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Biofloc Technology in Aquaculture Systems Generates Higher Income in Mono-Sex Nile Tilapia Farming in Bangladesh

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Abstract: An experiment was conducted for six months to demonstrate the suitability of biofloc technology in farming system of mono-sex GIFT tilapia *Oreochromis niloticus*. The experiment was carried out with four treatments and three replicates of each. Three supplemental feeds such as commercial tilapia feed (CF), wheat bran (WB), biofloc technology (BFT) and rice bran + wheat bran (50:50) (RWB)were designated for this experimentation. The stocking density was 125 fingerlings/decimal with a mean initial weight of 2.80±0.03 g of each. Fish were fed at the rate of 6% of fish body weight at the beginning. The feeding rate was gradually reduced to 2% in the third month and finally increased to 3% for rest of the period. After 6 months of rearing, mono-sex GIFT tilapia in CF attained a significantly ($P<0.05$) higher mean final weight (150.61±7.47 g) and specific growth rate (3.32±0.05) than those of WB, BFT and RWB, respectively. However, there was no significant ($P>0.05$) difference in survival rate of fish among the treatments. Although overall production was the highest in CF (3803 kg/acre/6 months) receiving commercial tilapia feed, but the net profit was highest (Tk. 99,453.3/acre/6 months) in BFT receiving periphyton due to the lower cost for the production of periphyton. Based on the results of the study, the use of periphyton as feed is more economically profitable than wheat bran and even commercial tilapia feed for the culture of monosex tilapia in ponds.

Key words: Biofloc Technology · Periphyton · Growth Performance and *Oreochromis niloticus*

INTRODUCTION

The aquaculture industry is increasing rapidly at a rate of 9% per year since the 1970s [1]. But land costs and strong dependence on fishmeal and fish oil is the main impediment forthe expansion of aquaculture [2, 3]. To prepare commercialfeedforaquaculture, such ingredients are one of the prime constituents [4,5]. About 50% expenditure for aquaculture production derive from feed costs, which is predominant due to the cost of protein component in commercial diets [6]. The environmental congenial and cost effective aquaculture system called "Biofloc Technology (BFT)" is considered as an efficient alternative system since nutrients could be continuously recycled and reused. The technologies are supportive for sustainability of aquaculture, cost effective and environmentally sustainable [4,7,8].

Nowadays, BFT are being effectivelypracticed in large-scale shrimp farming in Asia, Latin and Central America, as well as in small-scale greenhouses in USA, South Korea, Brazil, Italy, China and others.The Interest of people towards the closed aquaculture systems is increasing because of having biosecurity, environmental and marketing advantages over conventional extensive and semi-intensive systems [9]. The sustainable approach of such system is based on growth of periphyton in the culture medium, benefited by the minimum or zero water exchange.The heat and fluctuation of temperature is prevented by maintaining minimum water exchange [10]. The biofloc technology has two most important roles: (i) maintenance of water quality which amplifies the natural productivity and (ii) enhancing culture feasibility by nutrition and reducing feed conversion ratio and feed costs. This natural productivity plays a vital role in

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recycling nutrients and maintaining the water quality [9, 11]. Biofloc is consumed by shrimp or fish demonstrating numerous benefits such as improvement of growth rate [8, 12], decrease of FCR and associated costs in feed [13].

The Nile tilapia, *Oreochromis niloticus* (Linnaeus) which is considered as one of the most important species of fish in tropical and sub-tropical aquaculture [1]. It serves as an important sources of animal protein and income throughout the world [14]. Tilapia can grow and reproduce facing a wide range of environmental conditions and tolerate stress induced by handling [3]. The mono-sex male populations of tilapia arewell recognized for increased production potential and low management requirements [15-17]. Today, tilapia has become the shining star of aquaculturewith many farms beginning, which is also popular as 'aquatic chicken' and the rate of consumption has increased across the globe [18]. Annual global production of cultured tilapia has increased continuously in recent years [19]. Since Fish feed accounts for over 50% of the total cost of fish production [20], aquaculturesustainability depends on feed source and management. Consequently, developing nutrition strategies such as bioflocs and periphytonbased culture are initiated to maximize the contribution of natural food which would help to expand aquaculture production.In this regard, this paper communicates the concept and nutritional capacity of biofloc technology based on periphyton production that has contributed to the success of tilapia production in biofloc aided ponds.

MATERIALS AND METHODS

The experiment was conducted in 12 experimental ponds (80 m^2) situated in the Field Laboratory Complex, Patuakhali Science and Technology University for a period of 6 months covering the peak season of culture from March, 2014 to August, 2014.

Experimental Design: The experiment was carried out in completely randomized design (CRD) with four treatments and three replications. Commercial tilapia feed (CF), rice bran (RB), Biofloc technology (BFT) and rice bran + wheat bran (50:50) (RWB)was designated for experimentation. Bamboo pole were set up for ensuring periphytonproduction facilities in biofloc technology in aquaculture system.

Rearing of Tilapia in Ponds: Twelve rectangular shaped experimental ponds (80 m^2) with an average depth of 1.0 m were used for this study. All ponds were prepared by completely drying by draining out the water and then ponds were treated with lime at the rate of 250 kg/acre. After 7 days, the ponds were filled with water. About one month old fingerlings of monosex GIFT tilapia (*O. niloticus*) with mean initial weight of 2.80±0.03 g of each were collected from Reliance Aqua Farm, Trisal, Mymensingh. Each pond was stocked with 250 respective fingerlings of tilapia. Fish were fed at the rate of 6% of fish body weight at the beginning. The feeding rate was gradually reduced to 2% in the third month and finally increased to 3% for rest of the period. The analyzed proximate composition of experimental feeds is shown in Table 1.

Table 1: Proximate composition (% dry matter basis) of the supplemental feeds used in the experiment

	Treatments			
Components	CF	RB	BFT	RWB
Dry matter	88.41	83.38	22.50	85.10
Protein	30.27	14.14	14.44	14.32
Lipid	7.32	18.15	3.45	11.28
Ash	17.98	8.33	27.5	6.78
Crude fiber	14.2	9.44	-	10.12
NFE[1]	30.23	49.94	-	57.50

[1]NFE: Nitrogen free extract was estimated on a dry weight basis by subtracting the percentages of crude protein, lipids, crude fibre and ash from 100%.

RESULTS AND DISCUSSION

Water Quality Parameters: The values of water quality parameters such as water temperature, dissolved oxygen, pH and transparency in different treatments are shown in Table 2. The mean values of water temperature in different treatments were 23.33±1.04, 23.21±1.06, 23.10±1.03 and 23.15±1.03°C in CF, WB, BFT andRWB,respectively (Table 2). The highest (29.91°C) and lowest (17.86°C) water temperature in the present study might be due to the bright sunshine and cold weather.The amount of dissolved oxygen in the water is directly influenced by temperature[21] and also affects metabolism in bothmicrobial community and the cultured species, which determines fish growth aspects [21]. InBFT set ups, an intermediate water temperature of 20-25°C could be best to obtain stable flocs proposed by Craig and Helfrich [20]. Tilapia (*O. niloticus*) did not grow at temperature below 16°C and did not survive at temperature below 10°C for more than a few days [3]. In the present study, the day temperature in the ponds did not fall below 17.86°C and fish probably did not stop eating.

Dissolved oxygen (DO) varied from 4.25 to 6.10 mg/l with mean values of 5.18±0.17, 5.05±0.16, 4.83±0.17 and 4.92±0.19 mg/l in CF, WB, BFT and RWB, respectively

Table 2: Mean values (±SE) of water quality parameters observed throughout the study period

Water quality parameters	CF	WB	BFT	RWB
Temperature (°C)	23.33±1.04	23.21±1.06	23.10±1.03	23.15±1.03
Dissolved oxygen (mg/l)	5.18±0.17	5.05±0.16	4.83±0.17	4.92±0.19
pH	7.00±0.03	7.06±0.04	7.10±0.05	7.08±0.05
Transparency (cm)	34.24±0.25	29.86±0.01	26.06±0.39	31.06±0.30

Values are mean ± standard error, CF: commercial feed, WB: wheat bran, BFT: biofloc technology, RWB: rice and wheat bran

Table 3: Growth performances of mono-sex tilapia (*O. niloticus*) during the study period

Parameters	CF	WB	BFT	RWB
Mean initial weight (g)	$2.80^{a1} \pm 0.03$	$2.80^{a} \pm 0.03$	$2.80^{a} \pm 0.03$	$2.80^{a} \pm 0.03$
Mean final weight (g)	$150.61^{a} \pm 7.47$	$126.80^{b} \pm 2.84$	$92.34^{b} \pm 3.71$	$122.35^{b} \pm 1.84$
Mean weight gain (g)	$147.81^{a} \pm 7.47$	$124.00^{b} \pm 2.84$	$89.54^{b} \pm 3.71$	$119.54^{b} \pm 1.84$
SGR (% day)	$3.32^{a} \pm 0.05$	$3.18^{b} \pm 0.02$	$3.14^{b} \pm 0.03$	$3.15^{b} \pm 0.02$
FCR	$1.84^{c} \pm 0.04$	$2.07^{b} \pm 0.04$	0.00	$2.09^{b} \pm 0.04$
Survival (%)	$83.33^{a} \pm 6.51$	$81.33^{a} \pm 3.21$	$78.67^{a} \pm 3.06$	$81.00^{a} \pm 3.00$
Production (Kg/decimal)	$15.39^{a} \pm 0.42$	$12.60^{b} \pm 0.30$	$9.67^{b} \pm 0.35$	$12.10^{b} \pm 0.22$
Production (Kg/ha)	$3802.88^{a} \pm 139$	$3112.2^{b} \pm 101$	$2388.5^{b} \pm 117$	$2989.5^{b} \pm 72$

Values in a same row having same superscripts are not significantly different (*P>0.05*)

[22] considered 5.00 to 7.00 mg/l of dissolved oxygen content of water to be fair or good in respect of productivity and water having dissolved oxygen below 5 mg/l to be unproductive. Slightly lower dissolved oxygen was found in the present study but this low dissolved oxygen level did not produce any negative effect since tilapia had high tolerance to low dissolved oxygen levels. The pH values of pond water under different treatments were found to be alkaline and ranged from 6.97 to 7.20 with mean values of 7.0±0.03, 7.06±0.04, 7.10±0.05 and 7.08±0.05 in CF, WB, BFT and RWB, respectively. Notably, scientists concur that changes in pH directly influences the stability of both bioflocs present and cultured fish in the ponds [23].Swingle[23] stated that pH range from 6.5 to 9.0 was suitable for fish culture. The pH is an environmental stressor which has leading effects on physiological functioning of some fishes [22]. It is very difficult to control pH in any given biofloc system [10] probably due to different chemical and biological processes in BFT units.The observed transparency ranged from 24.10 to 36.50 cm (Table 2). In the present study, the transparency of water varied on different sampling dates, which might be due to variations in abundance of plankton. Boyd [21] stated that transparency values of about 15-40 cm were appropriate for fish culture.Moreover, it was investigated that the effectiveness of BFT formaintaining good water quality in over-wintering ponds for tilapia [22].

Growth Performance of Fish: Many authors considered that BFT is a more sustainable and environmentally friendly aquaculture system, which has been tried both at laboratory and commercial scale for various aquaculture species including tilapia [22, 23]. There is general consensus thatthe production performance of tilapia can be enhanced by application of BFT [24,25]. Therefore,information on bioflocparameters and their influencing factors should be important in the development of BFT and aquaculture at large.The feeding habit of tilapia allow for grazing on attachedperiphyton as well as filter feeding on bioflocs suspended in the water column.

Although there was no significant (*P>0.05*) variation among the initial weights of fish, at the end of the rearing period the mean weight gain of monosex GIFT tilapia was the highest in CFreceiving commercial tilapia feed while the growth was the lowest in BFT receiving periphyton (Table 3). There was no significant (*P>0.05*) difference among the mean weight gain of tilapia in WB, BFT and RWB, respectively. Supplemental feeding with formulated commercial diet resulted in the highest growth of *O. niloticus*. Tilapia fed RB and BFT as single ingredient caused weight gain of 124.0 and 118.54 g, respectively. However, fish fed RWB resulted in the intermediate weight gain of fish between WB and BFT. Similar results were also reported by Hossain [26] who had a weight gain of 140.60±2.84 g from over-wintered culture of mono-sex tilapia fed on formulated diet for a period of 6 months. However, the stocking size of fry used by Hossain *et al.* [26] was lower than that used in the present study.

In the present study, specific growth rate (SGR) varied from 3.14 to 3.32. Significantly (*P<0.05*) higher value was obtained in CF receiving commercial tilapia feed. However, there was no significant (*P>0.05*) difference of SGR values in WB, BFT and RWB, respectively. The SGR values obtained in the present study are much higher than those (1.40-1.81) reported by Dan and Little[27]for mono-sex GIFT tilapia fry. The lower SGR reported by Dan and Little [27] might be due to the higher stocking density used compared to that of the present study.

Survival Rate: The number of surviving fish is the most important consideration in BFT culture system of tilapia. The mean survival of fish in different treatments varied from 78.67 to 83.33%. There was no significant (*P>0.05*) differences in survival of fish among the different treatments. The survival rate obtained in the present study was higher than that of 33-54% for mono-sex over-wintered fry as reported by Dan and Little [27]. The higher survival of fish in the present study might be due to the bigger size of fingerlings (2.8 g).

Feed Utilization: The mean values of food conversion ratio (FCR) in different treatments varied from 1.84 to 2.23. Most available fish feeds have a feed conversion ratio (FCR) of 3, therefore to produce 1 kg live weight fish, 1-3 kg dry weight feed is needed [4]. Significantly (*P<0.05*) lower FCR value was obtained in treatment BFT receiving periphyotn. There was no significant (*P<0.05*) difference of FCR values in WB and RWB which were significantly higher than that of BFT. Hossain [26] found FCR value of 1.64±002 for over-wintered culture of mono-sex GIFT tilapia fed on formulated diet. The sustainability of the aquaculture industry cannot be achieved unless progressive reduction of wild fish inputs into fish feed is addressed [4, 28]. So far, nutrition research has concentrated on the replacement of animal protein by plant proteins [28].

Total Fish Production: The biomass of tilapia can be harvested up to 200-300 tons.ha-1 in well managed ponds with BFT [19] *Oreochromis niloticus* tilapia culture could produce an equivalent of 155 ton/ha/crop)in an intensive BFT [24]. The production of mono-sex GIFT tilapia in different treatments were 3802.88±139, 3112.2±101, 2882.5±117 and 2989.5±72 kg/ha/6months in CF, WB, BFT and RWB, respectively. The highest production (3803 kg/ha) was recorded in CF receiving commercial tilapia feed and the lowest production (2883 kg/ha) was obtained in BFT receiving periphyton. There was no significant (*P>0.05*) difference of total production in treatment WB, BFT and RWB receiving rice bran, periphyton and rice bran + wheat bran, respectively. In the present study, supplemental feeding with formulated feeds i.e. commercial tilapia feed resulted in higher growth of *O. niloticus* than supplemental feeding with a single ingredient such as rice bran and wheat bran. The total production (kg/ha/6 months) obtained in the present study is similar to that obtained byHossain *et al*. [26] andDan and Little [27] for over-wintering tilapia fry. In a 50 day study[10] found an average daily growth rate of 0.27-0.29 g per fish for the hybrid tilapia (*O. niloticus x O.aureus*) stocked at a size of 50 and 100 g respectively in biofloc technology of tilapia during winter season.

Economic Analysis: A simple economic analysis was performed to estimate the net profit from this culture operation (Table 4). The net profit generated from the 6 months culture period was calculated as Tk. 48,519.0, 94,749.2, 99,453.3and 71,230.7/acre in CF, WB, BFT and RWB, respectively. The highest net profit of Tk. 99,453.3/acre/6months was obtained in BFT receiving periphyton and the lowest was Tk.48,519.0/acre/6 months in CF receiving commercial tilapia feed (Table 4 and Fig.1).

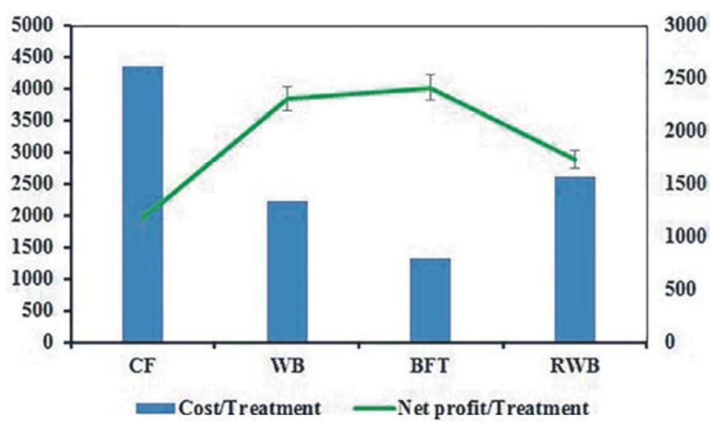

Fig. 1: The cost benefit ratio of mono-sex tilapia farming in Bangladesh for a period of 6 months from March, 2014 to August, 2014.

Table 4: Economic analysis of over-wintered culture of mono-sex tilapia in ponds for 6 months experimentation

Investment (Tk.)	CF	WB	BFT	RWB
Pond preparation	67.500	67.500	67.500	67.500
Cost of fingerlings	750.00	750.00	750.00	750.00
Feed cost	3240.0	1261.0	00	1625.0
Operational cost	304.30	155.88	500.00	183.18
Total cost	4361.8	2234.40	1317.5	2625.70
Production (Kg/ treatment)	92.340	75.600	62.200	72.600
Gross income from sale	5540.40	4536.00	3732.0	4356.0
Net profit/treatment/6months	1178.60	2301.60	2414.5	1730.30
Net profit/ha/6months	48,519.0	94,749.2	99,453.3	71,230.7

Sale price of tilapia = Taka 120.00/ kg.; Operational cost was considered as 7.5% of total cost

In the present study, although overall production was the highest in CF receiving commercial tilapia feed, but the highest net profit was obtained in BFT due to receive periphyton. Some profits were also found in WB and RWBbut these were lower than that of BFT and economically farmers may not get more benefit from WB and RWB. Therefore, the results of the present study suggested that it is possible to successfully culure mono-sex GIFT tilapia with BFT and culture ofmono-sex tilapia using periphyton is more economic and beneficial than wheat bran and even commercial tilapia feed for the culture of mono-sex tilapia in the farming system of Bangladesh.

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