J Krishi Vigyan 2020 (Special Issue) : 74-80 DOI : 10.5958/2349-4433.2020.00084.7

Effect of Periphyton (*Streblus asper* lour.) assemblage on Water quality Parameters and Growth Perfomance of Jayanti Rohu and Amur Common Carp in the Aquaculture System

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ABSTRACT

The study was conducted to investigate the effect of periphyton assemblage on water quality parameters and growth performances of Jayanti Rohu and Amur common carp in the aquaculture system**.** During the study, all water quality parameters were within the limits suitable for fish production. There was slight variation in water temperature during the entire study period and the mean values ranged from 24.03 ± 0.96 °C, 24.60 ± 0.76 °C and 25.10 ± 0.70 °C in T0, Tl and T2 respectively. The average pH and transparencies values were 7.45 cm and 23.85 cm in T0, 7.42 cm and 23.58 cm in Tl, and 7.54 cm and 22.64 cm in T2, respectively. The chlorophyll-*a* content of water did not show any significant ($p<0.05$) difference among the treatments. The mean values were 98.62 ppm, 95.35 ppm and 94.85 ppm in treatments T0, Tl and T2 respectively. The average initial weights of Jayanti Rohu and Amur Carp were 20.27± 0.45 g, 14.61 ± 1.18 g; 11.48 ± 0.11 g and 11.72 ± 0.65 g; 14.53 ± 1.72 g and 14.08 ± 3.37 g in T0, T1 and T2, respectively. At the end of 120 days of experimental study, the average final body weight of Jayanti Rohu was 84.49 ± 1.38 g, 81.92 ± 1.58 g and 96.69 ± 2.42 g observed in T0, T1 and T2 respectively whereas the average final body weight of Amur Carp observed was 56.93± 1.64, 53.98 ± 1.35 and 60.01 ± 1.94 in T0, T1 and T2 respectively.

Key Words: Amur Carp, Aquaculture system, Jayanti Rohu, Periphyton, Production, Productivity.

INTRODUCTION

In the existing systems of aquaculture, natural productivity is increased by the use of fertilizers and addition of supplementary feed. However, current fertilizer practices and the use of supplementary feed are not very efficient, as only 5 to 15per cent of the nutrient input from fertilizers is retained in fish biomass (Schroeder*,* 1990). In feed-driven pond systems, only about 15 to 30 per cent of the nutrient is converted into harvestable goods (Acosta Nassar *et al*, 1994; Gross *et al,* 2000); the remaining is lost to the soil, the effluent and the atmosphere (Beveridge *et al,* 1994). For this reason, the fish farming community has long felt the need for an alternative and cost-effective fish culture system. Improving the nutrient efficiency is a major challenge for resource-poor fish farmers in developing an aquaculture system. Periphyton-based fish culture is a viable alternative for making semi-intensive aquaculture systems more nutrient-efficient, as periphyton is used effectively by many species that thrive in the lower food chain.

The periphyton or aufwuchs, which comprises the organisms that live on submerged surfaces, includes both the attached forms and the associated organisms. The group is made up of algae, zoological and filamentous bacteria, protozoan bound, bryozoan, rotifers and free-swimming microorganisms. Though there is a common scientific theory that the phytoplankton community is the most important in terms of energy fixing and fuelling, the research has shown that macrophytes

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and periphytes are significant and often the dominant contributors to the primary production. In addition, extensive nutrient budgets have shown that epiphyte (or periphyton) absorbs a large fraction of nutrients such as available carbon, nitrogen, and phosphorus during their growth and help in decomposition of macrophytes.

Streblus asper Lour, family: Moraceae locally known as Saura Gach is a small tree that is indigenous to tropical lands like India. It is a well-known ethnomedicinal herb, and is also well recorded for its use in traditional Indian folk medicine. The traditional fishermen of Assam use this tree as an age-old practice by using the Saura Gach branches as a fish aggregating device along with the natural weed masses. This is basically a periphyton-based aquaculture program also known as "brush park fishery" or "brush shelter fishery". In this backdrop, a study was conducted to evaluate the effect of periphyton assemblage on different water quality parameters and the growth performances of two improved variety of fishes *i.e*. Jayanti Rohu and Amur common carp.

MATERIALS AND METHODS

The experiment was conducted at the College of Fisheries fish farm, Assam Agricultural University, Raha in Nagaon district of Assam around 100 km from Guwahati. The experiment was conducted for a period of 120 days in 12 numbers of cement tanks in quadruplicates using completely randomized design (CRD). Four tanks were provided with *Streblus asper* Lour as artificial substrate for periphyton growth (Treatment T1), another four tanks were provided with periphyton plus supplementary feed (Treatment T2) and the remaining four tanks without any substrate and supplementary feed were designated as control (T0).

Prior to start of the experiment, all the tanks were cleaned properly and exposed to sunlight for few days until the bottom mud got cracked. Further, after estimation of pH, quicklime (CaO) was applied @ 250 kg/ha. After filling the tanks, fertilization was done with raw cow dung, urea and single super phosphate @ 10,000, 100 and 50 kg/ ha/ yr, respectively.

During the study, *S. asper* (Saura Gach) was used as a substrate to facilitate periphyton growth which was collected from adjacent villages and cut into 1.2 m long, small spilts which were then placed vertically in the eight tanks and maintained at a density of 45 pieces in each tank. After a month, there was a luxuriant growth of periphyton that was attached to the substrates.

Monitoring of water quality parameters

The physico-chemical parameters of water of all the experimental tanks were analysed on fortnightly basis. Water temperature was recorded using a Celsius thermometer. Dissolved oxygen was determined by a portable DO meter (YSI model 58), pH of water was determined with a pH meter (Jenway, model 3020). Chlorophyll-*a* was determined after filtering water sample through Whatman filter paper (46 cm) using a spectrophotometer (Milton Roy Spectronic, model 1001 plus). For analysis of total hardness, total alkalinity, ammonia-nitrogen, nitrite-nitrogen and nitrate-nitrogen, water samples were collected, preserved and then analyzed in the laboratory following the method described by (APHA, 2005). The transparency of the water was recorded with the help of a Secchi disk reading following Boyd (1978) formula.

Fish growth studies

Sampling was carried out every fortnightly for assessment of growth and health performance. Random fish samples were collected, weighed and measured and adjusted accordingly. The length was measured with the help of a measuring scale, while weight was recorded with the help of an electronic weighing balance and the growth of individual fish species were recorded. All calculations and statistical analysis were carried out using Statistical Packages for Social Sciences (SPSS version 16.0 for windows, 2013) in one-way analysis of variance (ANOVA).

Table 1. Water quality parameters (mean ± SE) of the experimental tanks recorded at 15 days interval.

Parameters	Tanks	Sampling days								
		0	15	30	45	60	75	90	105	120
Temperature (^{0}C)	T0	18.25±0.25	20.33± 0.23	26.2±0.56	23.18±03	24.88±0.56	25.63±0.22	26±0	25.83±0.18	26±0
	T1	21.58±0.21	25.96±0.05	20.43±0.09	23.2±0.04	25.63±0.19	26.08±0.05	26.2±0	26.15±0.07	26.18±0.06
	T2	19.63±0.56	26.08±0.05	24.88±0.57	25.63±0.20	25.3±0.20	26.23±0.05	26±0	26.2±0.05	26±0.09
Transparency (cm)	T0	25.88±0.13	20.78±0.60	21±0.17	24.10±0.16	24.88±1.76	26.2±0.56	20.65±0.04	26.18±3.18	24.06±0.05
	T1	21.35±0.16	22.5±0.22	21.58±0.21	23.2±0.45	23.6±0.04	23.43±1.83	26.23±2.78	26.23±0.05	24.06±3.18
	T2	21.75±0.51	19.67±0.44	23.96±0.57	23.25±0.57	20.1±0.05	26.23±2.03	17.88±0.05	24.9±2.78	25.10±0.05
pH	T0	7.35±0.09	7.40±0.04	7.65±0.05	7.30±0.24	7.40±0.24	7.40±0.13	7.53±0.19	7.43±0.11	7.53±0.19
	T1	7.48±0.15	7.38±0.15	7.40±0.07	7.23±0.13	7.45±0.18	7.18±0.09	7.65±0.18	7.40±0.25	7.65±0.26
	T2	7.75±0.18	7.63±0.08	7.48±0.28	7.30±0.11	7.08±0.09	7.83±0.21	7.73±0.10	7.53±0.28	7.60±0.23
DO (ppm)	T0	5.18±0.10	6.15±0.06	4.50±0.16	4.50±0.24	4.75±0.18	5.98±0.13	4.50±0.11	6.08±0.05	4.70±0.29
	T1	4.18±0.09	5.98±0.13	4.18±0.06	4.55±0.25	5.03±0.37	6.13±0.05	4.63±0.05	5.85±0.32	4.80±0.06
	T2	4.88±0.42	4.68±0.48	4.98±0.16	4.45±0.25	4.90±0.44	5.05±0.22	4.88±0.23	5.05±0.22	4.80±0.09
Hardness (ppm)	T0	113±2.68	116.25±1.89	122.25±1.38	129.25±6.64	121.5±1.19	120.5±0.87	121.25±2.72	120±0.91	119.75±1.38
	T1	117±1.83	119.5±4.77	121.25±1.31	125±5.90	120.25±1.49	118.75±0.48	120.5±3.86	119.5±0.96	122±2.86
	T2	139±5.18	119.5±3.97	118.75±3.97	118.25±1.11	124.75±2.06	120.75±1.25	123.5±2.63	122.75±2.69	124.75±3.42
Total alkalinity (ppm)	T0	100±0.41	111.5±1.32	144.25±7.44	115.75±5.27	139.5±8.15	148.75±11.2	157±12.34	136.5±13.90	162.5±4.05
	T1	124.5±17.68	135.25±12.49	160±3.89	142.5±7.51	127.75±15.45	113.25±1.18	133±12.34	124.5±10.18	150.5±10.70
	T2	114±2.27	113.5±1.55	123±1.08	141.25±8.76	138.25±14.60	158.25±3.94	148.25±7.76	149.5±10.54	134.5±11.88
Ammonia (ppm)	T0	0.04±0.01	0.04±0.01	0.03±0.01	0.18±0.11	0.04±0.02	0.038±0.02	0.03±0.02	0.033±0.01	0.033±0.01
	T1	0.16±0.12	0.058±0.02	0.04±0.02	0.12±0.03	0.04±0.01	0.03±0.01	0.05±0.01	0.04±0.01	0.038±0.01
	T2	0.18±0.14	0.05±0.02	0.05±0.05	0.05±0.01	0.05±0.01	0.05±0.02	0.03±0.01	0.038±0.01	0.04±0.01
Nitrite (ppm)	T0	0.13±0.03	0.14±0.02	0.15±0.02	0.18±0.03	0.18±0.03	0.1±0	0.13±0.03	0.18±0.08	0.18±0.05
	T1	0.15±0.03	0.2±0.06	0.16±0.01	0.15±0.03	0.2±0.04	0.18±0.08	0.13±0.03	0.1±0	0.15±0.05
	T2	0.2±0.04	0.2±0.07	0.25±0.06	0.14±0.02	0.18±0.05	0.1±0	0.15±0.05	0.15±0.05	0.1±0
Nitrate (ppm)	T0	0.63±0.19	1.38±0.11	1.7±0.42	1.38±0.08	2.13±0.17	1.93±0.05	1.3±0.16	1.98±0.03	1.10±0.26
	T1	1.2±0.23	1.15±0.29	1.88±0.08	1.73±0.10	1.6±0.20	1.98±0.03	1.42±0.55	1.93±0.05	1.23±0.38
	T2	1.33±0.34	1.43±0.19	1.5±0.18	1.23±0.32	1.8±0.23	1.68±0.13	0.78±0.31	1.65±0.12	1.45±0.23
Phosphate-phosphorus (ppm)	T0	0.1±0.01	0.08±0.01	0.08±0.01	0.07±0.01	0.08±0.01	0.09±0.01	0.08±0.01	0.15±0.01	0.12±0.01
	T1	0.26±0.01	0.24±0.02	0.23±0.01	0.21±0.02	0.19±0.01	0.21±0.02	0.22±0.01	0.16±0.02	0.14±0.01
	T2	0.26±0.01	0.25±0.02	0.24±0.02	0.24±0.02	0.22±0.01	0.21±0.01	0.21±0.01	0.14±0.01	0.12±0.01
Water chlorophyll-a (ppm)	T0	94.29±1.13	89.36±1.70	100.53±0.80	97.26±2.05	103.43±1.46	87.98±1.04	101.27±1.46	105.1±3.93	108.33±1.32
	T1	87.73±0.75	95.79±2.96	94.52±0.58	92.52±0.77	87.14±1.04	82.59±3.08	110.72±2.17	102.01±1.16	105.1±3.92
	T2	81.97±0.65	86.06±2.00	92.58±1.79	98.87±0.67	101.2±1.46	89.12±1.30	93.83±1.83	108.33±1.32	101.61±2.10

RESULTS AND DISCUSSION

Water quality parameters were analysed on fortnightly basis to detect any important changes that might have occurred in response to substrates of Saura Gach (Table 1). Mean± SE of different water quality parameters were also presented in (Table 2).

During the study period, water quality parameters of the experimental tanks were found to be within permissible limits recommended for warm water fish culture (Boyd, 1992).

Water temperature varied a very little over the entire period. Mean values were 24.03 ± 0.96, 24.60± 0.76 and 25.10 ± 0.70°C in T0, T1 and T2 respectively. Suitable range of water temperature for fish culture was 25°C to 35°C recommended by Aminul (1996). Rahman *et al,* (1982) found water temperature 26.06^{o}C to 31.97^{o}C which was within the suitable range for pond fish culture. Though slightly lower temperature was observed in tanks with substrate but did not showed significantly

Table 2. Mean (± SE) values of water quality parameters of different treatments.

Water quality parameters	(T0)	(T1)	(T2)
Temperature (^{0}C)	24.03±0.96	24.60±0.76	25.10±0.70
Transparency (cm)	23.85±0.80	23.58±0.58	22.64±0.99
pH	7.45±0.04	7.42±0.05	7.54±0.08
DO(ppm)	5.15±0.24	5.03±0.25	4.85±0.06
Total Alkalinity (ppm)	135.08±7.15	134.58±4.82	135.61±5.30
Total Hardness (ppm)	23.75±0.78	23.58±0.58	22.54±0.95
Nitrate- nitrogen (ppm)	1.5±0.16	1.57±0.10	1.43±0.10
Ammonia- nitrogen (ppm)	0.05±0.01	0.06±0.01	0.06±0.01
Phosphate- phosphorus (ppm)	0.10±0.09	0.20±0.01	0.21±0.02
Chlorophyll- *a* (ppm)	98.62±2.33	95.35±3.06	94.85±2.80

($p<0.05$) difference from other treatments. Lower temperature in substrate tanks could be attributed to the shading effect of substrates (Keshavanath *et al,* 2002).

The transparency of a water body normally indicates its productivity. It is usually affected by several factors such as silting, microscopic organisms, suspended organic matter, latitude, the season, and the intensity of sunlight. In the present study, average transparencies values were 23.85, 23.58, and 22.64 cm in T0, Tl, and T2, respectively. Addition of substrate showed significant ($p<0.05$) difference in transparency value with only feeding treatment but did not vary significantly ($p<0.05$) from control. It might be due to entrapping of organic detritus and dissolved suspended solids, remove nutrients from water column, organic matter breakdown by periphyton assemblage as stated by Azim *et al,* (2002). Periphyton substrates tend to entrap suspended organic material and it is likely to be more during supplementary feeding due to uneaten feed and fish faeces (Keshavanath *et al,* 2001). In treatment T2, transparency was found to be lowest among the all treatments which might be due to accumulation of left over feed, organic particles and fish faeces. In T2 treatment, transparency among all treatments was found to be lowest, which might be due to accumulation of leftover feed, organic particles, and fish faeces.

The average pH values were 7.45, 7.42 and 7.54 in T0, Tl and T2 respectively. The pH values were slightly in alkaline range in all the tanks which indicated good pH conditions for biological production and productivity. According to Boyd (1992), optimal pH range for fish pond should be in the range of 6.5 to 7.5. For fisheries the permissible pH range is 6.5-8.5 (EMECS, 2001)

Nitrite is an intermediate product of the bacterial process of aerobic nitrification, produced by the autotrophic Nitrosomonas bacteria which combine oxygen and ammonia. In any aquatic system, the ideal and normal measurement of nitrite is zero. Santhosh *et al*, (2015) recommended a concentration of nitrite in water not to exceed 0.5 ppm. The concentration of nitrite values in the present study was 0.1 ppm to 0.25 ppm which was in a permissible limit.

Nitrate is harmless and is produced by a combination of oxygen and nitrite from the autotrophic Nitrobacter bacteria. Nitrate is not considered lethal for use in aquaculture. In the presence of Nitrobacter, nitrite on further decomposition is converted to nitrate which is harmless. Santhosh *et al,* (2015) described the preferred nitrate range from 0.1 ppm to 4.0 ppm for fish cultivation. The nitrate level in the present study ranged from 0.63 ppm to 2.13 ppm, and was therefore within tolerable range.

Table 3. Initial and Final weight gain (g) ± SE of Jayanti Rohu and Amur common carp recorded at 15 days interval in different treatment groups during 120 days of culture period.

Treatment	Species	Sampling days								
		0 days (g)	15 days (g)	30 days (g)	45 days (g)	60 days (g)	75 days (g)	90 days (g)	105 days (g)	120 days (g)
T0	Jayanti Rohu	20.27± 0.45	25.37± 0.85	35.70 ± 1.51	50.99 ± 1.12	53.59 ± 0.67	59.14 ± 0.82	67.76 ± 1.16	78.81 ± 1.66	84.49 ± 1.38
	Amur Carp	14.61 ± 1.18	20.95 ± 1.16	16.08 ± 0.83	21.89 ± 1.73	30.39 ± 0.85	33.78 ±1.67	43.98 ± 0.52	52.87 ± 0.87	56.93 ± 1.64
T1	Jayanti Rohu	11.48 ± 0.11	17.30 ± 0.75	31.72 ± 1.06	43.64 ± 1.97	50.03 ± 0.57	54.95 ± 0.57	59.01 ± 0.57	69.06 ± 2.13	81.92 ± 1.58
	Amur Carp	11.72 ± 0.65	16.20 ± 0.67	23.56 ± 1.45	27.80 ± 2.01	33.39 ± 2.53	33.53 ± 1.09	39.24 ± 1.62	52.61 ± 0.93	53.98 ± 1.35
T2	Jayanti Rohu	14.53 ± 1.72	23.18 ± 1.40	31.16 ± 1.30	49.97 ± 0.66	61.65 ± 0.38	67.45 ± 0.92	74.75 ± 1.66	84.18 ± 2.03	96.69 ± 2.42
	Amur Carp	14.08 ± 3.37	16.08 ± 2.32	19.93 ± 2.42	22.47 ± 1.87	27.66 ± 1.59	33.11 ± 2.08	49.19 ± 0.80	60.93 ± 1.03	60.01 ± 1.94

*Values are given as mean ± SE (n=6)

In the present investigation mean values of ammonia- nitrogen in T0, T1 and T2 were found to be 0.05, 0.06 and 0.06 ppm respectively. Ammonia values in Tl and T2 were significantly lower ($p<0.05$) than the control treatment. Nitrogen values for ammonia however did not display any substantial difference ($p>0.05$) between T0 and T2. The concentration of ammonia-nitrogen was found to be slightly lower in Tl and showed substantially lower values ($p<0.05$) than all other treatments. Substrate allocation had a major effect on lowering the concentration of ammonia in Tl and T2. That could be due to higher periphyton assembly nitrification rates.

Langis *et al,* (1988) and Ramesh *et al,* (1999) reported that nitrification induced ammonia levels by the bacterial biofilms (periphyton) on the substrates. By converting highly nitrogenous toxins such as ammonia and nitrite into nitrate, nitrifying bacteria are known to improve the water quality (Rajkumar *et al*, 2016). Lower ammonia nitrogen value in substrate tanks could be attributed to nitrifying bacteria being established in the systems (Umesh *et al,* 1999). The chlorophyll-a content of water did not show any significant ($p<0.05$) difference among the treatments. The mean values were 98.62, 95.35 and 94.85 ppm in treatments T0, Tl and T2 respectively. Chlorophyll- a value in the treatment with only substrate found to be lower which might be due to the effect of periphyton acting on accumulation of dissolved organic particle making water more transparent. Mean chlorophyll-a concentration was higher in T0 but did not differ significantly from other treatments. This could be due to additional feed, which fertilized the tanks and increased the production of plankton (Azim *et al*, 2002).

Growth performance

The average body weight gain of Jayanti Rohu and Amur Carp at 15 days interval in different treatment groups during the entire culture period are presented in (Table 3). The average initial weights of Jayanti Rohu and Amur Carp were 20.27± 0.45 g and 14.61 ± 1.18 g; 11.48 ± 0.11 g and 11.72 ± 0.65 g; 14.53 ± 1.72 g and 14.08 ± 3.37 g in T0, T1 and T2 respectively. The average final body weight of Jayanti Rohu was 84.49 ± 1.38 g, 81.92 ± 1.58 g and 96.69 ± 2.42 g observed in T0, T1 and T2 respectively. Whereas the average final body weight of Amur Carp observed was 56.93± 1.64, 53.98 ± 1.35 and 60.01 ± 1.94 in T0, T1 and T2 respectively. The initial average net weights (mean± SE) were 17.44±2.83 g, 11.6±0.12 g and 14.31±0.23 g in T0, T1 and T2 respectively. After 120 days of experimental period, fishes were attained 70.71±13.78 g, 67.95±13.97 g and 78.35±18.34 g in T0, T1 and T2 respectively.

CONCLUSION

The present investigation showed that the periphyton-based aquaculture system could enhance the production by several folds compared to the conventional culture system. Thus, making the periphyton based aquaculture system more nutrients efficient. This could be a viable option, as periphyton has been used effectively by many fish species, thereby increasing aquaculture productivity. The development of such combination of conventional along with periphyton based culture technology appeared to be feasible and it could bring about major advances in the development of low cost farming in aquaculture.

REFERENCES

Acosta-Nassar M V, Morell J M and Corredor J E (1994). The nitrogen budget of a tropical semi-intensive freshwater fish culture pond. *J World Aquaculture Soc* **25**(2): 261-270.

AOAC (1995). *Official method of Analysis of the Association of Official Analytical Chemistry* .16th Edn., AOAC International, Washington, USA. 1141p.

Aminul I M (1996). *Qualities of water and soil in Aquaculture, Fish week compilation*, 96. DoF Publication, Ramna, Dhaka-1000.

APHA (2005). *Standard methods for the examination of water and waste water*. American Public Health Association. Washington DC.

Azim M E, Verdegem M C J, Khatoon H, Wahab M A, Van Dam A A and Beveridge M C M (2002). A comparison of fertilization, feeding and three periphyton substrates for increasing fish production in freshwater pond aquaculture in Bangladesh. *Aquaculture* **212**(1-4): 227-243.

Beveridge M C M, Wahab A and Dewan S (1994). Effects of daily harrowing on pond soil and water nutrient levels and on Rohu fingerling production. *The Prog Fish-Culturist* **56**(4): 282-287.

Boyd C E (1978). *Water Quality in Warm Water Fish ponds*. Auburn University. Craftmaster Printers, Opelika, Alabama.

Boyd C E (1992). *Water Quality Management for pond fish Culture*. Elsevier Science Publishers, B V, 1000 AH Amesterdam, The Netherlands, 316p.

EMECS (2001). Water Quality Conservation for Enclosed Water Bodies in Japan, International Centre for the Environmental Management of Enclosed Coastal Seas (EMECS) retrieved 20 April 2005 form:http://www.or.jp/

Gross A, Boyd C E and Wood C W (2000). Niloticus transformations and balance in channel catfish ponds. *Aquaculture Eng* **24**(1): 1-14.

Keshavanath P, Gangadhar B, Ramesh T J, Van Dam A A, Beveridge M C M and Verdegem M C J (2002). The effect of periphyton and supplemental feeding on the production of the indigenous carps Tor khudree and Labeo fimbriatus. *Aquaculture* **213**(1-4): 207-218.

Keshavanath P, Ramesh T J, Gangadhar B, Beverridge M C M, Van dam A A and Verdegem M C J (2001). On-Farm Evaluation of Indian Major Carp Production with Sugarcane Bagasse as substrate for Periphyton. *Asian Fisheries Sci* **14** : 367-376.

Langis R, Proulx D, De la Noüe J and Couture P (1988). Effects of a bacterial biofilm on intensive Daphnia culture. *Aquacultural Eng* **7**(1): 21-38.

Pauly D and Zeller D (2019). Agreeing with FAO: Comments on SOFIA 2018. *Marine Policy* **100**: 332-333.

Rahman S M, Shahin M A A, Chisty M A H, Rahman M M, Tareque A M H B and Hasan M M (1982). Growth performance of mirror carp (*Cyprinus carpio* var. *specularis*, Lacepede, 1803) fry fed with varying protein content feeds. *Our Nature* **10**(1): 17-23.

Rajkumar M, Pandey P K, Aravind R, Vennila A, Bharti V and Purushothaman C S (2016). Effect of different biofloc system on water quality, biofloc composition and growth performance in Litopenaeus vannamei (Boone, 1931). *Aquaculture Res* **47**(11): 3432-3444.

Ramesh M R, Shankar K M, Mohan C V and Varghese T J (1999). Comparison of three plant substrates for enhancing carp growth through bacterial biofilm. *Aquacultural Eng* **19**(2):119-131.

Santosh T C, Diniz G A, Brito A R D, Pires A J V and Franco M (2015). Effect of solid state fermentation on nutritional content and evaluation of degradability in cactus pear. *Revista Caatinga* **28**(3): 248-254.

Schroeder G L (1990). *Cow manuring in fish culture*. FAO *Aquacult Bull* **7:** (3-4).

Umesh N R, Shankar K M and Mohan C V (1999). Enhancing growth of common carp, Rohu and Mozambique tilapia through plant substrate: the role of bacterial biofilm. *Aquaculture Int* **7**(4): 251-260.

Received on 25/06/2020 Accepted on 14/08/2020