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Economic Viability of Biofloc Based System for the Nursery Rearing of Milkfish (*Chanos chanos*)

Ravindra Sontakke[1*] and Harsha Haridas[2]

[1]*ICAR-Central Institute of Fisheries Education, PanchMarg, Yari Road, Versova, Andheri (W), Mumbai-400061, India*
[2]*ICAR-Central Island Agricultural Research Institute, Garacharama, Port Blair, Andaman and Nicobar Islands 744101*
**Corresponding author*

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A B S T R A C T

Chanos chanos, commonly known as Milkfish is one of the most preferred and cultured brackish water finfish species across Southeast Asia. The major source of seed input is smaller fry collected from wild are sold off in minimum prize whereas fingerling size which can be attained in 1-2 month nursery rearing fetches a better prize. Experiments were conducted to find the growth and survivability of wild caught milk fish fry (5-6cm with 0.9 to 1g size), in clear water and biofloc base indoor culture (1 tonne tank) as well as traditional pond condition (0.02 ha) till the fingerling size (7-8cm with 4-5 g size). In biofloc based system the preferred size was attained after 30 days with 80% of survival whereas it took around 45 days in the clear water culture system and the survival was 52%. Simultaneously in traditional earthen pond the fingerlings were obtained in 30days duration with 56% survivability. The operational cost of the indoor biofloc and clear water system is projected for 0.1 ha area and the economic viability are compared with traditional pond culture for same area. Highest net income (deducting the cost of production from total profit) of Rs. 4,86,015/- was obtained from biofloc based system followed by traditional pond culture (3,32,420/-) with the lowest in the clear water system of Rs. 2,81,123/-. The study shows that the biofloc based nursery rearing of milkfish is economically viable and more profitable to the Clearwater culture system and can be practiced instead of traditional pond culture.

Introduction

The food and agriculture organization (FAO) recently predicted that current level of per-capita consumption of aquatic foods (19.7 kg in 2013, SOFIA, 2016) is necessary to uphold due to the increasing global population. For this, the world would require an additional 23 million tonnes of seafood by 2020. It can be expected that only aquaculture can meet the demand of this additional seafood production, which is estimated to contribute around 93.2 million metric tonnes by 2030 (World fish report 2016). In order to increase aquaculture yields, the country needs additional resources. In addition to the problem of finding the resources, there are many other factors such as increasing operational costs, the high cost of land for culture, the high cost of feed ingredients or commercial feed, production and disposal of waste sludge, discharge of effluent from aquaculture farms hinders the economic success or viability of commercial aquaculture.

In aquaculture, the major cost during the whole production cycle has been contributed by feeding of fish (Eyo, 2003, Akinrotimi *et al.,* 2007). Similarly, about 60-70% of the variable cost involved in the operation were attributed to feed alone which in turn reduced the farmer's profit (Gabriel *et al.,* 2007). Erondu *et al.,* (2006) noted that the principal factor which affects the development and expansion of the aquaculture industry is nothing but the cost of feed. Another major issue raised in today's situation is water scarcity which severely ruins food security and hampers the development of the sector. Almost 70 percent of all water removal were accounted from agriculture which became a significant cause of water scarcity. It was reported that approximately 2,000 to 5,000 liters of water are required to produce the food consumed by one person daily (www.fao.org). These issues can be overcome by increasing the fish biomass per unit area and reducing the use of expensive feed ingredients or high protein feeds.

When fish fed with high protein diets, the nitrogen (appr. 70 %) present in protein is discharged as waste into the surrounding culture water. This waste nitrogen can be incorporated into a functional form by the culture species in biofloc technology. By using biofloc technology as a culture system, two problems can be solved at once, i.e., reduction of protein inputs and elimination of water exchange to maintain water quality. Microbial floc not only helps to improve the environmental control over production by reducing the nitrogen and ammonia from the culture water but also act as nutrient trappers who can be useful in the feed management thereby reducing the feed cost. They are also helpful in enhancing the biosecurity and health. The BFT is achievable by using different types of organic carbon. Utilization of low-value carbohydrates for the production of biofloc can further reduce the cost of production in aquaculture. The use of Biofloc technology in commercial aquaculture is insufficient, and this technique is not yet fully standardized.

Nowadays, milkfish farming becomes a major aquaculture venture in the coastal states of India. As the problem arises in the shrimp industry, the fish farmer gains more interest towards the culture of brackish water fishes like milkfish, mullet, etc. due to their higher prices in the market. Milkfish get a high price of Rs. 150 per kg in the local markets of many coastal states like Kerala, Andhra Pradesh, Tamilnadu, etc. But some constraints like technical, social, economic, and environmental problems hamper the milkfish production (Schmittou *et al.,* 1985). Fish farmers should be skilled to practice intensive fertilization and extensive feeding in ponds. The high-priced imported inorganic fertilizers and commercial feeds restricted the improvement of technology. The major economic constraints existing in the cultural practices are the high capital and the high cost of credit. Generally, the farmers should know the productive and recent technology which can provide high economic returns compare to the traditional practices. Likewise, the rearing of fry to fingerling stage and their trade can provide more value and economic return to the farmers with less capital investment by using biofloc technology. Before initiating such kind of commercially intensive milkfish fingerling production units, its economic viability and feasibility need to be tested. So the present study aims to compare the economics of biofloc and regular water production unit.

Materials and Methods

Experimental design

The research was carried out at the Brackish water Fish Farm of Central Institute of Fisheries Education, Kakinada Centre, Kakinada, East Godavari District, Andhra Pradesh, India. Indoor experiment was conduct with one treatment (biofloc) and one control (clear water) with triplicates each following completely randomized design (CRD). Simultaneously in outdoor milkfish was reared in earthen pond (0.02ha area). The *Chanos chanos* fry of average weight (0.9 g) was stocked in 1-tonfiber reinforced plastics (FRP) tanks at the rate of 10 no.s/ 60 L respectively. Experiment was continued till the fishes reached fingerling size (7-8cm with 4-5 g size). Indoor tank was filled with dechlorinated brackishwater. During the experimental period, only control group tanks undergone 25% water exchanged, while the BFT group were compensated with dechlorinated brackish water for evaporation losses only. Continuous aeration was provided by using a centralized aeration unit. Fishes were fed with pellet feed containing 30% crude protein during the experiment. The feeding ration was divided into two equal doses and applied to each tank at 07.00 hrs, and 17.00 hrs. The feed was given daily at a rate of 4% of body weight. The carbon source was added on alternate days to maintain the C:N ratio and microbial load in the biofloc tanks. The carbon sources were calculated based on the quantity of feed added and the protein content in the feed by following the methodology of De Schryver *et al.*, 2008.

Preparation of biofloc and carbon source addition

The method demonstrated by Avnimelech (1999) for inoculum preparation and calculation of C:N ratio was followed in the experiment. The inoculum was prepared in small plastic troughs of 10 L capacity by agitating 10 mg L^{-1} ammonium sulfate (Nitrogen Source) and 400 mg L^{-1} carbon source with 20 g L^{-1} pond bottom soil collected from the fish pond of the experimental site (ICAR-CIFE, Kakinada center) for 24hours. After 24 hours, floc inoculums were added to the treatment tanks at the rate of 1: 100 ratio (inoculum: water) and vigorous aeration were provided to keep the biofloc suspended. The carbon-nitrogen ratio (C: N) of 15:1 was maintained in BFT.

Water quality

Water quality parameters viz. temperature, pH and dissolved oxygen (DO), alkalinity, ammonia, nitrite, and nitrate were monitored and analyzed as per the standard procedure (APHA, 1998). Temperature, pH, and dissolved oxygen were estimated daily whereas alkalinity, ammonia, nitrite, and nitrate were determined twice in a week during the experimental period. Floc volume was measured weekly by allowing the floc to settle down in the Imhoff cone for 30 min without disturbance. The salinity and temperature were measured using a refractometer and glass thermometer respectively. Dissolved oxygen (Winkler's method), Alkalinity, Ammonia, Nitrite and Nitrate were measured using test kits (Advance Pharma Co., Ltd, India; Nice Chemicals Pvt. Ltd, India; U International Company, India).

Growth performance

Growth performance of fishes, length, and weight were measured at an interval of 15 days by weighing ten fishes from each treatment replicates randomly. Fishes were starved for an overnight prior to sampling. Total body length of the fish was measured using a measurement scale while an electronic weighing balance was used to measure the body weight of the fish. Different growth parameters like specific growth rate (SGR), percentage weight gain (PWG), feed conversion ratio (FCR), protein efficiency ratio (PER), biomass and survival were measured using the following formulas.

Specific Growth Rate (SGR) (%) = (Log_e Final Weight –Log_e Initial Weight) / (Number of Days) X 100

Percentage weight Gain (PWG) (%) = (Final Weight – Initial Weight) / (Initial Weight) X 100

FCR = Feed given (dry weight) / Body weight gain (wet weight)

PER = Body weight gain (wet weight) / crude protein fed

Survival (%) = (Total No. of Harvested Animal) / (Total No. of Stocked Animal) X 100

Economic analysis

Based on the results obtained in the following experiment, economic evaluation (operational) of the biofloc systems were projected for the intensive culture of milkfish (*C. chanos)* by using the parameters given below.

Total production (in kg) =Number of animals X Average weight ÷ 1000

Feed requirement = Total production (in Kg) X FCR

Total profit = Total production (in kg) x Cost of fish (in Rs.)

Net profit = Total profit – Expenditure

Statistical analysis

Data obtained through the experiment regarding growth parameters and survival of milkfish were analyzed by the one-way analysis of variance (ANOVA) via (SPSS, 20.0, Chicago, USA).Differences were measured significant at $P < 0.05$ by using Duncan's multiple range test.

Results and Discussion

The observed water quality parameters are presented in Table 1. The water temperature of 28^oC was observed in both clear water and biofloc treatment 28^0C, while pH was in the range of 8.04 – 8.19. Dissolved oxygen was noticed as 5.63±0.11mg L^{-1} in biofloc and 6.08±0.10mg L^{-1} in the clear water group. Total alkalinity was found in the range of 197 to 210 mg L^{-1}.

Ammonia-N, nitrite-N, and nitrate-N were recorded in the range of 0.03 – 0.24mg L^{-1}, 0.12- 1.15mg L^{-1} and 0 -11.50 mg L^{-1}. The floc volume was observed in the biofloc group as 14 ml L^{-1}.

Growth performance

The milkfish fry was reared upto a period, where it attained its farmer's preferable size (approx. 3 inches or 7.5 cm; based on farmers feedback). It was found that the fishes reared in the biofloc group reached its preferable size in 30 days of rearing period, while in clear water (without biofloc) group, it took 45 days to attained the same size. Accordingly, growth parameters of milkfish were calculated as per their rearing period. Growth performance such as Average body weight (ABW), Average body length (ABL), percentage weight gain (PWG), specific growth rate (SGR), feed conversion ratio (FCR), protein efficiency ratio (PER) and survival of milkfish were measured and given in Table 2.

Higher final average body weight (ABW), average body length (ABL), specific growth rate (SGR), percentage weight gain (PWG), and biomass was recorded in the earthen pond and biofloc treatment and the least in control. Significantly higher survival was obtained in the biofloc group followed by earthen pond and lowest in control.

Economic analysis (Based on farmer's feedback)

Based on the results obtained in the experiments, economic evaluation (operational) of the biofloc system, earthen pond and clear water system were projected for nursery rearing of *Chanoschanos* (fry to fingerling) in 0.1 ha area.

Operational cost analysis of biofloc and clear water for nursery rearing of *Chanos chanos* (fry to fingerling)

The economic evaluation was done by projecting the values obtained in the experiment:

- Total area= 0.1 hectare (ha)
- Culture period for Clear water - 45 days
- Culture period for Biofloc and earthen pond- 30 days
- Stocking rate/ha = 10 No.s / 60L
- Survival in Clear water - 60%
- Survival in earthen pond- 56%
- Survival in Biofloc - 80%

1. The total production and Net profit for Clear water system were calculated as:
2. Survival= 1,66,666 * 52% = 86,666 No.s
3. Total profit = 86,666 x Rs. 5/- = Rs. 4,33,332/-
4. Total cost of production =1,52,209/-
5. Net profit of Clear water systems= 4,33,332 – 1,52,209 = Rs. 2,81,123/-

The total production and Net profit for earthen pond were calculated as:

1. Survival= 1,66,666 * 56% = 93,333 No.s
2. Total profit = 93,333 x Rs. 5/- = Rs. 4,66,665/-
3. Total cost of production =1,34,245/-

4. Net profit of earthen pond = 4,33,332 – 1,34,245= Rs. 3,32,420/-

The total production and Net profit for biofloc system were calculated as:

1. Survival= 1,66,666 * 80% = 1,33,333 No.s
2. Total profit = 1,33,333 x Rs. 5/- = Rs. 6,66,664/-
3. Total cost of production =1,80,649/-
4. Net profit of biofloc systems= 6,66,664 – 1,80,649= Rs. 4,86,015/-

Operational cost analysis of biofloc and clear water system is presented in Table 3.

The present results demonstrate the viability of rearing milkfish *(C. chanos)* fry to fingerling stage in the biofloc based system. The results obtained after the economic analysis indicates that biofloc based culture of milkfish were superior to clear water culture and traditional earthen pond system.

The optimum range of water quality parameters for fish culture was observed in the present study (Kamilya *et al.,* 2017). In this study, the biofloc based system had shown a significant effect on the growth performance and feed utilization of *C. chanos*. The rise in growth performance and feed utilization of the fishes reared in biofloc were reported by several researchers (Haridas *et al.*, 2017; Azim and Little, 2008; Luo *et al.*, 2014; Zhang *et al.*, 2016).

Additionally, biofloc can be used as a supplementary feed (Burford *et al.*, 2004; Kuhn *et al.*, 2010; Megahed, 2010) and provide additional protein, lipid, vitamin and mineral for the growth (Izquierdo *et al.*, 2006, Ju *et al.*, 2008, Wasielesky Jr *et al.*, 2006).

There are reports that some exogenous enzymes in the diets increases the digestion process efficiency (Lin *et al.*, 2007). These exogenous enzymes can be produced by microbes present in the biofloc which increases the feed digestibility and help in proteins, carbohydrates, and other nutrients the breakdown into smaller units (Xu and Pan, 2012). Thus, the microbes in the biofloc act as an extracellular enzyme and a supplemental feed source that improve the digestive function and might have supported in enhancing the growth performance and feed utilization in the present study.

Table.1 Water quality parameters of the experimental units observed during the culture period

Parameters	Clear water	Biofloc
Temperature (°C)	28.92±0.18	28.60±0.15
pH	8.19±0.02	8.04±0.02
Dissolved oxygen (mg l^{-1})	6.08±0.10	5.63±0.11
Alkalinity (mg l^{-1})	197.00±0.76	210.00±0.76
Ammonia (mg l^{-1})	0.24±0.05	0.15±0.03
Nitrite (mg l^{-1})	0.12±0.04	1.15±0.19
Nitrate (mg l^{-1})	-	11.50±2.06
Floc volume (ml l^{-1})	-	14.17±2.20

Table.2 Growth performance and survival of *Chanos chanos* observed during the culture period

Parameters	Treatment		
	Control*	Biofloc**	Earthen Pond**
Initial ABW (g)	0.98±0.02	0.96±0.01	0.97±0.01
Final ABW (g)	4.55±0.03	4.70±0.03	5.20±0.02
Initial ABL (cm)	5.62±0.11	5.61±0.17	5.61±0.18
Final ABL (cm)	7.55±0.16	7.59±0.16	7.81±0.17
PWG (%)	365.72±5.83	388.33±2.31	441.7±3.42
SGR (%/day)	3.42±0.03	5.29±0.02	5.97±0.02
FCR	1.20±0.01	0.80±0.01	1.45±0.01
PER	3.34±0.02	5.00±0.03	2.8±0.03
SURVIVAL (%)	52.00±2.31	80.00±2.31	55.90±2.65

*Reared for 45 days. **Reared for 30 days

ABW, average body weight; PWG, percentage weight gain; SGR, Specific growth rate; FER, feed conversion ratio; PER, protein efficiency ratio. Values in the same row with different superscripts differ significantly ($P < 0.05$) for each parameter. Values are presented as mean ± standard error.

Table.3 Operational cost analysis of biofloc and clear water system for nursery rearing of *Chanos chanos* (fry to fingerling)

S.No	Particulars	Rate	Quantity	Clear water System	Biofloc System	Earthen pond
1	Milkfish *(C. chanos)* fry	50 ps/piece	166666 no.s	83333	83333	83333
2	Feed requirement	Rs.23 /Kg	472.9 Kg	10876		
			501.0 Kg		11523	
			704.6 Kg			16207
3	Manures (Raw cowdung)	Rs.800/1.5 tonnes	0.15 tonnes	0	0	80
5	**Chemicals**:					
	Shell lime/Agriculture lime	Rs.20/kg	25 Kg	0	0	500
	Urea	Rs10/Kg	5kg	0	0	50
	Single super phosphate	Rs. 15/Kg	5kg	0	0	75
	Ammonium sulphate	Rs. 60/Kg	1kg	0	60	0
6	Carbon source	Rs 40/kg	168.33 Kg	0	6733	0
7	Labour charges	8000/month	1 no.	12000	8000	8000
8	Harvesting charges			1000	1000	1000
9	Miscellaneous			45000	70000	25000
	TOTAL COST (A)			**1,52,209**	**1,80,649**	**1,34,245**
	TOTAL PROFIT (B)			**4,33,332**	**6,66,664**	**4,66,665**
	NET PROFIT (B-A)			**2,81,123**	**4,86,015**	**3,32,420**

Similarly earthen pond with enhanced natural food such as micro algae and zooplankton might have led to the higher growth and low FCR compared to Clearwater counterpart.

The low FCR values obtained in the biofloc treatments may be due to the availability of nutritionally rich food and the probiotic effect of biofloc which also improve the digestion (Azim and Little, 2008; Luo *et al.*, 2014; Verma *et al.*, 2016; Zhang *et al.*, 2016).

The higher survival rate of 80.00±2.31was recorded in the biofloc treatment and lowest in control (52.00±2.31) which is supported by the earlier study of Mishra *et al.*, 2008. natural earthen pond also had a survival rate similar to clear water but slightly higher range i.e. 56%.

Economic analysis

The economic analysis of milkfish rearing in biofloc and clear water was performed by considering operational cost. The analysis was projected for a total area of 0.1 hectares (ha). Jaspe and Caipang, 2011 suggested that smaller nursery pond (0.1-1 hectare) is required for the intensive milkfish culture. The use of nursery ponds provides the year-round supply of milkfish fingerlings even if there is no ongoing hatchery operation(Jaspe *et al.*, 2012). The culture period of 2-3 months generally followed for the nursery phase of *C. chanos* (Hilomen-Garcia, 1997; Lazarus and Nandakumaran, 1986) and a small hatchery period of 18-21 days (Marte, 2003). Besides, many researchers described different stocking densities during the nursery phase. Jaspe and

Caipang, (2011) followed the stocking densities of 20 fry /m^2, 26 fry/$m^{2,}$ and39 fry/m^2 of milkfish in his study. Borlongan *et al.,* 2003 stocked 10No.s/50Lof milkfish juveniles (the mean weight = 0.42 g) for the feeding experiment. Acclimated fry at the rate of 4 fry/l were stocked by Santiago *et al.*, (1983)in eighteen 55L glass aquaria filled with 30L of water. Similarly, 10-40 pcs/m^3 in floating and fixed cages and 40-100 pcs/m^3 in offshore cages were described in the publication of Yap *et al.*, 2007. Other nursery studies gave direction towards the increasing survival of 50-60% with the stocking density of 25-50 fry/m^2 (Bombeo-Tuburan and Gerochi, 1988). The stocking density of 75 fry/m^2 with the highest survival of 71.5% fed with rice bran and the lowest survival of 51.7% at 50 fry/m^2 without supplemental feeding was revealed by Villegas and Bombeo 1981.The investigation of mass fry production in a 1-ha pond at the rate of 5,00,000fry was reviewed by Bombeo-Tuburan and Gerochi, 1988. The rearing of 30 to 50 milkfish fry/m^2 to fingerling size for 45 to 60 days in earthen nursery ponds was performed by (Rabanal and Ronquillo, 1975).

Results showed that the nursery phase (30 days) of milkfish fry grown to fingerling size in the biofloc based system was economically viable with the net income of Rs. 4,86,015/- after selling of fingerling (Rs.5/fingerling) compared to earthen pond of same culture duration (3,32,420/-) and the lowest was obtained in clear water system of Rs. 2,83,418/- after 45 days of culture. The selling price of newly grown fingerlings of the given size and age from the local farms was usually from Rs. 5/fish to Rs. 8/fish. In general, the highest portion of total production costs in both the culture systems was accounted for fish feed.

Total feed required for the experiment was calculated by taking final biomass and survival into consideration. The feed cost in the present study was highest in the earthen pond and biofloc system and lowest in clear water system due to the variation in biomass and survival. Increasing biomass in the biofloc system led to raising the feed cost but accounted for a higher profit.

Similarly, the biofloc based system excluded the cost of organic and inorganic fertilizers and included the cost of carbon source only. Reduced culture period coupled wither higher growth and survival has made biofloc system more profitable over the other two systems. Hence, the results of the present study confirmed that the nursery rearing of milkfish using biofloc based system provides more economic returns and ensure the continuous supply of fingerlings for grow-out culture operation.

In an instant, an innovative approach in the nursery production of wild-caught milkfish fry and its economic viability in the biofloc based system are described in this study. The milkfish fry accepted the variety of food present in the biofloc and earthen pond during the entire nursery rearing phase and reached the fingerling stage with a higher survival rate compared to the clear water culture. Based on the projected economic analysis in 0.1 ha area, the profitability was higher in the biofloc system than the other two system. This suggests that the biofloc based system can be adopted for nursery rearing of milkfish and the entrepreneurs can fetch a good profit in short duration.

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