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Effect of Feeding Frequency and Water Quality on Growth and Production of Tilapia Fish

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Abstract
Tilapia (Oreochromis niloticus) is one of the most vital fish commercially used nowadays all around the globe. The growth rate of Tilapia increases with an increase in feeding frequency relative to different water quality parameters, having some limitation on feeding frequency as well as feed rate. In the present study, three experiments were conducted in nine cement concrete tanks supplemented with aeration, each experiment was carried out to monitor the growth parameters of tilapia i.e., body weight, length, and girth of cultured fish based on different feeding regimes on a weekly basis. In all experiments, a mixture of boiled rice and mustard oil cake was used as a feed at 3% of fish body weight. A bioenergetics model which signify the variation in growth parameters has derived incorporating various water quality parameters such as ammonia (0.01-0.04mg/L), temperature (23.8-28.1 ◦C), pH (6.12-8.31), dissolved oxygen (6.10-8.61 mg/L or 87.1-101 %), nitrite (0.02-0.05 mg/L) using Hydrolab MS-5.The provided feeding rate per day was once, twice, and thrice in a day with respect to their experimental setups marked as 1,2, and 3. It was observed that tilapia fish grows more rapidly when fish were fed thrice in a day but the maximum percentage of uneaten food was found to be in experiment three compared to others. Whereas, in experiment two the survival percentage was found to be more (71.2%) without wasting any uneaten feed. In addition, the result showed that the feed intake capacity gets reduced as the fish attains maturity.

Keywords: *Aeration, Bioenergetics, Feed frequency, Hydrolab MS5, Model*

1. Introduction

Nile Tilapia (*Oreochromis niloticus*) is one of the most vital fish commercially used nowadays all around the globe. Fish provides around 1/3rd of the animal proteins taken by human beings (Ariño et al., 2013). With the increase in the population of human beings, the necessity for protein is expanding gradually that cannot be fulfilled by birds and animals alone. Fish culturing can play a major role by providing the additional protein supplement which is lacking in the diet. All around 100 countries grow Tilapia *(Oreochromis spp)* fish for commercial purposes (Makori et al., 2017). According to FAO, 2010 report, the worldwide production of Nile Tilapia in 2005 and 2009 was 1.66 million metric tons (MMT) and 2054 MMT respectively and it also mentioned that by 2030 the expected output of Tilapia can reach up to 7.3 million tonnes. Across the world, the Tilapia contributes sustainably to food security programs. In India, the estimated Tilapia fish production in 2017 is 18,000 tons in 2016 (Menaga and Fitzsimmons, 2017), with Andhra Pradesh being the height production that has received major attention from the Product Export Development Authority (MPEDA). As a result, the Tilapia could be considered to be a potentially suitable species for being cultured to meet the growing population's protein requirements and food security needs. Due to certain characteristics such as rapid growth, high disease-resistant, less feed requirement for growth, rapid changes of generation, standing well with environmental conditions, etc., make it one of the most ideal candidates for aquaculture around the world (El-Sayed, 2006). Meanwhile, it carries fertilized eggs and young fish in their mouths for long days i.e., called a mouth breeding species. Tilapia can be integrated into poly culture with shrimp or other fishes providing another cash crop and improving shrimp health reducing bacterial and viral diseases. Tilapia uses 22 to 46% of dietary starch productively whereas 22% is considered an ideal level for juvenile tilapia (Wang et al., 2000). Therefore, the growth of tilapia can be upgraded by utilizing ideal protein, lipid, carbs, and different supplements. Different studies have documented that the growth performance of tilapia fish gets influenced by several parameters including feeding quality, stocking density, water quality, rate and frequency of feed provided, activities of fish, etc. (Abdelghany and Ahmad, 2002; Thodesen (Da-Yong Ma) et al., 2011) in their study of integrated farming of several fishes such as tilapia, common carp, and silver carp found that with an increase in feeding rate the growth performance, body fat, protein content also increased. In addition, the maximum Feed Conversion Ratio (FCR) of cultured fish is attained with desired ration size and feeding frequency (Huntingford et al., 2012; Silva et al., 2012). A necessary (but sometimes overlooked) part of every aquaponic system is the fish. In actuality, the symbiotic connection that distinguishes this technique from others like hydroponics would not exist without the fish. Bacteria transform the waste that the fish make into nutrients that are the ideal food for the plants. Due to this, we decided to talk about the history of tilapia in India today. As early as 1952, Tilapia species were introduced into water systems in India. The fish gained popularity in southern areas like Tamil Nadu and Kerala, but because they reproduce quickly, it was not thought to be a wise decision. As a result, other fish species were displaced, overpopulated, and stunted. At that time, the versatile and swiftly reproducing species had already colonised the whole nation and posed a danger to several ecosystems. The Indian Fisheries Research Committee outlawed tilapia breeding in 1959. In India, a different type of tilapia was introduced in the late 1970s, although its impact was far less profound than that of the first species. According to current estimates, tilapia make about 7% of all fish species in the Ganges river system. Tilapia in India presently show significant potential to feed a nation as the demand for fish rises. Some strains have been successfully produced and offered for sale in Chennai. Other farmers are raising tilapia commercially in waste water in Kolkata's wetlands. Committees are looking into the possibility of importing strains of tilapia in India. Keeping all these in mind an experiment was carried out on the growth of Tilapia cultured in various tanks under the playhouse depending on various feeding regimes. Accordingly, a model was developed to predict the growth of fish.

2. Materials and Methods

2.1.Source of Fish

Juveniles Oreochromis niloticus (mean weight: 4.5 ± 0.8 g) were obtained from Chatla Lake, Silcoorie, Cachar, Assam, India and attuned for a period of seven days after which they were redistributed into nine number of 1000-L tanks. The Experiment was carried out in the Polyhouse of the Department of Agricultural Engineering, Assam University, Silchar, Assam, India. Twenty fish were kept in each tank.

2.2.Feeding of Fish

Fish were randomly distributed into experimental tanks, fed 1, 2, and 3 times a day and the meal times were equally spaced throughout the day from 0800 hr to 1800hr as described in (Table 1). A mixture of rice bran and mustard oil seed cake in the ratio 2:1 were used as a feed which were fed at a feeding rate of 3% of body weight (g/g). The experiment included three feeding frequencies and each treatment was replicated twice in a week. Table 1 Shows Feeding Regime in The Different Setups Over the Experimental Period.

Table 1 Feeding Regime in The Different Setups Over the Experimental Period

Treatment	Feeding Rate	Timing (Hours)
F1D	1	0800
F2D	2	0800, 1800
F3D	3	0800,1300, 1800

Keys:
F1D: Once daily feeding frequency.
F2D: Twice daily feeding frequency.
F3D: Thrice daily feeding frequency.

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Table 2 Water Quality Parameters in the Fish Tanks

	Parameters	NH_4	D.O. (mg/l)	pH	Temp (C)	D.O. (%)	NO_2
Day 1	**SET 1**	0.01	8.02	7.57	26.3	99.4	0.03
	SET 2	0.01	7.75	6.74	26.1	96.9	0.04
	SET 3	0.01	8.61	6.93	25.2	99.5	0.03
Day 8	**SET 1**	0.02	7.80	7.57	27.4	96.9	0.05
	SET 2	0.01	7.50	6.57	27.7	96.5	0.04
	SET 3	0.07	8.03	6.93	27.7	87.1	0.03
Day 15	**SET 1**	0.01	7.12	7.95	27.1	93.2	0.03
	SET 2	0.01	7.93	8.01	27.8	99.8	0.03
	SET 3	0.03	7.55	7.46	6.4	94.1	0.02
Day 22	**SET 1**	0.01	6.12	6.31	24.8	87.6	0.03
	SET 2	0.01	7.88	7.31	25.3	90.1	0.03
	SET 3	0.01	8.15	7.91	25.9	101	0.02

Keys:
SET 1 (SETUP 1): Tanks T1, T2, T3 with F1D.
SET 2 (SETUP 2): Tanks T4, T5, T6 with F2D.
SET 3 (SETUP 3): Tanks T7, T8, T9 with F3D.

3. Experimental Procedure

Feeding was done by small feeding tanks installed in each tank and the rations were adjusted weekly after sampling, based on calculated total weight of the fish in each treatment tank. The weight and total length of individual fish in each treatment tank were taken at the beginning of the experiment. Ten juveniles were randomly selected from each tank on weekly intervals and the length and weight measured. The Water quality parameters were examined with the help of Hydrolab MS5 to obtain any appreciable changes that might have occurred which is not favorable for the Tilapia. The overall mean values of each quality parameters as recorded from different are presented in the Table 2. Water filled up to the top mark of the tank leaving some clearance. Three tanks were collectively taken as one SET (SETUP) based on different feeding rates. In these 3 sets viz. SET 1, SET 2 and SET 3, three experiments were carried out i.e., on weekly basis for better fish growth and less harm to it. For the SET 1 the time of feeding was carried out at 8:00 am i.e. once in a day at morning, SET 2 timings were 8:00 am in morning and 6:00 pm in the evening and for SET 3 was three times in a day i.e. at 8:00 am, 1:00 pm and 6:00 pm. Aeration setup was done with a 2.5 hp. of Air compressor and Aeration stone balls attached to the ends of the Aeration pipes.

3.1. Evaluation of Growth Performance Parameter

Data obtained weekly from the experiment were used to calculate the following growth parameters:

Average weight gain (WG): This is the difference between the final weight at the end of the experiment and initial weight at the beginning of the experiment as indicated in the equation below:

$$\mathbf{WG} = \mathbf{FW - IW} \quad \dots (1)$$

FW = Final average weight (at end of experiment).
IW = Initial average weight (at the beginning of experiment).

Food Conversion Ratio (FCR) This is the ratio of total weight of dry feed given by total weight gain by fish.

Specific growth rate (SGR) (%): This is the percentage of the rate of difference between the natural logarithm of final weight and initial weight of the fish sample with time.

$$\mathbf{SGR} = \frac{ln ln\, w_f - w_i}{T} \times 100\,\% \quad \dots (3)$$

ln = Natural logarithm.
W_f = Average final weight of fish (g).
W_i = Average initial weight of fish (g).

$$\mathbf{FCR} = \frac{Total\ weight\ of\ dry\ feed\ given}{Total\ weight\ gained\ by\ fish} \quad \dots (2)$$

t = Duration of experiment in days.

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Survival Rate (SR) (%): This is the percentage of the total number of fish at the end of the experiment per units of sort number of fish at the beginning of the experiment as shown in the equation below:

$$\textbf{SR (\%)} = \frac{N_1}{N_0} \times 100\ \% \quad ...(4)$$

N_1 = Number of fish at the end of the experiment.
N_0 = Number of fish stocked in the beginning of the experiment.

4. Results and Discussion

4.1. Results

Water quality is crucial for the survival of aquatic life, as any changes can hinder growth or be fatal. Weekly monitoring for around 9 weeks showed significant variations as shown in Figures 1, 2, 3, 4 respectively.

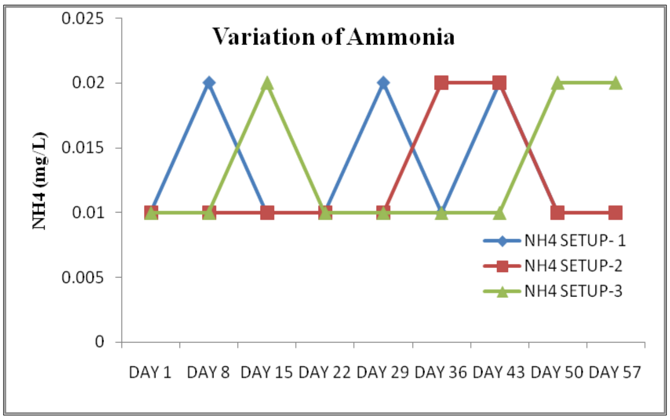

Figure 1 Variation Trend for Nh_4

Variations in parameters like NH_4, dissolved oxygen (D.O.), pH, temperature, and NO_2.Occasionally, NH_4 levels were higher, prompting a 20-30% water replacement with proper aeration to maintain quality.

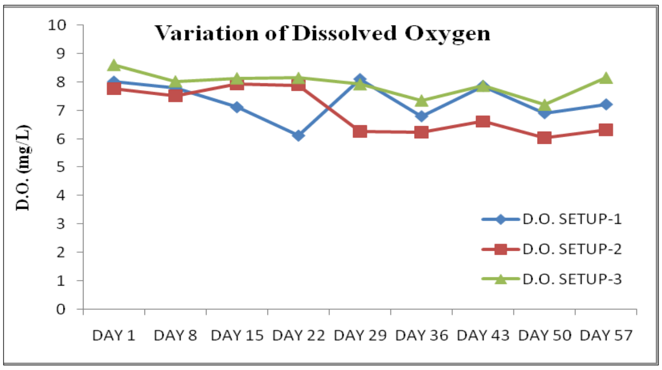

Figure 2 Variation Trend for Do

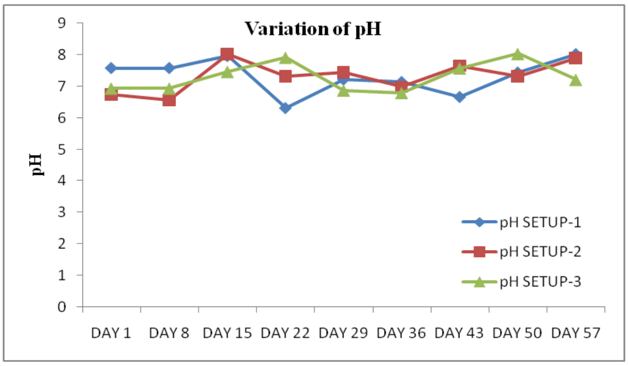

Figure 3 Variation Trend for Ph

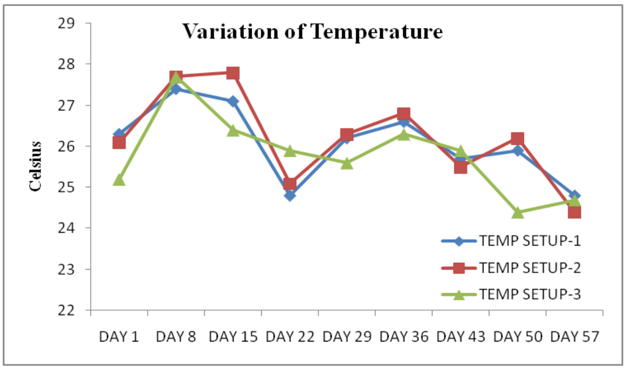

Figure 4 Variation Trend for Temp

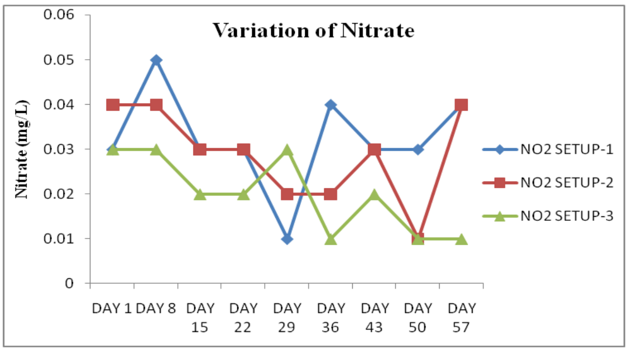

Figure 5 Variation Trend for No_3

Throughout the experiment, ammonia levels remained between 0.01-0.02 mg/l. The recorded ranges for D.O, pH, temperature, and NO_2 were 6.0-9.0 mg/l, 6.0-8.5, 24-28°C, and 0.01-0.05 mg/l, respectively. It has been observed that under cultured tanks Tilapia fish grew fastest with three feedings per day. However, this setup resulted in more uneaten food due to reduced feed intake as the fish matured. Optimal growth requires feeding less than 3% of body weight. As the feeding frequency increases the growth pattern such as weight, length and girth also increase shown in Table 2. The weight gain in SET 3

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was found to be higher. Likewise, no significant differences were found between FCR and weight gain, as these increase with the increase in the diet. Meanwhile, the survival rate was observed to be higher in SET 2 among all experiments. The variation in Length, Girth and weight was recorded Table 3. Table 4 shows Growth Parameters at Different Tanks.

Table 3 Feed Utilization or Requirements at Different Feeding Regimes

	IW (g)	FW (g)	WG (g)	FCR	SR (%)
SET 1	4.7	8.0	3.1	1.2	69.11
SET 2	7.7	11.9	4.2	1.6	71.2
SET 3	7.3	12.1	4.8	2.1	60.89

Table 4 Growth Parameters at Different Tanks

	SET 1			SET 2			SET 3		
	T1	T2	T3	T4	T5	T6	T7	T8	T9
AVG WEIGHT (g)	5.4	3.6	5.7	7.8	10.6	10.6	6.1	7.5	8.3
	6.5	4.9	5.8	9.1	12	12	7.8	9.2	10
	7.7	6.1	6.8	10.5	13.3	13.3	9.4	11	12
	8.9	7.2	7.9	11.9	14.8	14.8	11.3	12.9	14
LENGTH (cm)	5.6	4.8	5.4	6.6	6.5	5.3	6	6.2	5.4
	6.1	5.4	6	7.4	7.3	6.1	7	7.2	6.3
	6.9	6.3	6.9	8.4	8.1	7	7.9	8.1	7.3
	7.7	6.9	7.6	9.1	9	7.7	8.7	9.1	8.2
GIRTH (cm)	4.2	4.1	4.3	4.7	5	4.2	4.6	4.7	4.3
	4.7	4.5	4.7	5.3	5.5	4.7	5.5	5.6	5.3
	5.3	5.1	5.4	6	6.3	5.4	6.5	6.6	6.3
	6.8	6.6	6.1	6.9	7.1	6.3	7.6	7.7	7.4

Discussion

Considering the Feed utilization at different frequency of feed provided along with monitoring of different water quality parameters at cultured tanks it is found that SET 2 has highest survival rate and the weight gain is higher in SET 3. Simulation equation using Trend analysis is carried out to model some growth predicting models or bioenergetics equations for the Tilapia fish cultured in Tanks with supplemental artificial aeration. Figure 6 shows Weight Gain Curve,

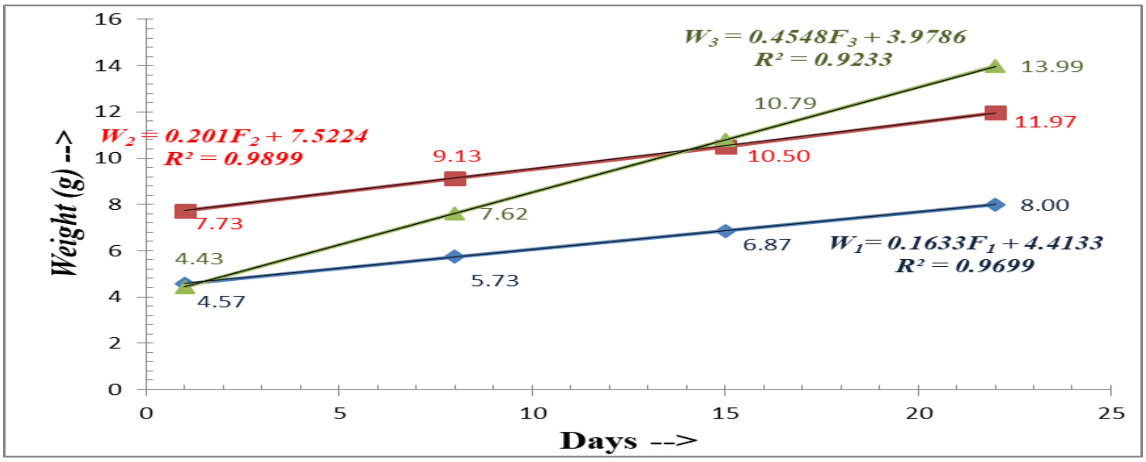

Figure 6 Weight Gain Curve

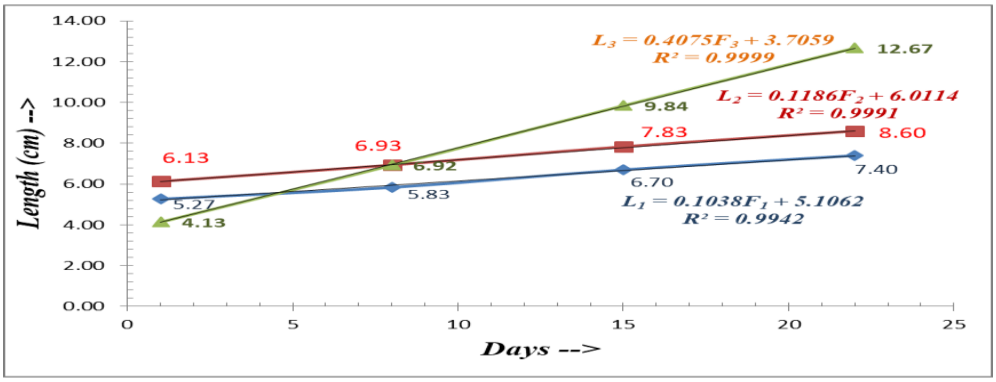

Figure 7 **Length Curve**

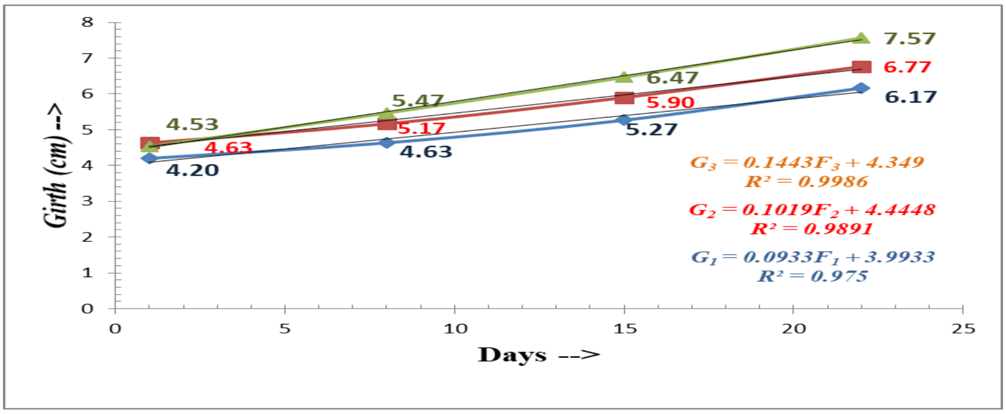

Figure 8 **Girth Curve**

Conclusion

The increase in feeding rate, the growth of fish also increases accordingly, but the desired feed rate will give the optimum growth with the increase in efficiency of the feeding regime by reducing the wastage of feeds. In this study, 150 Tilapia fishes were cultured in 10 oxidation tanks at a density of 10 fishes per tank and their growth parameters were monitored for 20 weeks at varying feeding regimes. In conjunction with the physicochemical water quality parameters like D.O., NH_4, temperature, pH, and NO_3 were also measured since the growth rate of fish was affected by these parameters. Experimentally it was found that feeding rate twice a day results the optimal growth with minimal wastage of feed and the survival rate percentage was highest.

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