to fish dividing into two parts daily. Aeration facilities using air stone aerator were installed for 24 hours. To assume the consecutive growth trends, weight of fish was recorded in 3 days interval to have better understanding on the yield performance in relation to the

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feed conversion ratio (FCR). Water quality parameters i.e., temperature and dissolved oxygen (DO) were recorded two times daily. The final weight gains of fish were 133.77±5.65 gm and 50.70±2.40 gm for $T_1$ and $T_2$, respectively. The mean percent weight gain of tilapia was higher in $T_1$ (1127.25±0.00) than $T_2$ (518.51±0.00 gm). Feed conversion ratio (FCR) in $T_1$ and $T_2$ were 1.97±0.11 and 1.70±0.07, respectively. The specific growth rates (SGR) of tilapia in $T_1$ 4.90±3.03 and 4.78±3.83 considering the data at the beginning and the end of the production cycle, respectively. Higher total production was obtained in $T_1$ (1070.19 gm) than $T_2$ (610.00 gm) with 100% survival in both the treatments. The present study reveals that, the efficiency of sinking feed was higher in $T_1$ than $T_2$ and farmers might be suggested to practice tank-based intensive aquaculture system to get higher production in a short period of time.

*Keywords: Sinking feed; stocking density; growth performance; feed conversion ratio (FCR); specific growth rate (SGR).*

## 1. INTRODUCTION

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 [1]. Aquaculture contributes around half of the fish for direct human consumption in Bangladesh and is set to grow further to replenish the nutritional gap. 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 [1]. Aquaculture plays an important role to enhance fish production, to ensure food security, alleviating poverty due to the depletion of the natural fish stocks [2]. Millions of people are getting engaged in aquaculture production with majority involved in small-scale production [3]. Tilapia is considered as significant fish species due to its excellent stability in aquaculture production which may reduce the gap of accelerating worldwide demand for protein sources [4].

The competition between aquaculture and other agricultural sectors is increasing in the context of land and water use. Therefore, intensive aquaculture is growing fast and practiced to enhance cumulative 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 a commendable alternative to enhance fish production since fish contributes about 60% of animal protein to our daily food [1]. Aquaculture system can be integrated into water conservation and management systems and tank culture can be an effective way of overcoming the problem of water shortages in the upcoming days. 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 [5].

To assess the growth trends and yield in relation to feed conversion ratio (FCR) 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 [6]. 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.

Due to inadequate knowledge regarding on ideal stocking density and feeding strategy culture of fish on a small-scale basis has often failed. The highest section of the production cost lies in feed, with protein containing the most expensive component in the production unit [7]. However, to improve fish culture at commercial level, it is important to establish an appropriate culture technique and management strategy that is based on identification of the daily feeding frequency and growth parameters observation [8] In aquaculture, feeding is crucial for its viability and success like other form of husbandry [9]. Feed cost is considered as one of the largest operational costs in aquaculture system [10]. It is important to suggest the optimum feeding rate for economic production of fish to reduce the wastage of feed. In general, the feeding regime and growth of fish are very much related to make a propitious production from the defined culture unit. Thus, the feeding strategy and proper demonstration of supplementary feed may provide a clue for maximum growth because the feeding frequency contribute to feed efficiency and growth response [11]. Tilapia (*Oreochromis niloticus*) is usually known as commercially important species for aquaculture throughout the world for its stability and hardness [12]. Thus, culture of tilapia in tank-based might provide an effective way of inducing a positive approach towards tilapia culture in Bangladesh.

The study was carried out in intensive and semi-intensive aquaculture system in tanks feeding with sinking 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.

Based on the above aforementioned context, this experiment was conducted to determine the growth performance of tilapia at different stocking density and various sampling stages to find out the effective strategy to increase the production of fish in tank-based aquaculture system.

## 2. MATERIALS AND METHODS

### 2.1 Experimental Tanks

Twelve square-shaped concrete tanks were constructed with a well-controlled security system so that outsiders can't interfere with or hinder the cultivation 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 =1$m^3$. 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. Tilapia was fed with floating feed to have better understating on the growth performance in different stocking density. 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.

### 2.2 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 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.

### 2.3 Selection of Feed and Feeding Frequency

Sinking types of commercial pellet feed named as 'Quality Feed' were used. The proximate composition of feed is shown in Table 2. In first 30 days of the experiment, the size 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.

### 2.4 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 (9:30am) and the rest half was delivered in the afternoon (4:30pm). The daily ration was calculated as the following rate in the Table 3.

### 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)

Percent (%) weight gain= (Mean final weight – Mean initial weight (gm)/ Mean initial weight (gm)) x100

$$\text{SGR (\%) per day} = \frac{\text{logW2-logW1}}{\text{T2-T1}} \times 100$$

$$\text{Survival rate} = \frac{\text{No. of harvested fish}}{\text{No. of fish stocked}} \times 100$$

Production = No. of fishes harvested × average final weight increases 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 $^{o}$C 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 10.90±0.19 gm and 0.96±0.07 gm for $T_1$ and $T_{2,}$ respectively. The final mean weight of each fish was for $T_1$ 133.77±5.65 gm and 50.70±2.40 gm 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 122.87±5.65 gm and for $T_2$ was 49.74±2.40 gm, 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 $T_2$. The higher weight gain in $T_1$ was observed from the 5$^{th}$ sampling. However, it was remarkable increment growth after about a month (Sampling stage 4, Table 4).

### 3.1.3 Percent weight gain (%)

The mean percent weight gains of fishes were 1127.25±0.00 and 518.51±0.00 for the treatments $T_1$ and $T_{2,}$ respectively. The higher percent weight (1127.25%) was found in $T_1$ where lower (518.51%) was in $T_{2.}$

### 3.1.4 Specific growth rate (SGR % per day)

The specific growth rates (SGR) of tilapia in $T_1$ and $T_2$ were found 4.90 ±3.03 and 4.78±3.83, respectively. The SGR between the treatments was significantly difference ($p>0.05$) in term of weight gain. The present study indicated the 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. The SGR of $T_1$ was shown increasing gradually. After that, at the last sampling stage, average trend of SGR was observed (Figs. 3 and 4). More specifically, the significant higher specific growth rates were observed at the middle stage (In between 4$^{th}$ June and 18$^{th}$ June) of the experiment and also in later stages (Table 4 and Fig. 1).

The SGR at the initial stage started from the higher range in $T_1$ compared to $T_2$ (Fig. 2 and Fig. 3).

### 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 feed used for feeding the fish in $T_1$ and $T_2$, respectively were 1.97±0.11 and 1.70±0.07 (Fig. 4).

### 3.1.6 Total production (g/cm$^3$)

The total productions of tilapia at the end of the study were 1070.19±0.00g and 610.00 ±0.00 g per cm$^3$ in $T_1$ and $T_{2,}$ respectively. The production was higher in the $T_1$ than that of $T_2$ (Fig. 5).

### 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 5. 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 1. Design and layout of the experimental tank**

| Intensive Culture Unit | | | | Semi-intensive Culture Unit | | | |
|---|---|---|---|---|---|---|---|
| **Treatment** | **Replication** | **Stocking density (fry/tank)** | **Average initial weight (g)** | **Treatment** | **Replication** | **Stocking density (fry/tank)** | **Average initial weight (g)** |
| $T_1$ | $R_1$ ($tn_1$) | | 6.92 | | $R_1$ ($tn_1$) | | 0.82 |
| | $R_2$ ($tn_2$) | | 6.97 | | $R_2$ ($tn_2$) | | 0.89 |
| | $R_3$ ($tn_3$) | 8 | 7.28 | $T_2$ | $R_3$ ($tn_3$) | 4 | 0.71 |
| | $R_1$ ($tn_4$) | | 15.92 | | $R_1$ ($tn_4$) | | 0.93 |
| | $R_2$ ($tn_5$) | | 13.61 | | $R_2$ ($tn_5$) | | 1.06 |
| | $R_3$ ($tn_6$) | | 14.72 | | $R_3$ ($tn_6$) | | 1.36 |

**Table 2. Proximate composition of sinking feed as per labeling on the feed bag**

| Proximate composition | Sinking feed (%) |
|---|---|
| Moisture | 11 |
| Protein | 25 |
| Fat | 7 |
| Starch | - |
| Fibre | - |
| Ash | - |
| Calcium | 2.5 |
| Phosphorus | 1.0 |

**Table 3. Feeding chart for the experimental fish**

| Days | Amount of feed (% of the total body weight of fish) |
|---|---|
| $1^{st}$ 30 days | 20% |
| $2^{nd}$ 30 days | 15% |
| Final 30 days | 10% |

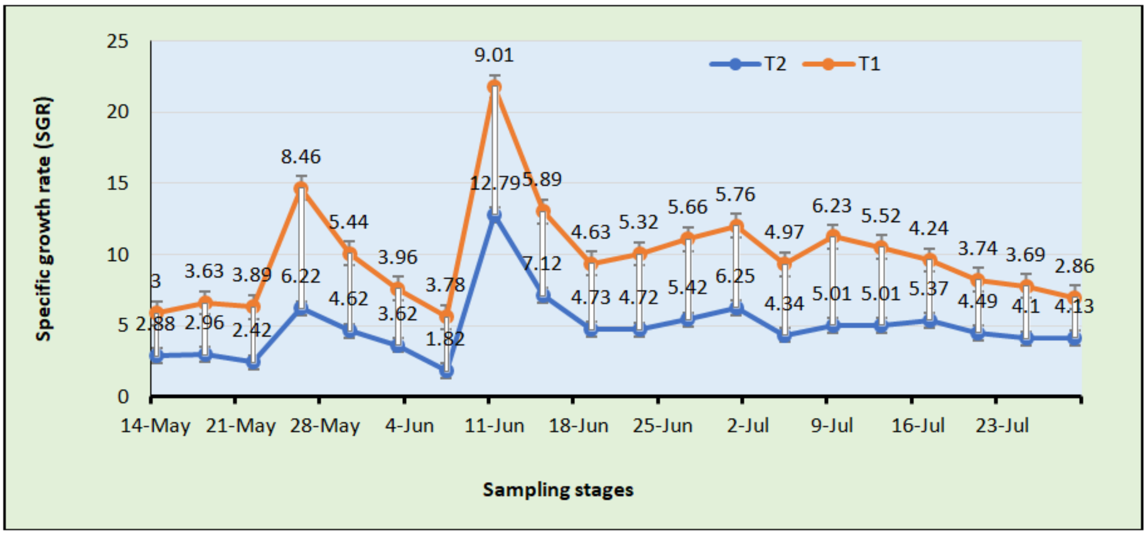


**Fig. 1. Specific growth rate at various sampling stages**

**Table 4. 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 | 7.07±5.26 |
| 02 | 18 May,17 | 3.63±1.204 | 5.45±7.90 |
| 03 | 22 May,17 | 3.89±2.784 | 6.49±7.25 |
| 04 | 26 May,17 | 8.46±2.099 | 2.36±9.80 |
| 05 | 30 May,17 | 5.44±0.479 | 3.54±4.40 |
| 06 | 03 Jun, 17 | 3.96±1.335 | 4.43±2.44 |
| 07 | 07 Jun, 17 | 3.78±1.781 | 2.98±0.61 |
| 08 | 11 Jun, 17 | 9.01±3.120 | 11.74±1.62 |
| 09 | 15 Jun, 17 | 5.89±2.173 | 9.78±3.05 |
| 10 | 19 Jun, 17 | 4.63±0.297 | 8.76±1.88 |
| 11 | 23 Jun, 17 | 5.32±1.109 | 5.78±1.41 |
| 12 | 27 Jun, 17 | 5.66±0.706 | 16.43±2.27 |
| 13 | 01 July, 17 | 5.76±5.729 | 8.54±3.62 |
| 14 | 05 July, 17 | 4.97±1.786 | 5.76±2.99 |
| 15 | 09 July, 17 | 6.23±1.299 | 5.67±1.57 |
| 16 | 13 July, 17 | 5.52±1.251 | 7.87±1.18 |
| 17 | 17 July, 17 | 4.24±0.667 | 6.54±0.92 |
| 18 | 21 July, 17 | 3.74±1.623 | 2.87±0.78 |
| 19 | 25 July, 17 | 3.69±0.610 | 3.76±1.40 |
| 20 | 29 July,17 | 2.86±0.595 | 2.34±1.60 |

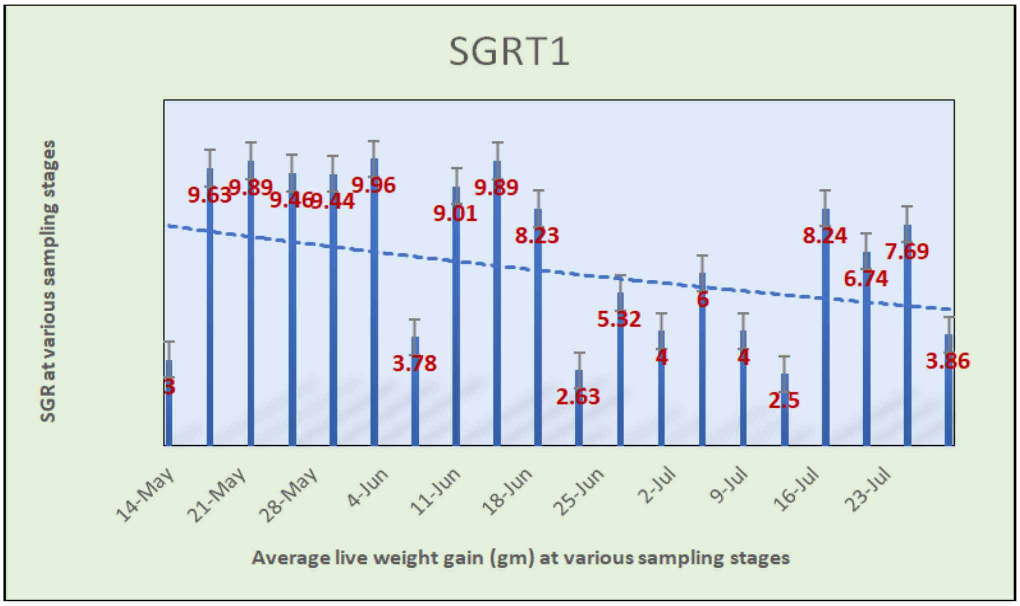


**Fig. 2. Specific growth rate of tilapia in intensive culture system ($T_1$)**

## 4. DISCUSSION

At the end of the experiment, the mean weight of the fish in $T_1$ was 133.77±5.65 gm and 50.70±2.40 gm in $T_2$. In this present study, the difference in weight gain was found between the treatments. The mean initial weight of the tilapia in $T_1$ was 10.90±0.19 gm and in $T_2$ was 0.96±0.07. 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 [13].

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 4$^{th}$ and 18$^{th}$ June (Fig. 1) and at the end of the experiment the trend line of SGR was observed about to elevate. The mean value of SGR in $T_1$ and $T_2$ were 4.90±3.03 and 4.78±3.83, respectively. From these data, the specific growth rate of tilapia in $T_1$ was higher than $T_2$ in first 30 days (around) and in the middle stage both SGR increased simultaneously. 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 5$^{th}$ sampling stage. The trend line of both SGR was also in downward direction at the end of the experiment (Figs. 2 and 3). 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 sinking feed in tilapia farming is more effective in the early and middle stages.

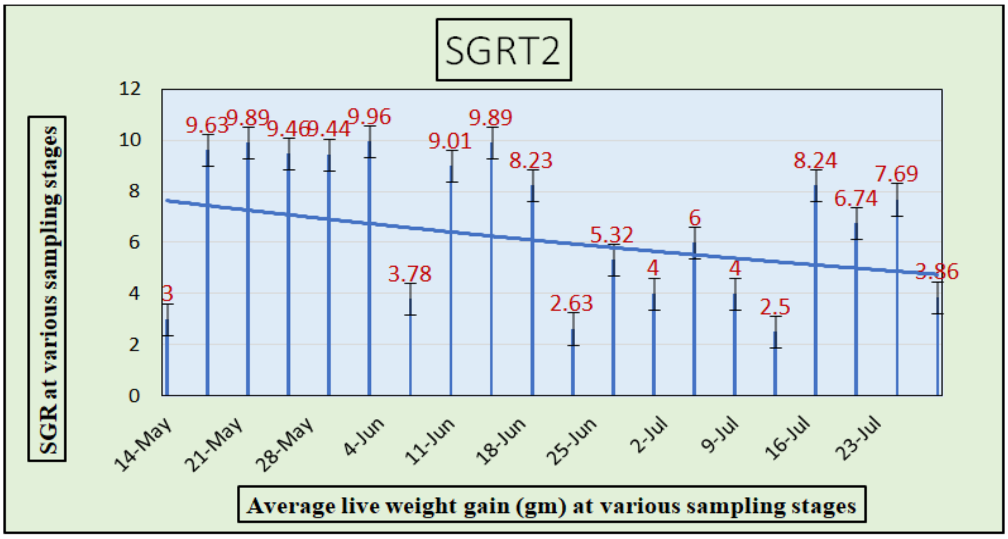


**Fig. 3. Specific growth rate of tilapia in semi-intensive culture system ($T_2$)**

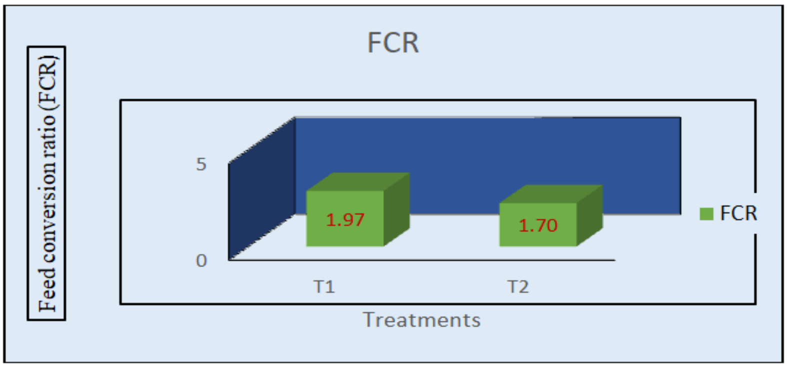


**Fig. 4. Feed conversion ratio in $T_1$ and $T_2$**

**Table 5. Water temperature of experimental tanks**

| | Intensive | | | Semi-intensive | | |
|---|---|---|---|---|---|---|
| Water quality parameters | Treatments | Morning | Evening | Treatments | Morning | Evening |
| Temperature ($^0$C) | $T_1$ | 25.71±1.45 | 27.31±1.57 | $T_2$ | 26.78±1.59 | 27.67±1.67 |
| DO (mg/l) | $T_1$ | 6.75±0.83 | 6.37±0.79 | $T_2$ | 6.88±0.81 | 6.84±0.82 |

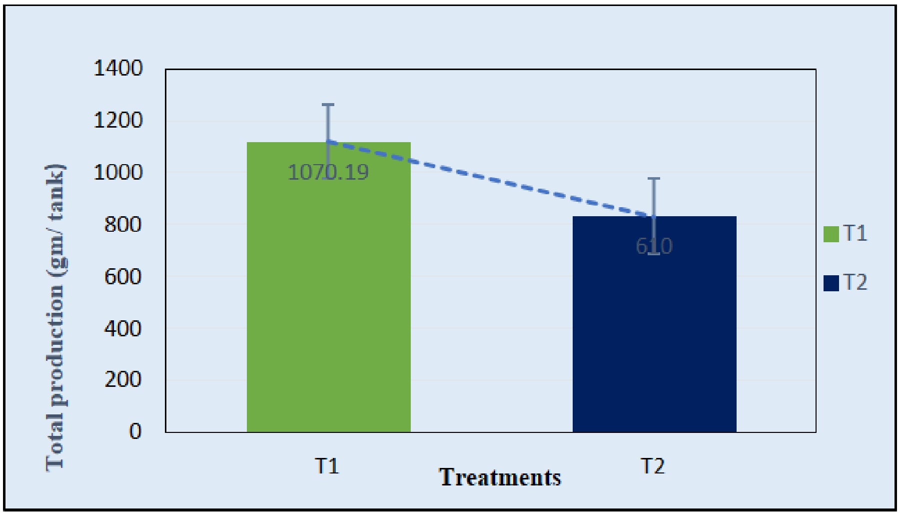


**Fig. 5. Total production of tilapia in the two treatments ($T_1$ and $T_2$)**

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 [14]. The FCRs of tilapia in present study were 1.97±0.11 and 1.70±0.07 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. 4). 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 found in $T_1$ 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 sinking feed with pre-determined estimation of the required amount of ration derived from percent body weight, waste the high-cost feed and money.

Hussain et al. [15] 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.

The mean total production per $cm^3$ was 1070.19 gm and 610.00 gm in $T_1$ and $T_2$, respectively. In the present study, the production was lower than the finding of Rana [16] 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 production was higher in $T_1$ than $T_2$ (Fig. 5). Rana [16] recorded the production of tilapia (*O. niloticus*) at the rate of 28MT/ha/100 days in pond.

The suitable range of tilapia culture is 26 to 32$^0$C [17]. Battes et al. [18] 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 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.

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. Balarin and Hatton [19] 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 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 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

Due to lack of proper knowledge on specific growth rate at different stages of fish growth and production, tilapia farmers in Bangladesh practicing inefficient feeding systems wasting high-cost floating feed. In this experimental, the proper amount of feed needed for the fish culture in different stages of growth can be calculated by knowing the specific growth rate (SGR). It was found that total production was increased with the increase of stocking density. Overall, 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 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 higher stocking density (320 fish per decimal) performed the better results in comparison with low stocking density and further study is needed to explore the cost-benefit analysis of tilapia farming in tank-based aquaculture system to assist the farmers to achieve higher amount of fish from a small parcel of land.

## DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

## REFERENCES

1. DOF. Jatio Matshya Saptaho Shankalan, Department of Fisheries, Ministry of Fisheries and Livestock, Dhaka, Bangladesh. 2020;144-145.
2. Alhassan EH, ED Abarike and CL Ayisi, 2012. Effects of stocking density on the growth and survival of Oreochromis niloticus cultured in hapas in a concrete tank. African J. Agricl. Res., 7: 2405-2411.
3. Subasinghe R, Ahmad I, Kassam L, Krishnan S, Nyandat B, Padiyar A, Phillips M, Reantaso M, Miao W, Yamamoto K. Protecting small-scale farmers: a reality within a globalized economy? In: RP Subasinghe, JR Arthur, DM Bartley, SSD Silva, M Halwart, N Hishamunda, CV Mohan and P Sorgeloos (Editors), Farming the Waters for People and Food. Proceedings of the Global Conference on Aquaculture 2010, Phuket, Thailand. 22–25 September 2010, FAO, Rome and NACA (Network of Aquaculture Centres in Asia - Pacific), Bangkok. 2012;705-717.
4. Romano N, Ng WK. A review of the nutrition and feeding management of farmed tilapia throughout the culture cycle. Reviews in Aquaculture. 2013; 4:1-35.
5. Smith ES, Phelps RP. Reproductive efficiency, fry growth and response of Nile Tilapia. PD/ACRSP Fourteen Annual Technical Report. 2001;8.
6. Lugert V, Georg T, Jen T, Carsten S, Joachim K. A review on fish growth calculation: multiple functions in fish production and their specific application. Reviews in Aquaculture. 2016; 8:30-42.
7. Pandian TJ. Protein requirements of fish and prawns cultured in Asia. In: De Silva (Ed.), Fish Nutrition Research in Asia. Proceedings of the 3rd Asian Fish Nutrition Network Meeting, Asian Fisheries Society, Philippines. 1989;11-22.
8. Phillips TA, Summerfelt RC, Clayton RD. Feeding frequency effects on water quality and growth of walleye fingerlings in intensive culture. Progress Fish-Culturist. 1998; 60:1-8.4.

9. Lovell RT. Feeding practices. In: Nutrition and feeding of channel catfish, Southern Cooperative series. 1977;218: 50-55.
10. De Silva SS, Davy FB (1992) Fish nutrition research for semi-intensive culture system in Asia. Asia Fisheries Science 5(1992): 129-144.
11. Jarboe HH, Grant WJ. The influence of feeding time and frequency on the growth, survival, feed conversion and body composition of channel catfish, *Ictalurus punctatus*, cultured in a three tier, close recirculating raceway. J. Appl. Aquaculture. 1997;7(1):13-62.
12. Chowdhury DK. Optimal feeding rate for Nile tilapia (*Oreochromis niloticus*), M.Sc thesis, Department of Animal and Aquacultural Sciences, Norwegian University of Life Sciences, UK. 2011;1-76.
13. Roy R. Effects of stocking density on the growth and survival of GIFT Tilapia fed on formulated diet, MS Thesis, Department of Aquaculture, Bangladesh Agricultural University, Mymensingh;2009.
14. Watanabe WO, Losordo TM, Fitzsimmons K, Hanley F. Tilapia production systemin the Americas: technical advances, trends and challenges. Reviews in Fisheries Science. 2002;10(3-4):465-498.
15. Hussain MG, Rahman MA, Akhteruzzaman M. A study on the production of *O. niloticus* (Linnaeus) under intensive system in Bangladesh. Bangladesh J. Fish Res. 1987;1(2):19-23.
16. Rana KMS. Development of black solider fry larve rearing technique to supplement fish feed, MS Thesis, Department of Aquaculture, Bangladesh agricultural University, Mymensingh;2014.
17. Khan S, Hossain MS, Hossain MM. Production and economics of GIFT strain of tilapia (*Oreochromis niloticus*) in small seasonal ponds. Progressive Agriculture.2008;19(1):97-104.
18. Battes K, Constania L, Valencive N, Lordache L, Tarus T.: Carp culture in floating cages. Bulletin of Correct Piscis. 1979;1(1-2):68-95.
19. Balarin JD, Hatton JP. Tilapia: A guide to their biology and culture in Africa. Unit of Aquatic Pathology, University of Stirling, Scotland. 1979;174.

## APPENDICES

**Appendix 1. T-Test showing the level of significance in terms of difference in initial and final weight gain of the two treatments ($T_1$ and $T_2$)**

| Independent Samples Test | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
| | | F | Sig. | t | Df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | 95% Confidence Interval of the Difference | |
| | | | | | | | | | Lower | Upper |
| VAR00001 | Equal variances assumed | 2.799 | .190 | -11.373 | 4 | .000 | -7.69333 | .67644 | -9.57145 | -5.81522 |
| | Equal variances not assumed | | | -11.373 | 2.114 | .006 | -7.69333 | .67644 | -10.45862 | -4.92805 |

| Independent Samples Test | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
| | | F | Sig. | t | Df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | 95% Confidence Interval of the Difference | |
| | | | | | | | | | Lower | Upper |
| VAR00002 | Equal variances assumed | .068 | .191 | -8.533 | 4 | .001 | -41.08667 | 4.81530 | -54.45608 | -27.71725 |
| | Equal variances not assumed | | | -8.533 | 3.973 | .001 | -41.08667 | 4.81530 | -54.49161 | -27.68172 |

**Appendix 2. T-Test showing the level of significance in terms of difference in average weight gain for three (3) days interval during experimental period between $T_1$ and $T_2$**

| Independent Samples Test | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
| | | F | Sig. | t | Df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | 95% Confidence Interval of the Difference | |
| | | | | | | | | | Lower | Upper |
| VAR00001 | Equal variances assumed | 5.657 | .980 | -4.282 | 4 | .013 | -11.93000 | 2.78583 | -19.66471 | -4.19529 |
| | Equal variances not assumed | | | -4.282 | 2.006 | .050 | -11.93000 | 2.78583 | -23.88094 | .02094 |

**Independent Samples Test**

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | 95% Confidence Interval of the Difference | |
| | | | | | | | | | Lower | Upper |
| VAR00002 | Equal variances assumed | 2.520 | .120 | -10.752 | 4 | .000 | -14.59000 | 1.35698 | -18.35757 | -10.82243 |
| | Equal variances not assumed | | | -10.752 | 2.158 | .007 | -14.59000 | 1.35698 | -20.03834 | -9.14166 |

**Independent Samples Test**

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | 95% Confidence Interval of the Difference | |
| | | | | | | | | | Lower | Upper |
| VAR00003 | Equal variances assumed | 6.806 | .940 | -9.463 | 4 | .001 | -16.22000 | 1.71413 | -20.97918 | -11.46082 |
| | Equal variances not assumed | | | -9.463 | 2.283 | .007 | -16.22000 | 1.71413 | -22.78403 | -9.65597 |

**Independent Samples Test**

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | 95% Confidence Interval of the Difference | |
| | | | | | | | | | Lower | Upper |
| VAR00004 | Equal variances assumed | 3.378 | .924 | -12.470 | 4 | .000 | -15.81333 | 1.26810 | -19.33416 | -12.29251 |
| | Equal variances not assumed | | | -12.470 | 2.610 | .002 | -15.81333 | 1.26810 | -20.21232 | -11.41435 |

**Independent Samples Test**

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | **F** | **Sig.** | **t** | **df** | **Sig. (2-tailed)** | **Mean Difference** | **Std. Error Difference** | **95% Confidence Interval of the Difference** | |
| | | | | | | | | | Lower | Upper |
| VAR00005 | Equal variances assumed | 6.770 | .855 | -8.613 | 4 | .001 | -21.02667 | 2.44135 | -27.80495 | -14.24838 |
| | Equal variances not assumed | | | -8.613 | 2.262 | .009 | -21.02667 | 2.44135 | -30.44696 | -11.60637 |

**Independent Samples Test**

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | **F** | **Sig.** | **t** | **df** | **Sig. (2-tailed)** | **Mean Difference** | **Std. Error Difference** | **95% Confidence Interval of the Difference** | |
| | | | | | | | | | Lower | Upper |
| VAR00006 | Equal variances assumed | 13.220 | .154 | -7.226 | 4 | .002 | -22.51667 | 3.11627 | -31.16881 | -13.86453 |
| | Equal variances not assumed | | | -7.226 | 2.021 | .018 | -22.51667 | 3.11627 | -35.79126 | -9.24208 |

**Independent Samples Test**

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | **F** | **Sig.** | **t** | **df** | **Sig. (2-tailed)** | **Mean Difference** | **Std. Error Difference** | **95% Confidence Interval of the Difference** | |
| | | | | | | | | | Lower | Upper |
| VAR00007 | Equal variances assumed | 15.087 | .133 | -5.589 | 4 | .005 | -28.13667 | 5.03406 | -42.11344 | -14.15989 |
| | Equal variances not assumed | | | -5.589 | 2.004 | .030 | -28.13667 | 5.03406 | -49.75783 | -6.51551 |

**Independent Samples Test**

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | **F** | **Sig.** | **t** | **df** | **Sig. (2-tailed)** | **Mean Difference** | **Std. Error Difference** | **95% Confidence Interval of the Difference** | |
| | | | | | | | | | Lower | Upper |
| VAR00008 | Equal variances assumed | 5.392 | .158 | -4.182 | 4 | .014 | -35.71333 | 8.53954 | -59.42289 | -12.00377 |
| | Equal variances not assumed | | | -4.182 | 2.027 | .051 | -35.71333 | 8.53954 | -71.98654 | .55987 |

**Independent Samples Test**

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | **F** | **Sig.** | **t** | **df** | **Sig. (2-tailed)** | **Mean Difference** | **Std. Error Difference** | **95% Confidence Interval of the Difference** | |
| | | | | | | | | | Lower | Upper |
| VAR00009 | Equal variances assumed | 9.344 | .649 | -6.606 | 4 | .003 | -43.32333 | 6.55809 | -61.53150 | -25.11517 |
| | Equal variances not assumed | | | -6.606 | 2.171 | .018 | -43.32333 | 6.55809 | -69.51496 | -17.13170 |

**Independent Samples Test**

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | **F** | **Sig.** | **t** | **df** | **Sig. (2-tailed)** | **Mean Difference** | **Std. Error Difference** | **95% Confidence Interval of the Difference** | |
| | | | | | | | | | Lower | Upper |
| VAR00010 | Equal variances assumed | 12.687 | .396 | -13.532 | 4 | .000 | -55.83667 | 4.12634 | -67.29323 | -44.38010 |
| | Equal variances not assumed | | | -13.532 | 2.027 | .005 | -55.83667 | 4.12634 | -73.36286 | -38.31047 |

**Independent Samples Test**

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | 95% Confidence Interval of the Difference | |
| | | | | | | | | | Lower | Upper |
| VAR00011 | Equal variances assumed | 6.361 | .057 | -19.800 | 4 | .000 | -62.04000 | 3.13335 | -70.73956 | -53.34044 |
| | Equal variances not assumed | | | -19.800 | 2.148 | .002 | -62.04000 | 3.13335 | -74.66874 | -49.41126 |

**Independent Samples Test**

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | 95% Confidence Interval of the Difference | |
| | | | | | | | | | Lower | Upper |
| VAR00012 | Equal variances assumed | 11.093 | .087 | -7.714 | 4 | .002 | -52.72333 | 6.83453 | -71.69904 | -33.74763 |
| | Equal variances not assumed | | | -7.714 | 2.099 | .014 | -52.72333 | 6.83453 | -80.84479 | -24.60188 |

**Independent Samples Test**

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | 95% Confidence Interval of the Difference | |
| | | | | | | | | | Lower | Upper |
| VAR00013 | Equal variances assumed | 4.656 | .763 | -7.730 | 4 | .002 | -60.08667 | 7.77283 | -81.66751 | -38.50582 |
| | Equal variances not assumed | | | -7.730 | 2.527 | .008 | -60.08667 | 7.77283 | -87.66411 | -32.50922 |

**Independent Samples Test**

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | 95% Confidence Interval of the Difference | |
| | | | | | | | | | Lower | Upper |
| VAR00014 | Equal variances assumed | 7.083 | .745 | -9.675 | 4 | .001 | -63.68667 | 6.58265 | -81.96303 | -45.41030 |
| | Equal variances not assumed | | | -9.675 | 2.345 | .006 | -63.68667 | 6.58265 | -88.37131 | -39.00202 |

**Independent Samples Test**

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | 95% Confidence Interval of the Difference | |
| | | | | | | | | | Lower | Upper |
| VAR00015 | Equal variances assumed | 3.373 | .861 | -9.295 | 4 | .001 | -66.45000 | 7.14933 | -86.29972 | -46.60028 |
| | Equal variances not assumed | | | -9.295 | 2.507 | .005 | -66.45000 | 7.14933 | -91.95284 | -40.94716 |

**Independent Samples Test**

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | 95% Confidence Interval of the Difference | |
| | | | | | | | | | Lower | Upper |
| VAR00016 | Equal variances assumed | 1.430 | .777 | -8.391 | 4 | .001 | -64.45000 | 7.68075 | -85.77517 | -43.12483 |
| | Equal variances not assumed | | | -8.391 | 2.587 | .006 | -64.45000 | 7.68075 | -91.25960 | -37.64040 |

**Independent Samples Test**

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | 95% Confidence Interval of the Difference | |
| | | | | | | | | | Lower | Upper |
| VAR00017 | Equal variances assumed | 2.512 | .351 | -16.316 | 4 | .000 | -59.60333 | 3.65302 | -69.74575 | -49.46092 |
| | Equal variances not assumed | | | -16.316 | 2.748 | .001 | -59.60333 | 3.65302 | -71.85574 | -47.35093 |

**Independent Samples Test**

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | 95% Confidence Interval of the Difference | |
| | | | | | | | | | Lower | Upper |
| VAR00018 | Equal variances assumed | .886 | .845 | -15.385 | 4 | .000 | -54.48333 | 3.54138 | -64.31579 | -44.65088 |
| | Equal variances not assumed | | | -15.385 | 3.595 | .000 | -54.48333 | 3.54138 | -64.76871 | -44.19795 |

**Independent Samples Test**

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | 95% Confidence Interval of the Difference | |
| | | | | | | | | | Lower | Upper |
| VAR00019 | Equal variances assumed | .318 | .184 | -9.459 | 4 | .001 | -49.16667 | 5.19763 | -63.59759 | -34.73574 |
| | Equal variances not assumed | | | -9.459 | 3.757 | .001 | -49.16667 | 5.19763 | -63.97324 | -34.36009 |

| Independent Samples Test | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | **Levene's Test for Equality of Variances** | | **t-test for Equality of Means** | | | | | | |
| | | **F** | **Sig.** | **t** | **df** | **Sig. (2-tailed)** | **Mean Difference** | **Std. Error Difference** | **95% Confidence Interval of the Difference** | |
| | | | | | | | | | Lower | Upper |
| VAR00020 | Equal variances assumed | .068 | .066 | -8.533 | 4 | .001 | -41.08667 | 4.81530 | -54.45608 | -27.71725 |
| | Equal variances not assumed | | | -8.533 | 3.973 | .001 | -41.08667 | 4.81530 | -54.49161 | -27.68172 |

**Appendix 3. T-Test showing the level of significance in terms of difference in average specific growth rate (SGR) for the three (3) days interval during experimental period between $T_1$ and $T_2$**

| Independent Samples Test | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | **Levene's Test for Equality of Variances** | | **t-test for Equality of Means** | | | | | | |
| | | **F** | **Sig.** | **t** | **df** | **Sig. (2-tailed)** | **Mean Difference** | **Std. Error Difference** | **95% Confidence Interval of the Difference** | |
| | | | | | | | | | **Lower** | **Upper** |
| VAR00001 | Equal variances assumed | 4.507 | .362 | -1.878 | 4 | .134 | -6.03667 | 3.21362 | -14.95910 | 2.88577 |
| | Equal variances not assumed | | | -1.878 | 2.019 | .200 | -6.03667 | 3.21362 | -19.74053 | 7.66720 |

| Independent Samples Test | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | **Levene's Test for Equality of Variances** | | **t-test for Equality of Means** | | | | | | |
| | | **F** | **Sig.** | **t** | **df** | **Sig. (2-tailed)** | **Mean Difference** | **Std. Error Difference** | **95% Confidence Interval of the Difference** | |
| | | | | | | | | | Lower | Upper |
| VAR00002 | Equal variances assumed | .963 | .137 | -.924 | 4 | .408 | -2.89667 | 3.13515 | -11.60123 | 5.80790 |
| | Equal variances not assumed | | | -.924 | 2.996 | .424 | -2.89667 | 3.13515 | -12.88235 | 7.08901 |

**Independent Samples Test**

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | **F** | **Sig.** | **t** | **df** | **Sig. (2-tailed)** | **Mean Difference** | **Std. Error Difference** | **95% Confidence Interval of the Difference** | |
| | | | | | | | | | Lower | Upper |
| VAR00003 | Equal variances assumed | .000 | .320 | -.527 | 4 | .626 | -.68000 | 1.29124 | -4.26504 | 2.90504 |
| | Equal variances not assumed | | | -.527 | 3.953 | .627 | -.68000 | 1.29124 | -4.28179 | 2.92179 |

**Independent Samples Test**

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | **F** | **Sig.** | **t** | **df** | **Sig. (2-tailed)** | **Mean Difference** | **Std. Error Difference** | **95% Confidence Interval of the Difference** | |
| | | | | | | | | | Lower | Upper |
| VAR00004 | Equal variances assumed | 1.818 | .553 | 2.236 | 4 | .089 | 4.28000 | 1.91402 | -1.03418 | 9.59418 |
| | Equal variances not assumed | | | 2.236 | 2.761 | .119 | 4.28000 | 1.91402 | -2.12126 | 10.68126 |

**Independent Samples Test**

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | **F** | **Sig.** | **t** | **df** | **Sig. (2-tailed)** | **Mean Difference** | **Std. Error Difference** | **95% Confidence Interval of the Difference** | |
| | | | | | | | | | Lower | Upper |
| VAR00005 | Equal variances assumed | 2.622 | .686 | -1.981 | 4 | .119 | -2.88667 | 1.45706 | -6.93211 | 1.15878 |
| | Equal variances not assumed | | | -1.981 | 2.109 | .179 | -2.88667 | 1.45706 | -8.85564 | 3.08230 |

**Independent Samples Test**

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | 95% Confidence Interval of the Difference | |
| | | | | | | | | | Lower | Upper |
| VAR00006 | Equal variances assumed | 2.086 | .491 | .751 | 4 | .494 | .93333 | 1.24241 | -2.51614 | 4.38281 |
| | Equal variances not assumed | | | .751 | 2.801 | .511 | .93333 | 1.24241 | -3.18474 | 5.05140 |

**Independent Samples Test**

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | 95% Confidence Interval of the Difference | |
| | | | | | | | | | Lower | Upper |
| VAR00007 | Equal variances assumed | 4.919 | .251 | -3.160 | 4 | .034 | -3.37000 | 1.06640 | -6.33079 | -.40921 |
| | Equal variances not assumed | | | -3.160 | 2.441 | .067 | -3.37000 | 1.06640 | -7.24918 | .50918 |

**Independent Samples Test**

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | 95% Confidence Interval of the Difference | |
| | | | | | | | | | Lower | Upper |
| VAR00008 | Equal variances assumed | 3.026 | .243 | 1.356 | 4 | .247 | 3.37667 | 2.49046 | -3.53795 | 10.29128 |
| | Equal variances not assumed | | | 1.356 | 2.719 | .277 | 3.37667 | 2.49046 | -5.03312 | 11.78646 |

**Independent Samples Test**

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | **F** | **Sig.** | **t** | **df** | **Sig. (2-tailed)** | **Mean Difference** | **Std. Error Difference** | **95% Confidence Interval of the Difference** | |
| | | | | | | | | | Lower | Upper |
| VAR00009 | Equal variances assumed | .383 | .210 | -.006 | 4 | .995 | -.02333 | 3.77299 | -10.49883 | 10.45216 |
| | Equal variances not assumed | | | -.006 | 3.721 | .995 | -.02333 | 3.77299 | -10.81538 | 10.76871 |

**Independent Samples Test**

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | **F** | **Sig.** | **t** | **df** | **Sig. (2-tailed)** | **Mean Difference** | **Std. Error Difference** | **95% Confidence Interval of the Difference** | |
| | | | | | | | | | Lower | Upper |
| VAR00010 | Equal variances assumed | .647 | .064 | -1.692 | 4 | .166 | -1.18667 | .70136 | -3.13396 | .76063 |
| | Equal variances not assumed | | | -1.692 | 3.692 | .172 | -1.18667 | .70136 | -3.19962 | .82628 |

**Independent Samples Test**

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | **F** | **Sig.** | **t** | **df** | **Sig. (2-tailed)** | **Mean Difference** | **Std. Error Difference** | **95% Confidence Interval of the Difference** | |
| | | | | | | | | | Lower | Upper |
| VAR00011 | Equal variances assumed | .268 | .458 | .939 | 4 | .401 | 1.60000 | 1.70350 | -3.12968 | 6.32968 |
| | Equal variances not assumed | | | .939 | 3.907 | .402 | 1.60000 | 1.70350 | -3.17457 | 6.37457 |

**Independent Samples Test**

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | 95% Confidence Interval of the Difference | |
| | | | | | | | | | Lower | Upper |
| VAR00012 | Equal variances assumed | .142 | .665 | 1.371 | 4 | .242 | 1.11333 | .81214 | -1.14154 | 3.36821 |
| | Equal variances not assumed | | | 1.371 | 3.615 | .249 | 1.11333 | .81214 | -1.23960 | 3.46627 |

**Independent Samples Test**

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | 95% Confidence Interval of the Difference | |
| | | | | | | | | | Lower | Upper |
| VAR00013 | Equal variances assumed | 9.203 | .580 | .926 | 4 | .407 | 3.87667 | 4.18668 | -7.74743 | 15.50076 |
| | Equal variances not assumed | | | .926 | 2.122 | .447 | 3.87667 | 4.18668 | -13.18224 | 20.93558 |

**Independent Samples Test**

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | 95% Confidence Interval of the Difference | |
| | | | | | | | | | Lower | Upper |
| VAR00014 | Equal variances assumed | 4.730 | .563 | .968 | 4 | .388 | 1.38667 | 1.43306 | -2.59214 | 5.36547 |
| | Equal variances not assumed | | | .968 | 2.308 | .423 | 1.38667 | 1.43306 | -4.05375 | 6.82708 |

**Independent Samples Test**

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | **F** | **Sig.** | **t** | **df** | **Sig. (2-tailed)** | **Mean Difference** | **Std. Error Difference** | **95% Confidence Interval of the Difference** | |
| | | | | | | | | | Lower | Upper |
| VAR00015 | Equal variances assumed | 3.508 | .549 | 1.761 | 4 | .153 | 1.86000 | 1.05638 | -1.07297 | 4.79297 |
| | Equal variances not assumed | | | 1.761 | 2.787 | .183 | 1.86000 | 1.05638 | -1.65186 | 5.37186 |

**Independent Samples Test**

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | **F** | **Sig.** | **t** | **df** | **Sig. (2-tailed)** | **Mean Difference** | **Std. Error Difference** | **95% Confidence Interval of the Difference** | |
| | | | | | | | | | Lower | Upper |
| VAR00016 | Equal variances assumed | 6.214 | .552 | 3.011 | 4 | .040 | 2.88000 | .95653 | .22424 | 5.53576 |
| | Equal variances not assumed | | | 3.011 | 2.384 | .076 | 2.88000 | .95653 | -.66140 | 6.42140 |

**Independent Samples Test**

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | **F** | **Sig.** | **t** | **df** | **Sig. (2-tailed)** | **Mean Difference** | **Std. Error Difference** | **95% Confidence Interval of the Difference** | |
| | | | | | | | | | Lower | Upper |
| VAR00017 | Equal variances assumed | 6.524 | .067 | 1.742 | 4 | .157 | 3.50667 | 2.01334 | -2.08327 | 9.09661 |
| | Equal variances not assumed | | | 1.742 | 2.126 | .216 | 3.50667 | 2.01334 | -4.68135 | 11.69468 |

**Independent Samples Test**

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | 95% Confidence Interval of the Difference | |
| | | | | | | | | | Lower | Upper |
| VAR00018 | Equal variances assumed | 3.083 | .914 | 3.004 | 4 | .040 | 2.77333 | .92328 | .20990 | 5.33677 |
| | Equal variances not assumed | | | 3.004 | 2.155 | .087 | 2.77333 | .92328 | -.93785 | 6.48451 |

**Independent Samples Test**

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | 95% Confidence Interval of the Difference | |
| | | | | | | | | | Lower | Upper |
| VAR00019 | Equal variances assumed | .000 | 0.854 | 5.261 | 4 | .006 | 2.38667 | .45368 | 1.12706 | 3.64627 |
| | Equal variances not assumed | | | 5.261 | 3.991 | .006 | 2.38667 | .45368 | 1.12596 | 3.64737 |

**Independent Samples Test**

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | 95% Confidence Interval of the Difference | |
| | | | | | | | | | Lower | Upper |
| VAR00020 | Equal variances assumed | 1.699 | .944 | 6.884 | 4 | .002 | 2.68333 | .38981 | 1.60103 | 3.76563 |
| | Equal variances not assumed | | | 6.884 | 2.710 | .009 | 2.68333 | .38981 | 1.36404 | 4.00263 |

**Appendix 4. T-Test showing the level of significance in terms of difference in water temperature during experimental period between $T_1$ and $T_2$**

**Independent Samples Test**

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | 95% Confidence Interval of the Difference | |
| | | | | | | | | | Lower | Upper |
| VAR00001 | Equal variances assumed | 1.845 | .175 | 1.399 | 484 | .162 | .20165 | .14409 | -.08148 | .48477 |
| | Equal variances not assumed | | | 1.399 | 478.194 | .162 | .20165 | .14409 | -.08148 | .48478 |

**Independent Samples Test**

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | 95% Confidence Interval of the Difference | |
| | | | | | | | | | Lower | Upper |
| VAR00002 | Equal variances assumed | 2.801 | .095 | 1.367 | 484 | .172 | .19053 | .13939 | -.08334 | .46441 |
| | Equal variances not assumed | | | 1.367 | 473.889 | .172 | .19053 | .13939 | -.08336 | .46443 |

**Appendix 5. T-Test showing the level of significance in terms of difference in dissolved oxygen (DO) during experimental period between $T_1$ and $T_2$**

| Independent Samples Test | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | **Levene's Test for Equality of Variances** | | **t-test for Equality of Means** | | | | | | |
| | | **F** | **Sig.** | **t** | **df** | **Sig. (2-tailed)** | **Mean Difference** | **Std. Error Difference** | **95% Confidence Interval of the Difference** | |
| | | | | | | | | | Lower | Upper |
| VAR00001 | Equal variances assumed | .007 | .934 | 3.424 | 484 | .001 | .27613 | .08065 | .11767 | .43459 |
| | Equal variances not assumed | | | 3.424 | 483.875 | .001 | .27613 | .08065 | .11767 | .43459 |

| Independent Samples Test | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | **Levene's Test for Equality of Variances** | | **t-test for Equality of Means** | | | | | | |
| | | **F** | **Sig.** | **t** | **df** | **Sig. (2-tailed)** | **Mean Difference** | **Std. Error Difference** | **95% Confidence Interval of the Difference** | |
| | | | | | | | | | Lower | Upper |
| VAR00002 | Equal variances assumed | 3.809 | .052 | 4.791 | 484 | .000 | .33185 | .06926 | .19576 | .46795 |
| | Equal variances not assumed | | | 4.791 | 481.814 | .000 | .33185 | .06926 | .19576 | .46795 |



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