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Effect of growth performance and survival of *Oreochromis niloticus* Nile tilapia fish under biofloc system

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Abstract
Biofloc technology is recognized as sustainable, eco-friendly and economical technology for fish and shrimp aquaculture due to its numerous beneficial outcomes such as disease prevention, maintaining water quality and promoting growth. One of the most significant species for aquaculture that has drawn interest from all over the world is tilapia because of its unique qualities, which include its capacity to consume particles, its tolerance for moderate oxygen levels, its high density in captivity and its adaptability to a variety of environmental conditions, this species has been successfully cultivated under biofloc conditions. The present study was aimed to evaluate effect of growth performance and survival of *Oreochromis niloticus* Nile tilapia fish under biofloc system. Sixty day investigation was conducted both with and without biofloc. After a few weeks of all treatments and controls the essential water quality parameters were maintained within an optimal range. The growth parameters were analyzed at end of the experiment after sixty days. Average body weight gain of fish was measured every fourth night. The growth performance of *Oreochromis niloticus* Nile tilapia fish was found better in biofloc treatment compared to control. Protein efficiency ratio, feed efficiency ratio, specific growth ratio, feed conversion ratio and survival percentage was found better in treatment. Hence it can be concluded that Nile tilapia fish is most suitable for culture under biofloc technological system as compared to conventional farming system.

Keywords: *Oreochromis niloticus* Nile tilapia fish, biofloc, growth & survival

1. Introduction

Aquaculture is the world's fastest growing food production sector. It contributes about 49.2% of the world's total food fish production and offers over hundreds of millions of people livelihoods, food and nutrition security. The world total fisheries and aquaculture production was reached a recorded 214 million tonnes in 2020. Of which, aquaculture production was reported 122.6 million tonnes. World per capita fish consumption reached record of 20.2 kg in 2020. (Anon., 2020) [1]. The world's population is rapidly increasing and by 2050, it is expected to exceed 9 billion, requiring food production to be doubled to meet demand. The global supply of nutritionally balanced and high quality protein food to a growing population is a major challenge. Indian aquaculture is rapidly developing toward the goal of achieving the blue transformation and ranking second place in the entire globe.

Being the world's second-most significant species for farming, among farmers, tilapia is extremely popular. Therefore, it is especially important to use new technologies for the cultivation of this species (Menaga *et al.*, 2019) [9]. Nowadays, a higher percentage of *oreochromis* species are farmed in aquaculture than many tilapia species (El-Sayed, 2006) [5]. According to FAO data, 2,666 tonnes of tilapia worth $3.269 million were exported by India overall in 2018. The Production of Tilapia in Indian aquaculture accounts for 30,000 tonnes of the total tilapia production, which is currently estimated to be around 70,000 tonnes. Nile tilapia, *Oreochromis niloticus*, is grown in dense conditions, climatically adapted to allow growth in various regions of the world and highly marketability. This fish has unique qualities, which include its capacity to consume particles, its tolerance for moderate oxygen levels and its high density in captivity and its adaptability to a variety of environmental conditions, this species has been successfully cultivated under biofloc conditions.

The biofloc technology is one effective solution to solve problem of traditional culture system. Biofloc technology mainly works on an efficient use of nutrient input without water exchange. The principle of this technology is to recycle nutrient by maintaining a high carbon/nitrogen (C/N) ratio in the water in order to stimulate heterotrophic bacterial growth which converts ammonia into microbial biomass. Biofloc develops when bacterial biomass combines with other microorganisms and water-suspended particles. Biofloc is subsequently consumed directly by grown fish. Using biofloc technology the feed efficiency and the feed conversion ratio of the fish in biofloc system is better compared to conventional methods. Biofloc can reduce the overall cost of feed while simultaneously enhancing the overall quality of the water, which boosts the growth of the cultured organisms. Therefore need to check the growth and survival of *Oreochromis niloticus* Nile tilapia under the biofloc system.

2. Materials and Methods

The experiment was conducted for sixty days to compare growth performance and survival of *Oreochromis niloticus* Nile tilapia fish under biofloc system. The materials used and methodology adopted for present research work is described as following.

2.1 Experimental Laboratory

The experiment was conducted at Centre of Excellence in Aquaculture, Kamdhenu University, Ukai, Songadh, District Tapi, Gujarat, India. Water used for the culture that collected from bore at Singal khanch village, Songadh. The laboratory work was carried out in the Centre of Excellence in Aquaculture laboratory.

2.2 Biofloc Production

Preclianed FRP tanks (6 numbers) of 150 L capacity water used to prepare for biofloc inoculums. Tanks were filled with water up to 150 L and continuously vigorous aeration was provided by using air blower. The dry pond soil was obtained from department of fisheries Ukai aqua farm of District Tapi and Singal khanch village, Ukai, Songadh. Jaggery procured from jaggery shops was fermented with commercial yeast 24 hour prior to use. The methodology of Avnimelech (1999) [3] was follow for developed floc inoculums by using 20 gm L^{-1} pond soil, 10 mg L^{-1} ammonium sulphate and 200 mg L-1 fermented sugarcane molasses, within 48 hour inoculums were equally transfer in to the experimental tank at the rate of ratio 1:100 (inoculums: water). Carbon source was calculated based on protein contain of feed and quantity of feed used. This was added every twice in week. Amount of carbohydrate requirement (ΔCH) for assimilate ammonium converted in microbial protein was calculated based on following the standard protocol of Avnimelech (1999) [3] and crab *et al.* (2012) [4]. This is slightly modified based on carbon content of molasses and protein content of feed used. We assumed that in calculation using carbohydrate sources has 50% carbon. To remove 1 g concentration of total ammonia nitrogen 20 g of carbohydrate required (ΔCH) to add in this system to maintain carbon: nitrogen ratio of 15:1

$$\Delta CH = (\Delta N)/0.05 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

We assumed 50% of feed nitrogen that ammonium ($\Delta NH4^{+}$) added in to water by extraction and bacterial decomposition of uneaten feed residue.

$$\Delta N = \text{quantity of feed} \times \%\ \text{nitrogen in feed} \times \%\ \text{nitrogen in excretion} \ldots\ldots (2)$$

Therefore equation of 1 and 2

$$\Delta CH = \text{quantity of feed} \times \%\ \text{nitrogen in feed} \times \%\ \text{nitrogen in excretion} / 0.05 \ldots (3)$$

In the beginning experimental phase, fish were fed 8% of average body weight of feed with 32% of protein. So for 1 kg of fish biomass 80 gm (25.6 gm protein) of feed is required. However, 16% of protein in feed was assumed to be converted in to nitrogen therefore, with addition of 1 kg feed, 4.096g of nitrogen will be produced out of which 75% (3.072 g) of nitrogen dissolve in to the water. Thus, 3.06 g of nitrogen is produce from 1 kg of fish after giving 80 g of feed. The C:N ratio was maintained at > 15:1 while adding 37.8 g of organic carbon. After 10 day of culture period feeding rate was reduced up to 3% for that calculation done according to it.

2.3 Experimental Animals

Oreochromis niloticus (Nile tilapia fish) was procured from Centre of Excellence in Aquaculture, Kamdhenu University, Ukai, Sonagadh, District Tapi, Gujarat, India. Fish were acclimatized and nursed with commercial feed for one week day in the 150 L FRP tank. Fish were transferred in to the tank for acclimatization for seven days before the start of research. Only healthy and active fishs of average size 2.28-2.85 gm were stocked in the experimental tank with and without biofloc. The stocking density of fish was maintained at 30 nos 150 liter in tank.

2.4 Experimental setup

The experiment was carried out in square plastic tank of 150 liter capacity. The experiment was set up following a completely randomized design as presented in Table no. 1. Experimental tanks were washed with potassium permanganate solution (5 ppm) and sun-dried before the start of the experiment. Tank water was further disinfected by bleaching powder @ 60 ppm and then supplied with 2 air stone hoses type of diffuser system connected to 0.5 HP blowers for vigorous aeration. Aeration was provided throughout the experimental duration. Zero water exchange system (with intermittent water addition to maintain water volume in all tank) were followed during the whole experimental period of 60 days.

Table 1: Experimental design

Sr. No.	Control	Treatment	Replications
1	Control without biofloc	Treatments with biofloc	Triplicate

2.5 Experimental Diet and Feeding

Animals were fed at the rate of 8% of their body weight during the experiment with commercially available feed (CP) having crude protein 32%, crude fat 6%, fiber 4% and moisture 12%. Feeding frequency was two times a day similar to actual fish farm at 07:00 AM (morning) and 7:00 PM (evening).

2.6 Growth Parameters
Randomly 30% of fish in every tank were sampled fortnightly for the collection of data required for estimation of growth parameters. The weight of animal was measured by using electronic weighing balance. The care was taken while sampling to minimize stress on the animal. Following growth parameters were estimated.

2.6.1 Growth Measurement

$$\text{Average body weight } = \frac{\text{Total body weight of fish}}{\text{Number of fish}}$$

Mean weight increment = Final average body weight – Initial average body weight

2.6.2 Specific Growth Rate (SGR)
SGR (specific growth rate) as a percentage was calculated using the formula given below.

$$\text{SGR } = \frac{\text{Log}_e(\text{Final weight}) - \text{Log}_e\text{ (Initial weight)}}{\text{Number of days}} \text{x100}$$

2.6.3 Food Conversion Ratio (FCR)
FCR is the weight of the food consumed divided by the body weight gain, all over a specified period of time. The FCR (Food Conversation Ratio) was calculated using the following formula:

$$\text{FCR } = \frac{\text{Amount of feed given (g)}}{\text{Body weight gain(Wet weight)(g)}}$$

2.6.4 Feed Efficiency Ratio (FER)

$$\text{FER } = \frac{\text{Body weight gain (wet weight)(g)}}{\text{Feed given(Dry weight)(g)}}$$

2.6.5 Protein Efficiency Ratio (PER)
Protein efficiency ratio is a measure of utilization of dietary protein. PER was estimated using the following formula.

$$\text{PER } = \frac{\text{Body weight gain (g)}}{\text{Protein fed (g)}}$$

2.6.6 Survival
The survival of the fish was estimated using the following formula

$$\text{Survival (\%)} = \frac{\text{No. of fish survived after rearing}}{\text{No. of fish stocked}} \text{x 100}$$

2.7 Statistical analysis
Statistical analysis of different growth and survival were analyzed by one-way analysis of variance (ANOVA) using SPSS VERSION 20.0. Duncan's multiple range tests was used for post hoc comparison of mean ($p<0.05$) between different groups. All the data presented in the text, figures and tables expressed are mean±standard error and statistical significance of the test was set at $p<0.05$.

3. Results
Sixty days experiment was carried out to compare the growth performance and survival of *Oreochromis niloticus* (Nile tilapia fish) rearing under biofloc. Parameters observed and other results obtained during the experimental period are presented following.

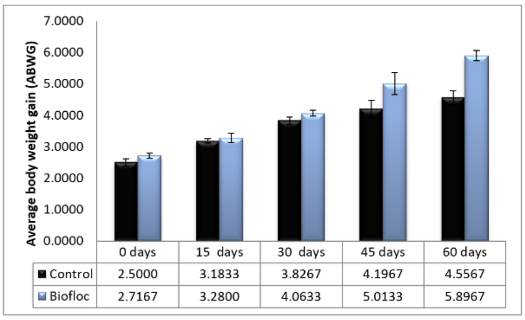
3.1 Growth Parameters
The present study showed better growth performance and yield in biofloc as compared to control. Treatment biofloc showed higher growth performance (ABWG) compared to control. Higher SGR, PER, FER, SGR, Survival and lowest FCR were found in biofloc treatment compared to control. Detailed result and discussion related to growth performance are presented in the following section.

3.1.1 Average Body Weight Gain (ABWG)
Average body weight gain (ABWG) of *Oreochromis niloticus* (Nile tilapia fish) reared under treatments biofloc and control is presented in table-2 and fig 1. *Oreochromis niloticus* (Nile tilapia fish) showed the highest average body weight gain in biofloc treatment (5.8967±0.16180 gm) as compared to control (4.5567±0.23104 gm). In this research trial Average body weight gain (ABWG) of fish was observed increasing trend in control and biofloc treatment during the experimental period. There was significant different ($p<0.05$) was observed in biofloc treatment as compared control. Better growth of fish in treatment as compared control to may be attributed due to under biofloc.

Table 2: Average body weight gain (ABWG) during the culture period

	0 days	15 days	30 days	45 days	60 days
Control	2.5000±0.11719	3.1833±0.06360	3.8267±0.11695	4.1967±0.26585	4.5567±0.23104
Biofloc	2.7167±0.08819	3.2800±0.14799	4.0633±0.09939	5.0133±0.35177	5.8967±0.16180

*Values are presented as mean ± SE



*Values are presented as mean ± SE

Fig 1: Average body weight gain (ABWG) during the culture period

3.1.1.1 Growth Performance

Growth performance and survival of *Oreochromis niloticus* (Nile tilapia fish) control and biofloc treatment during experimental trial.

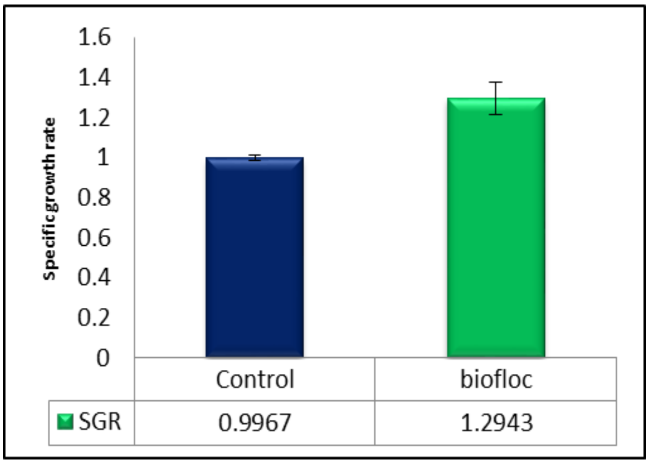
Table 3: SGR, FCR, FER, PER and Survival during the culture period

	SGR	FCR	FER	PER	Survival (%)
Control	0.9967±0.01313	9.7830±1.51355	0.1080±0.01982	0.3386±0.06193	75.5556±1.11111
Biofloc	1.2913±0.08314	5.5103±0.33998	0.1829±0.01142	0.5715±0.03568	84.4444±1.11111

*Values are presented as mean ± SE

3.1.2 Specific Growth Rate (SGR)

SGR of *Oreochromis niloticus* (Nile tilapia fish) observed in treatments and control are presented in table-3 and fig.2. The highest SGR recorded was in biofloc treatment (1.2913±0.08314) and control (0.9967±0.01313) during end of experiment. There is significant different ($p<0.05$) was found in biofloc treatment in compared to control at the end of the experiment specific growth rate during the research trial.

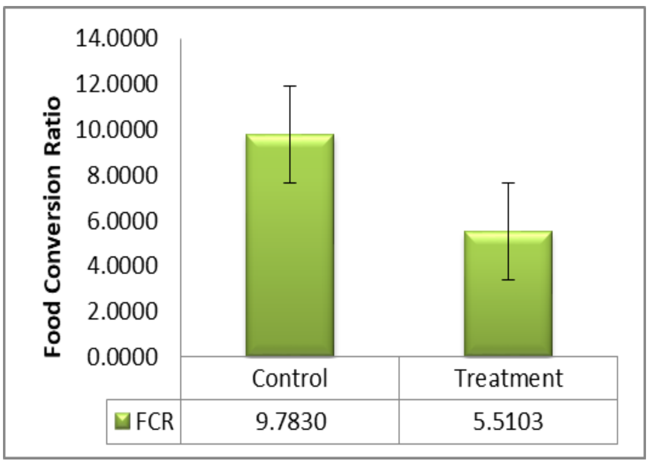


*Values are presented as mean ± SE

Fig 2: Specific growth rate during the culture period

3.1.3 Feed Conversion Ratio (FCR)

FCR of *Oreochromis niloticus* (Nile tilapia fish) observed in treatments biofloc and control are presented in table-3 and fig. 3. Lowest FCR was found in biofloc treatment (5.5103±0.33998) as compared to control (9.7830±1.51355). There is significant different ($p<0.05$) was found in biofloc treatment compared to control at the end of the experiment feed conversion ratio during the research trial.

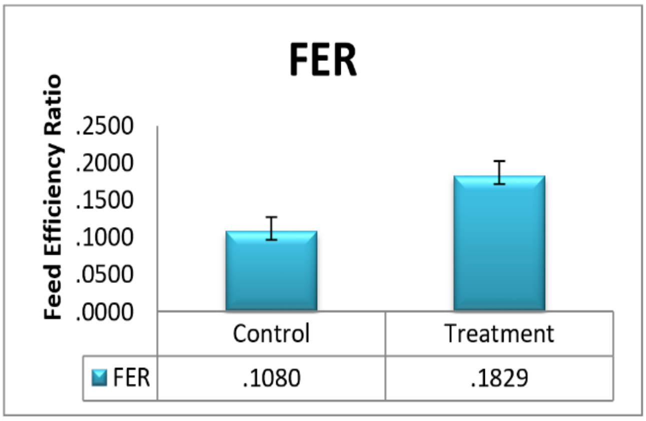


*Values are presented as mean ± SE

Fig 3: Food Conversion Ratio during the culture period

3.1.4 Feed Efficiency Ratio (FER)

FER of *Oreochromis niloticus* (Nile tilapia fish) observed in treatments and control are presented in table-3 and fig.4. It was observed that FER is maximum (0.1829±0.01142) in biofloc and control (0.1080±0.01982). There is significant different ($p<0.05$) was found in biofloc treatment compared to control at the end of the experiment feed efficiency ratio during the research trial.

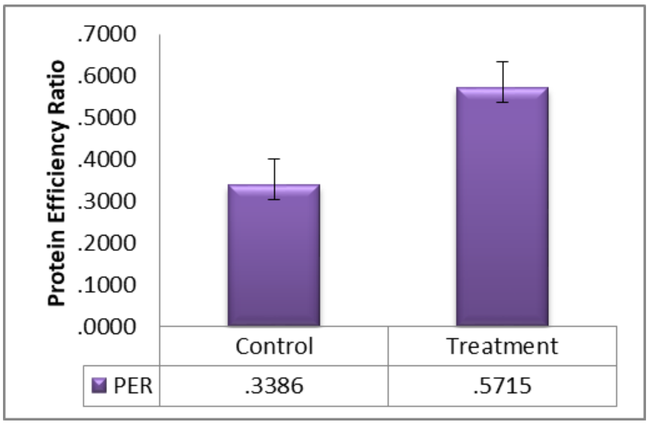


*Values are presented as mean ± SE

Fig 4: Feed Efficiency Ratio during the culture period.

3.1.5 Protein Efficiency Ratio (PER)

PER of *Oreochromis niloticus* (Nile tilapia fish) observed in treatments and control are presented in table-3 and fig.5. It was observed that PER is maximum (0.5715±0.03568) in biofloc treatment and in control (0.3386±0.06193). In the present study, PER was maximum in treatment with biofloc and minimum in control. There is significant different ($p<0.05$) was found in biofloc treatment compared to control at the end of the experiment protien efficiency ratio during the research trial.

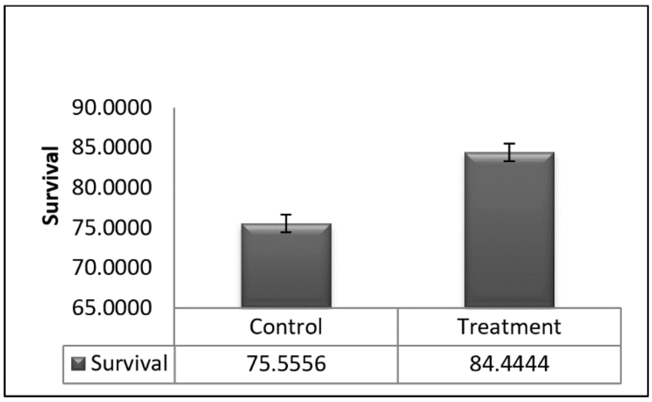


*Values are presented as mean ± SE

Fig 6: Protein Efficiency Ratio during the culture period

3.1.6 Survival

Survival of *Oreochromis niloticus* (Nile tilapia fish) observed in treatments and control are presented in table-3 and fig.7. Survival of *Oreochromis niloticus* (Nile tilapia fish) at the end of the experiment was maximum in biofloc (84.4444±1.11111) and lowest in the control (75.5556±1.11111). In the present study maximum survival rate was 84.44% in the with biofloc treatment higher than 75.55% control. There is significant different (p<0.05) was found in biofloc treatment compared to control at the end of the experiment survival during the research trial.



*Values are presented as mean ± SE

Fig 7: Survival during the culture period

4. Discussion

Growth performance of Nile tilapia fish was significance difference in the biofloc treatments (p<0.05) exhibited higher growth and control exhibited low growth performances. This may be explained by the fact that the biofloc that is produced is a medium that is rich in organic material and contains a high protein level for *O. niloticus*, which improves growth performance and survival for the cultured fish in the system. Biofloc is a natural food source for *O. niloticus* that has a high protein content, which enhances the growth and survival of the cultured fish in the system. The highest average body weight gain was observed in biofloc treatment and lowest average body weight gain observed in control. similar trend was reported by (Hossam M. Hwihy *et al.*, 2021) [6, 7]. The lowest average body weight gain in control treatment and highest average body weight gain in biofloc treatment with *Oreochromis niloticus* (Nile tilapia). The specific growth rate is a good indicator among the different growth parameters used in the aquaculture experiment. Earlier researches on fish and biofloc based system reported that biofloc shows the highest specific growth rate compared to control. The observed specific growth rate of *Oreochromis niloticus* (Nile tilapia) during the study there is significant different (p<0.05) was found in biofloc treatment in compared to control. Similar trend was reported by (Anusha S *et al.*, 2020) [2] biofloc based system reported that biofloc shows the highest specific growth rate compared to control. Food conversion ratio is one of the important parameters which determine the profitability of any culture venture as it measures the amount of biomass produced per kg of feed given. Similar results were earlier reported in (Anusha S *et al.*, 2020) [2] biofloc culture system revealed the lowest FCR was found in biofloc treatment as compared to control. Feed efficiency ratio high found in biofloc treatment compared to control at the end of the experimental research trial. Similar result was observed the better Feed efficiency ratio of *Oreochromis niloticus* (Nile tilapia) in biofloc compared to control (Hwihy H. *et al.*, 2021) [6, 7]. The protein efficiency ratio is a measure to know how efficiently fish can utilize the protein present in the feed (Nalawade and Bhilave, 2011) [10]. Protein is the most expensive ingredient in aqua feed. Excess protein in feed will be wasted which increases the operational cost and inorganic nitrogen load in the pond. In the present study, PER was better found in biofloc treatment compared to control. Similarly, the study conducted by (E. Prabu *et al.*, 2018) [11] on the biofloc culture system revealed the lower protein efficiency ratio of *Oreochromis niloticus* (Nile tilapia) in control compare to biofloc treatment. The present study suggest that biofloc is the most economical and alternative farming practice than the current farming practice. Because in biofloc system floc act as an additional microbial protein feed source and helps in efficient utilization of feed (digestion) which enhance the protein efficiency ratio of the fish and reduce the commercial feed expenses. Survival of *Oreochromis niloticus* (Nile tilapia fish) was found better in biofloc treatment compared to control. Similar results observed in *Oreochromis niloticus* (Nile tilapia fish) Biofloc had shown an increase in growth and higher survival rate compared to control (Kenneth, R. *et al.*, 2018) [8].

5. Conclusions

In conclusion, in nut shell it can said that biofloc based culture is very well suitable for *Oreochromis niloticus* (nile tilapia fish). Nile tilapia fish performance under biofloc was better as compared to control. Hence farmers can be recommended nile tilapia fish culture under biofloc in the pond for a better harvest.

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