Biological Forum – An International Journal **14(1): 224-233(2022)**

ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

Effect of Biofloc Technology with different Carbon sources on Growth Performance of Pearl Spot *Etroplus suratensis* under Flow through System

V. Susitharan[1], C.B.T. Rajagopalsamy[2], C. Sindhu[3], S.J. Abisha Juliet Mary[4] and R. Dinesh[5]*
[1]*Department of Aquaculture, Central Institute of Fisheries Education, (Mumbai), India.*
[2]*Department of Aquaculture, Dr. M.G.R. Fisheries College and Research Institute, Tamil Nadu Dr. J. Jayalalithaa Fisheries University, Ponneri, (Tamil Nadu), India.*
[3]*Department of Fish Biology and Resource Management, Fisheries College and Research Institute, Tamil Nadu Dr. J. Jayalalithaa Fisheries University, Thoothukudi, (Tamil Nadu), India.*
[4]*Department of Fish Pathology and Health Management, Dr. M.G.R. Fisheries College and Research Institute, Tamil Nadu Dr. J. Jayalalithaa Fisheries University, Thalainayeru, (Tamil Nadu), India.*
[5]*Mandapam Centre for Sustainable Aquaculture, Tamil Nadu Dr. J. Jayalalithaa Fisheries University, Ramanathapuram, (Tamil Nadu), India.*

(Corresponding author: R. Dinesh)*
(Received 17 October 2021, Accepted 10 December, 2021)
(Published by Research Trend, Website: www.researchtrend.net)

ABSTRACT: Biofloc is an unsung hero of sustainable aquaculture that has been recently adopted by most fish and shrimp farmers to scale up their production. The present study evaluated the effect of biofloc technology with different carbon sources on water quality and growth performance of pearl spot (*Etroplus suratensis*) in a flow through system consisting of a reservoir tank (1000 L), rearing tanks (500 L), and effluent tank (300 L) for 60 days. The biofloc has been made with different carbon sources, viz., Jaggery (T1), Cassava flour (T2), Corn flour (T3) and a control with a conventional carbon source (sugar treated) and with a carbon/nitrogen (C/N) ratio of 15:1 in a reservoir tank. The effluent from the rearing tank is collected in the effluent tank, then the effluent is pumped into the reservoir tank. The Pearl spot *E. suratensis* was stocked at a rate of 25 fishes per 0.3 cubic metre, with mean length and weight ranging from 2.62 ± 0.005 cm to 2.71 ± 0.005 cm and 1.05 ± 0.002 g to 1.08 ± 0.002 g. The Ammonia-N level in the biofloc treated nursery rearing tanks was lower (0.04 to 0.12 µg/l) than in the biofloc holding reservoir tanks (0.51 to 2.65 µg/l). The maximum mean floc volume was observed in T1 (12.37 ± 0.024 ml/l), whereas the minimum mean floc volume was observed in the control (11.7 ± 0.023 ml/l). The regression coefficient in the length weight relationships was highly significant (P<0.01) and the 'b' value (1.9085) recorded in T1 was greater than that recorded in control, which confirms better growth performance. The mean length gain and the mean body weight gain of fishes in T1 were observed to be 4.57 ± 0.02 cm and 3.61 ± 0.03 g, respectively, which was higher than the other treatments and control. T1 had a higher SGR of pearl spot young ones (3.29 ± 0.00658%) than the control (2.93 ± 0.0059%) and other treatments T2 (2.49 ± 0.00498%) and T3 (2.64 ± 0.00528%). The growth increment in T1 when compared with control was 23.8%. From the present study, it is evident that the experimental biofloc treatment with Jaggery can improve the quality of culture water and results in better growth of pearl spots compared to Sugar, Corn flour and Cassava flour treatments as carbon sources.

Keywords: Biofloc, Pearl spot, Carbon sources, Jaggery, Growth performance.

INTRODUCTION

Biofloc technology, witnessed as a recently developed technology, proves to increase the sustainability, biosecurity, and development of high-intensity grow-out systems with no water or less water discharge over the entire crop cycle. So, this biofloc-based pearl spot culture could be an important low-cost strategy to enhance pearl spot production in an eco-friendly manner by improving the conversion of plant nutrients like NH_3-N into harvestable products. In ex-situ BFT, heterotrophic bacteria convert inorganic nitrogen forms (e.g., ammonia, nitrite, and nitrate) to bacterial biomass by controlling the carbon-to-nitrogen ratio (C/N) and aeration in the SGR (Liu *et al*., 2019; Yogev and Gross, 2019). However, in situ, where flocs and aquatic animals are cultured in the same system, BFT promotes high growth rates of bacteria and a subsequent increase in total suspended solids.

Based on various research reports, biofloc is found to be composed of 30.4% crude protein, 4.7% crude lipid, 8.3% fibre, 39.2% ash, and 29.1% nitrogen free extract on a dry matter basis when wheat bran and molasses were used as carbohydrate sources (Ballester *et al*., 2010). An experiment by Najdegerami *et al*. (2016) using biofloc as a dietary stimulant in common carp feed has given 75% better results in improving growth performances and digestive enzyme activity. This growth improvement and high digestive enzyme activity can be achieved with the help of bioactive compounds known to be present in the biofloc (Burford *et al*., 2003; Ju *et al*., 2008).

Several studies have suggested that BFT can improve water quality (Avnimelech, 2012; Xu *et al*., 2016). BFT also improves digestive enzyme activity and growth performance (Xu and Pan, 2012; Zhang *et al*., 2016) and non-specific immunity and biosecurity (Xu and Pan, 2013). Bioactive components found in biofloc can improve the growth and immunity of fish and shrimp (Khanjani and Sharifinia, 2020). Also, several studies have shown that BFT can improve growth performance in a variety of finfish species, including *Cyprinus carpio* (Minabi *et al*., 2020), *Oreochromis niloticus* (Kishawy *et al*., 2020; Zaki *et al*., 2020), *Rhynchocypris lagowskii* (Yu *et al*., 2020), *Labeo rohita* (Sawant *et al*., 2020).

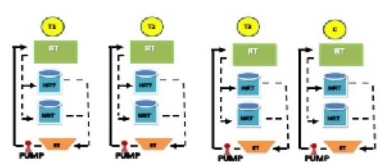
Etroplus suratensis, commonly known as "pearl spot", is a euryhaline cichlid species distributed along the coastal regions of Peninsular India and Sri Lanka (Munro, 1955). The Pearl spot is a hardy species with good flavour and taste. It has equal nutritional value as compared to other animal food products and is also affordable for low-income groups. Its non-predacious habits and easy adaptability to different kinds of water are useful features for its successful cultivation in ponds and cages. The culture of pearl spot, a state fish of Kerala, known locally as Karimeen, is popular because of its wide salinity tolerance, omnivore feeding habit (Bindu and Padamakumar, 2008) and high market price. It is a perfect fish for commercial culture in freshwater and brackish water, since it can thrive very well in both waters. It is also a year-round breeder in a natural environment system with one or two peaks, making it ideal for polyculture. It is also valued as an ornamental fish due to its unique coloration and remarkable pattern, and it is a year-round breeder in a natural environment system with one or two peaks. Hornell (1923) reported that the pearl spot is the first Indian food fish that has been transplanted to other countries.

Aquaculture practises could cause environmental impacts such as eutrophication, modification of land and changes in biodiversity (Tovar *et al*., 2000). Land-based recirculating aquaculture systems (RAS) are an alternative system to overcome these problems and other concerns such as water scarcity, diseases, etc. (Avenue and Kong, 1995; Timmons and Ebeling, 2007). The fact that all the parameters of the water (temperature, acidity, salinity, disinfection, etc.) can be controlled in this system forms the major advantage of the flow through system. It also allows for organic waste to be treated before being disposed of in the natural ecosystem. The nursery rearing of finfish larvae needs an environment where there is rich oxygen content and good food availability. However, the water should not be overly agitated. But in the BFT system, the water will always be in agitation in order to keep the biofloc in suspension. To utilise the BFT system in the nursery rearing of finfishes, the flow through system with a biofloc reservoir tank will solve the problem of calm environment in the nursery rearing tank. At the same time, the biofloc will be supplied from the reservoir tank to the nursery rearing tanks. With this in mind, the present study has been designed to analyse the impact of biofloc on the nursery rearing of pearl spot *Etroplus suretensis* under a flow through system.

MATERIALS AND METHODS

Experimental Setup. The whole setup comprises four rectangular reservoir tanks (RT) of 1 cubic metre, eight circular nursery rearing tanks (NRT) of 0.3 cubic metre capacity, and four rectangular effluent tanks (ET) of 0.25 cubic metre. The whole setup was divided into 4 compartments based on the different carbon sources used in the experiments, and each experimental setup had 1 reservoir tank, 2 nursery rearing tanks, and 1 effluent tank. The diagrammatic representation of the experimental setup is given in Fig. 1. The reservoir tank was used for the development of biofloc in the outdoor environment, which was placed slightly higher than the nursery rearing tank to allow the flow of the water in the flow through system. The wet biofloc produced in this reservoir tank was fed to the nursery rearing tanks, which served as feed for the fish reared in the experimental tanks. The waste generated in the nursery rearing tank was removed through the effluent tank, which was further recycled into the reservoir tank where the biofloc utilised NH_3-N to generate bacterial biomass. The whole experiment was conducted at the Mariculture Research Farm Facility, Tharuvaikulam.

(a)



(b)

Fig. 1: (a) Experimental setup (b) Diagrammatic representation of the experimental setup.

Floc development and Experimental animal. The biofloc was developed in a reservoir tank as per the protocol described by Avnimelech (1999). The activities followed for the development of biofloc from day 1 to day 4 are given in Table 1. Day 1 started with the application of urea, TSP, and dolomite, which is then given a proper feed and the carbon sources are added on the day 3. On day 4, kaolin clay was added to develop the floc. After the 4th day, the ammonia level was assessed and carbon sources were added to induce the growth of the biofloc. The water level was maintained at 80% in each of the tanks. Aeration was provided with a compressor and vigorous aeration was given for the fast development of biofloc in the reservoir tank. When the pH of the water fell below a certain level, $NaHCO_3$ was added to raise it. Addition of water for evaporation loss and floc removal was done on a weekly basis for proximate composition analysis. The J.K. Centre for Sustainable Aquaculture, Pulicat, Chennai, provided 600 pearl spot *Etroplus suratensis* seeds. After the biofloc development, fish were stocked into nursery rearing tanks at the rate of 25 per 0.3 cubic metre. A 60 day culture experiment was conducted to evaluate the growth performance of pearl spots under a flow through system. The carbon sources were added at a rate of 60% feed applied to BFT tanks to maintain an optimum C:N ratio of bacteria (Avnimelech, 1999). The carbon source was completely mixed with tank water and spread to the tank surfaces in the afternoon.

Table 1: Steps followed for the development of biofloc.

Day	Activity (Application in g/ 1000 L)
1	Urea - 27.5g, TSP - 2.5g, Feed pellet - 100g, Dolomite - 150g
2	Feed pellet - 100g, Dolomite - 150g
3	Feed pellet - 100g, Dolomite - 150g, Carbon source - 250 g
4	Kaolin - 150g

Water quality parameters. During the experimental period, water quality parameters such as temperature, dissolved oxygen, pH, and salinity were recorded once every 6 days in the biofloc reservoir tank, and ammonia-N, nitrite-N, nitrate-N, and alkalinity were measured once every 10 days. Temperature, dissolved oxygen, pH, and salinity were measured once every four days in the nursery rearing tank, while ammonia-N, nitrite-N, nitrate-N, and alkalinity were measured once every seven days. Water temperature was measured in the morning using a thermometer with 0.1^oC accuracy. The pH of the rearing water was measured using the laboratory model Elico pH meter. A modified Winkler's titration method was adopted to estimate the dissolved oxygen. The total alkalinity, total ammonia-N, nitrite-N, and nitrate-N were assessed twice a week using standard methods (APHA, 1998).

Bio growth parameters. The length and weight of the fish were measured by taking a sample of 50 fish before stocking them in the experimental tanks. The length was assessed in cm and the average weight was assessed in grams. After stocking, the growth was analysed by random sampling with a scoop net at intervals of 15 days in both the control and experimental tanks. Fortnightly growth sampling was carried out on the 15th, 30th, 45th, and 60th days of the culture period. From the pooled growth data of pearl spot, length and weight gain, mean length and mean weight gain, and specific growth rate (SGR), average daily growth, and total biomass gain were assessed using the following formulae (Raj *et al*., 2008; Zaid and Sogbesan, 2010). Length and weight relationships were assessed by using the log-based power curve equation proposed by Bagenal (1978).

Mean weight gain (g) = Final body weight – Initial body weight Mean Length gain (cm) = Final body length – Initial body length

Average daily growth = Mean final weight – Mean initial weight/days of culture

Percentage of survival = (Number of animals survived at the end of experiment /Number of animals stocked at the start of experiment) × 100 Specific growth rate = **(**(Ln final mean weight – Ln initial mean weight)/number of days**)** × 100

Total biomass gain = Sum of weight at the end of experiment – Sum of weight at the start of experiment

Proximate composition analysis. Proximate composition analysis was done three times during the experimental period. Concentrated floc from biofloc tanks was collected, dried at room temperature, and then preserved in a refrigerator. The moisture, crude protein, lipid, ash, and fibre were analysed according to standard procedure (AOAC, 1995). Moisture was determined by oven drying at 105–110°C for 6 hours and protein by the Micro Kjeldhal method after acid digestion. Lipid was determined by Soxhelet's method by extracting it in ether, which is continuously volatilized at 60–80°C. Crude fibre was estimated by dried fat free residues after digestion with dilute acid (0.255N) and alkali (0.313N). Ash was determined by ignition at 600 °C for 6 hours in a muffle furnace.

Floc volume. The biofloc volume was the measure of biofloc in the treatment reservoir tanks (T1, T2 and T3) and control tank (C), which was determined by adopting the method explained by Avnimelech and Kochba (2009) using Imhoff cones. The cone was immersed in the water and the level of the water was noted at 1000 ml in the Imhoff cone (Fig. 2). Biofloc volume was measured once every 4 days in the control and treatment reservoir tanks.

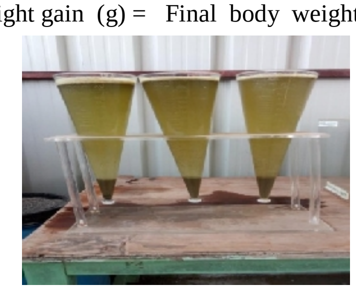


Fig. 2. Collection of wet biofloc using Imhoff cone.

Statistical analysis. The results of the present study were analysed statistically using the one-way ANOVA test and regression analysis, and the levels of significance at P<0.05 and P<0.01 were considered for validation (Snedecor and Cochran, 1967).

RESULTS

A. Water quality parameters

Natural productivity plays an important role in recycling nutrients and maintaining the water quality in the BFT systems. It was demonstrated that the addition of carbon sources in BFT systems increased growth and production while contributing to favourable water quality conditions. In the present study, the different water quality parameters (Table 2) were measured during the 60 days of pearl spot rearing, which were discussed in detail below. The mean water temperature (28 to 32°C), dissolved oxygen (5.4 to 7.65 mg/l), pH (7.1 to 7.9), alkalinity (104.08 to 142.22 mg/l), ammonia-N (0.51 to 2.65 µg/l), nitrite-N (0.25 to 4.24 µg/l), nitrate-N (0.19 to 5.24 µg/l) and salinity (35 to 40 ppt) of the biofloc holding reservoir tanks showed no significant differences (P>0.05) between the treatments. Also, the mean water temperature (28.25 to 31.25 °C), dissolved oxygen (5.1 to 6.26 mg/l), pH (7.75 to 8.2), alkalinity (96.22 to 106.3 mg/l), ammonia-N (0.04 to 0.79 µg/l), nitrite-N (0.015 to 0.15 µg/l), nitrate-N (0.001 to 0.055 µg/l) and salinity (35 to 36.25 ppt) of the nursery rearing tanks showed no significant differences (P>0.05) between the treatments.

B. Growth parameters

In the present study, the mean weight gain of Pearl spot *E. suratensis* in nursery rearing experiments with Treatment 1 (4.57 ± 0.00914 g) showed higher values compared to the control (3.69 ± 0.011 g) (Table 3 to 6). The SGR of pearl spot young ones in the jaggery-treated tank (T1) was higher (3.29 ± 0.00658%) than the control (2.93 ± 0.0059%) and the other treatments (T2 (2.49 ± 0.00498%) and T3 (2.64 ± 0.00528%).

Table 2: Water quality parameters of the experimental reservoir tanks and nursery rearing tanks.

Parameters	Reservoir tanks				Nursery rearing tanks			
	Treatments		Control		Treatments		Control	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
Temperature (°C)	28	32	29	32	28.5	31.25	28.25	31.25
pH	7.1	7.8	7.1	7.9	7.75	8.2	7.8	8.2
DO (mg/l)	5.4	7.65	6.56	7.37	5.1	6.26	5.29	6.1
Salinity (ppt)	35	40	35	39.5	35	36.25	35	36.25
Alkalinity (mg/l)	104.8	140	106.56	142.22	96.22	106.3	96.52	105.89
Ammonia-N (µg/l)	0.51	2.56	0.69	2.65	0.045	0.79	0.04	0.12
Nitrite-N (µg/l)	0.25	4.22	0.64	4.24	0.015	0.15	0.025	0.12
Nitrate-N (µg/l)	0.19	5.24	0.23	5.22	0.001	0.055	0.0015	0.055

Table 3: Bio-growth parameters of Pearl Spot *Etroplus suratensis* reared in Control (Sugar) nursery experimental tanks.

DOC	Mean length gain (cm)	Mean weight gain (g)	ADG (g)	SGR (%)	Total biomass gain (g)	Survival rate (%)
15th	0.71 ± 0.001^a	0.55 ± 0.001^a	0.036 ± 0.001^a	2.78 ± 0.005^a	13.55 ± 0.027^a	96 ± 0.1^a
30th	1.67 ± 0.003^a	1.49 ± 0.004^a	0.049 ± 0.002^a	2.93 ± 0.005^a	37.10 ± 0.074^a	100 ± 0.2^a
45th	2.41 ± 0.004^a	2.37 ± 0.007^a	0.053 ± 0.002^a	2.61 ± 0.005^a	59.10 ± 0.120^a	92 ± 0.5^a
60th	3.06 ± 0.006^a	3.69 ± 0.011^a	0.062 ± 0.001^a	2.51 ± 0.007^a	85.05 ± 0.170^a	100 ± 0.3^a

Table 4: Bio-growth parameters of Pearl Spot *Etroplus suratensis* reared in Treatment 1 (Jaggery) nursery experimental tanks.

DOC	Mean length gain (cm)	Mean weight gain (g)	ADG (g)	SGR (%)	Total biomass gain (g)	Survival rate (%)
15th	0.94 ± 0.0018^c	0.69 ± 0.0013^c	0.046 ± 0.00009^c	3.29 ± 0.0065^c	17.2 ± 0.034^d	96 ± 0.1^b
30th	1.49 ± 0.0029^c	1.66 ± 0.0033^c	0.056 ± 0.00011^c	3.11 ± 0.0062^c	41.6 ± 0.083^d	100 ± 0.2^b
45th	2.59 ± 0.0051^c	2.68 ± 0.0053^c	0.059 ± 0.00011^c	2.78 ± 0.0055^c	66.9 ± 0.133^d	100 ± 0.2^b
60th	3.62 ± 0.0072^c	4.57 ± 0.0091^c	0.077 ± 0.00015^c	2.77 ± 0.0055^c	111.55 ± 0.223^d	100 ± 0.2^b

Table 5: Bio-growth parameters of Pearl Spot *Etroplus suratensis* reared in Treatment 2 (Cassava flour) nursery experimental tanks.

DOC	Mean length gain (cm)	Mean weight gain (g)	ADG (g)	SGR (%)	Total biomass gain (g)	Survival rate (%)
15th	0.87 ± 0.0017a	0.62 ± 0.0012b	0.041 ± 0.000082a	3.07 ± 0.0061a	15.5 ± 0.0310b	100 ± 0.2b
30th	1.67 ± 0.0033a	1.41 ± 0.0028b	0.047 ± 0.000094a	2.81 ± 0.0056a	35.2 ± 0.0704b	96 ± 0.1b
45th	2.36 ± 0.0047a	2.16 ± 0.0043b	0.048 ± 0.000096a	2.47 ± 0.0049a	53.95 ± 0.1079b	100 ± 0.2b
60th	3.21 ± 0.0064a	3.66 ± 0.0073b	0.061 ± 0.000122a	2.49 ± 0.0049a	91.25 ± 0.1825b	100 ± 0.2b

Table 6: Bio-growth parameters of Pearl Spot *Etroplus suratensis* reared in Treatment 3 (Corn flour) nursery experimental tanks.

DOC	Mean length gain (cm)	Mean weight gain (g)	ADG (g)	SGR (%)	Total biomass gain (g)	Survival rate (%)
15th	0.8 ± 0.0016b	0.61 ± 0.0012b	0.041 ± 0.00008b	2.99 ± 0.0059b	15.4 ± 0.0308c	96 ± 0.1b
30th	1.66 ± 0.0033b	1.48 ± 0.0029b	0.049 ± 0.00009b	2.89 ± 0.0057b	37.05 ± 0.0741c	100 ± 0.2b
45th	2.45 ± 0.0049b	2.55 ± 0.0051b	0.057 ± 0.00011b	2.69 ± 0.0053b	63.65 ± 0.1273c	100 ± 0.2b
60th	3.34 ± 0.0066 b	4.15 ± 0.0083b	0.069 ± 0.00013b	2.64 ± 0.0052b	103.75 ± 0.2075c	100 ± 0.2b

C. Length and weight relationship

From the length and weight relationship graph depicted (Fig. 3 to 6), it could be inferred that all the regression coefficients are highly significant (P<0.01). While comparing the 'b' values among different treatments, the 'b' value (1.9085) recorded in the Jaggery treated biofloc treatment (T1) was greater than that recorded in the control, which confirms better growth performance. Similarly, the T1 value was greater than the values recorded in T2 (1.7991) and T3 (1.891).

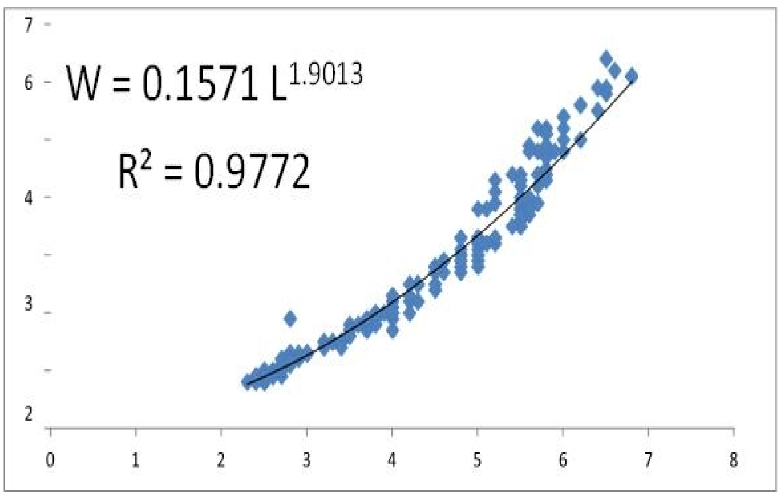


Fig. 3. Length and weight relationship of Pearl Spot *Etroplus suratensis* reared in the control experimental tank.

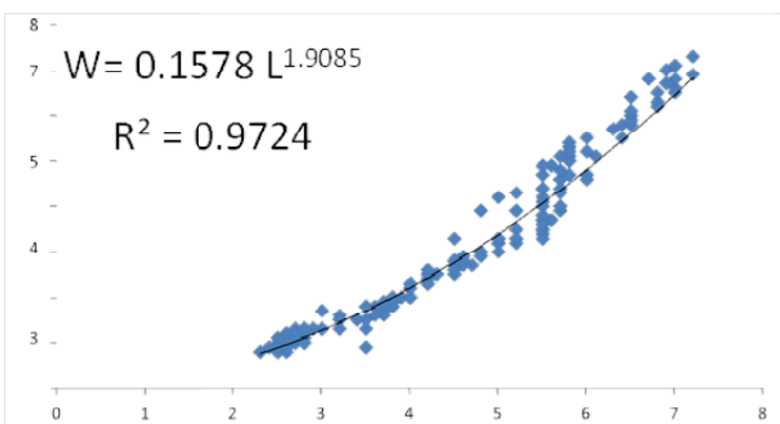


Fig. 4. Length and weight relationship of Pearl Spot *Etroplus suratensis* reared in T1 (Jaggery) experimental tank.

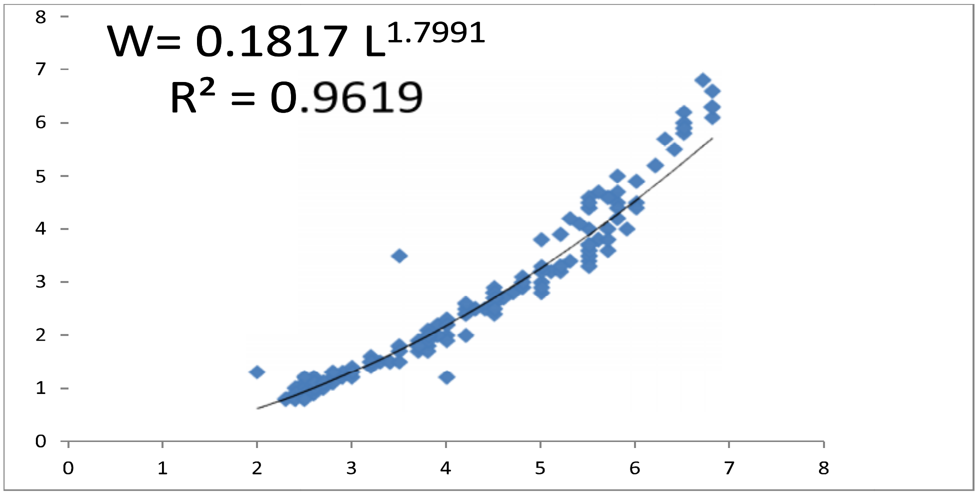


Fig. 5. Length and weight relationship of Pearl Spot *Etroplus suratensis* reared in T2 (Cassava flour) experimental tank.

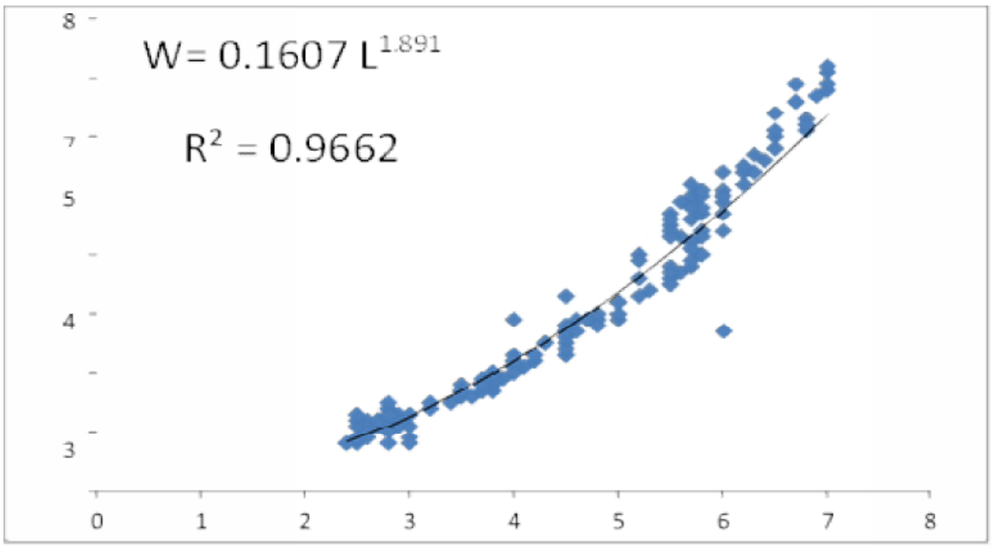


Fig. 6. Length and weight relationship of Pearl Spot *Etroplus suratensis* reared in T3 (Corn flour) experimental tank.

Proximate composition analysis. In the control reservoir tank (C), the percentages of moisture content, protein content, crude fiber, lipid and ash values were 12.74 ± 0.025 %, 23.91 ± 0.047 %, 13.56 ± 0.027 %, 0.79 ± 0.001 % and 30.99 ± 0.061 %, respectively. The maximum value of moisture content was observed in the corn flour treated experimental reservoir tank (16.23 ± 0.032%). The jaggery treated experimental tank (T1) showed a maximum value of crude protein of 28.23 ± 0.056 %, whereas the percentages of crude fibre content and ash content were maximum in the cassava flour treated experimental reservoir tank (T2) with 20.84 ± 0.041 % and 32.92 ± 0.065 %, respectively. The lipid content in the corn flour-treated experimental reservoir tank (T3) was the highest, at 3.56 0.0071%.The values are clearly described in Table 7.

Table 7: Proximate composition of biofloc developed in the experimental reservoir tanks using different carbon sources.

Treatments	Moisture (%)	Crude Protein (%)	Crude Fibre (%)	Lipid (%)	Ash (%)
C	12.74 ± 0.025	23.91 ± 0.047	13.56 ± 0.027	0.79 ± 0.001	30.99 ± 0.061
T1	14.69 ± 0.029	28.23 ± 0.056	14.96 ± 0.029	2.03 ± 0.004	28.08 ± 0.056
T2	11.01 ± 0.022	21.67 ± 0.043	20.84 ± 0.041	2.89 ± 0.005	32.92 ± 0.065
T3	16.23 ± 0.032	24.86 ± 0.049	17.77 ± 0.035	3.56 ± 0.007	26.61 ± 0.053

Floc volume. In the experimental biofloc holding reservoir tanks (T1, T2 and T3), the floc volume ranged from 9.2 to 14.8 ml/l. The floc volume of the experimental control reservoir tank (C) was found in the range of 7.6 to 14.5 ml/l. In the control tank (C), the mean floc volume was determined to have a value of 11.7 ± 0.023 ml/l, whereas in the jaggery-treated experimental reservoir tank (T1), it showed a maximum value of 12.37 ± 0.024 ml/l among all treatments. Moreover, the mean floc volume of the cassava treated experimental reservoir tank (T2) and the corn flour treated experimental reservoir tank (T3) was found to be 11.79 ± 0.117 and 11.87 ± 0.142 ml/l, respectively. Fig. 6 shows the volume of floc developed in the experimental reservoir tanks using different carbon sources.

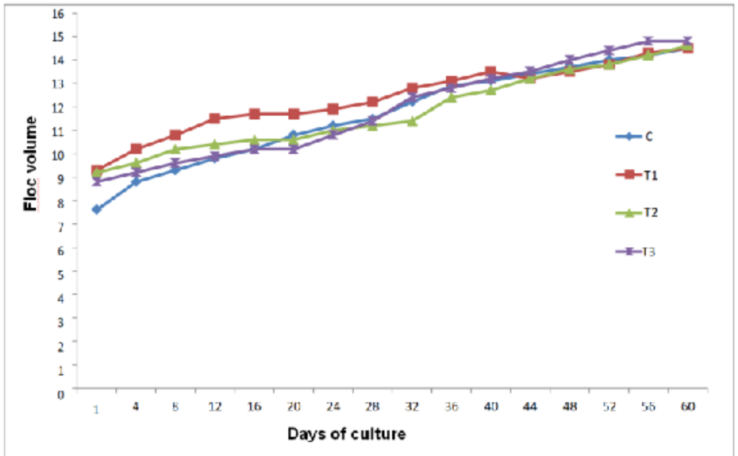


Fig. 7. Floc volume data of biofloc developed in the experimental reservoir tanks using different carbon sources.

DISCUSSION

In BFT fish rearing systems, the pH level may decrease due to the reduction in the alkalinity level (Becerra-Dorame *et al*., 2011; Furtado *et al*., 2011; Liu *et al*., 2014). The results of the present experiment also revealed a similar trend in alkalinity and the pH value were recorded in both the nursery rearing of young ones and the biofloc holding reservoir tanks. Normally, the requirement for dissolved oxygen is high since all the microbial communities other than the target fish species in the rearing system require dissolved oxygen. Oláh *et al*. (1987) studied the oxygen consumption of bacteria in fish ponds, which contributed as much as 77% of the total oxygen consumption. Avnimelech *et al*. (1992) stated that heterotrophic microbial populations consume a high level of dissolved oxygen in fish culture ponds. In the present study too, the dissolved oxygen levels in nursery rearing tanks were always lower than the experimental biofloc holding reservoir tank, although there was continuous aeration. The dissolved oxygen value, which ranged from 5.64 to 5.83 mg/l, indicated that the optimal DO was available for the higher productivity. Similar observations were made by Rahman *et al*. (2005). From the present study, it is clear that the heterotrophic microbial community present in the biofloc has consumed a high level of dissolved oxygen. Various microbial processes may be used to reduce ammonia levels in fish rearing environments, including nitrification, denitrification, mineralization, photosynthesis, and assimilation by heterotrophic bacteria (Ebeling *et al*., 2006). Thus, nitrogenous waste such as ammonia–N could be used for the production of microbial protein. Avnimelech *et al.* (1992) showed that the ammonia-N generated from the faecal pellet and uneaten fish feed was more effectively removed by carbon addition than through the conventional water exchange method. In the present investigation, the ammonia–N levels in the experimental nursery rearing tank were less than those recorded in the experimental biofloc holding reservoir tanks. The level of decrease in ammonia-N value was observed with a minimum value of 0.04 μg/l in the Treatment 3 nursery rearing tank.

The higher fish production due to biofloc feeding by fish has been recorded by many authors (Hari *et al*., 2004; Azim and Little, 2008; Kuhn *et al*., 2009). The researchers have documented a highly variable growth rate, i.e., from a low level of 13.8% to a higher level of 65.1%. In the current study, the mean weight gain of Pearl spot *E. suratensis* in a nursery rearing experiment with Treatment 1 (4.57 ± 0.00914 g) showed higher values than the control (3.69 ± 0.011 g), which is 23.8% higher than the control. These results were in line with the results of Crab *et al.* (2009), who have documented a higher mean weight gain in fish reared in biofloc tanks than in the control system. Among the various growth parameters used in the aquaculture research experiment, the specific growth rate (SGR) is a good indicator. The SGR of pearl spot young ones in the jaggery treated tank (T1) was higher in the current experiment, which is consistent with Hari *et al*. (2004), who found a higher SGR value of fish in the BFT system than in the control set of experiments. However, Anand *et al*. (2014) have documented an increment in the SGR of fish when biofloc was fed at a 4 and 8% level in feeds. The growth of pearl spot, *E. suratensis*, in a non-BFT system was carried out by Palavesam *et al*. (2008). The highest SGR recorded was 0.829 ± 0.031%. But in the current investigation, the values were higher (2.77 ± 0.005%) than those of the results of Palavesam *et al*. (2008) indicating the potential of the BFT system.

The length and weight relationship of finfish follows an allometric growth pattern and the slope ‘b’ value in the W= aLb equation normally varies from 2 to 3 for fishes growing under optimum environmental conditions. Karthikeyan (2006); Suman (2007) assessed the length and weight relationship in Angel fish and Rosy barb, respectively. During the rearing experiment, Karthikayan (2006) observed a "b" value greater than 2 for angel fishes, whereas Suman (2007) observed a "b" value less than 2 for Rosy Barb. The results of the present study were similar to those of Karthikeyan (2006), revealing that the growth of fishes was in a positive pattern.

The crude protein content of biofloc ranged from 21.67 ± 0.043 to 28.23 ± 0.056% (Anand *et al*., 2014). Further, the team has recorded a higher level (4.35%) of crude lipid in biofloc than that recorded in the present investigation. The maximum ash content recorded in the present study (32.92 ± 0.065%) was much higher than that of the values by Anand *et al*. (2014). In contrast to the present investigation, Rostika (2014) recorded a very high level (53.5%) of protein, a moderate level of crude lipid (3.53%) and a high level of ash content (7.5%). Ju *et al*. (2008) opined that the variation in the proximate composition of biofloc was usually based on the contributing or dominating living organisms present in the biofloc.

In the current experiment, the floc volume data showed that the mean and range of values recorded in the treatment reservoir tanks were higher than the control. The floc serves as a potential feed in biofloc rearing tanks and is available all day (Avnimelech, 2012). The researcher has further calculated the feed available in the BFT system, which is 14 mg of dry floc weight per cubic centimetre of floc volume in the BFT pond. The TSS content assessed in the present study was higher than that assessed by Avnimelech (2012).

CONCLUSION

The present investigation has given a clear insight into the nursery rearing of Pearl Spot *E. suratensis*, which readily accepted biofloc as an in-situ feed without any supplementary pellet feed for the entire duration of experimental nursery rearing. Furthermore, the growth increment of the pearl spot in terms of SGR was 2.34 times greater in BFT than in conventional systems which appear to be impressive. Therefore, the present study concludes that jaggery can result in better growth and production of pearl spots. These findings will entice stakeholders to accelerate adoption in the field for improved growth and yield.

Acknowledgement. The authors are thankful to the Vice Chancellor, Tamil Nadu Dr.J.Jayalalithaa Fisheries University for the necessary support and encouragement.
Conflicts of Interest. None.

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How to cite this article: V. Susitharan, C.B.T. Rajagopalsamy, C. Sindhu, S.J. Abisha Juliet Mary and R. Dinesh (2022). Effect of Biofloc Technology with Different Carbon Sources on Growth Performance of Pearl Spot *Etroplus suratensis* under Flow Through System. *Biological Forum – An International Journal*, *14*(1): 224-233.