



EFFICACY OF ORGANIC FISH FARMING FOR SUSTAINABILITY

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ABSTRACT

The present study was conducted in nine earthen ponds, each measuring 0.015 ha, for a period of 280 days to evaluate and compare the growth parameters of Indian Major Carps (*Catla catla*, *Labeo rohita* and *Cirrhinus mrigala*) stocked with 10000 fingerlings ha⁻¹ with a stocking ratio of 1:1:1 in Normal Culture System (NCS) (with cow dung as fertilizer and without any supplementary feed and aeration); Conventional Culture System (CCS) (with commercial fish feed and organic and inorganic fertilizer and without aeration) and Organic Culture System (OCS) (with organic fertilizer and organic fish feed and without aeration). Each of the above culture practices was replicated thrice. Normal and Conventional ponds were fertilized with cow dung (15450 kg ha⁻¹), urea (31 kg ha⁻¹) and triple super phosphate (TSP) (16 kg h a⁻¹), while the organic ponds were fertilized with vermin compost (12443 kg ha⁻¹) and vermiwash (93.33 L ha⁻¹). Fertilization was done one week before stocking, and supplemented by fortnightly application of the same amount for the duration of the study period. In NCS, culture of Indian major carp was conducted without any supplementary feed. In CCS, commercial feed and antibiotics were used. The commercial fish feed was pelleted feed (2 - 4 mm diameter) manufactured by a local commercial Fish Feed Company. The main ingredients were Fish meal, Soybean meal, Mustard oil cake, Wheat flour and Vitamins and minerals with crude protein content at 32%. In OCS, organic fish feed was used. The organic fish feed contained earth worm meal, maize meal and soybean meal with crude protein content at 32%. The feed was applied at different water depths (0.7 m, 1.0 m and 1.13 m) using nylon rope and nylon bag for feeding of surface, column and bottom feeders. This procedure increased access for the different feeders to feed and it also minimized energy loss. No feeding was done during sampling time or in rainy days. Pelleted feed was fed twice a day (9.30 a.m. and 3.00 p.m.) in both conventional and organic ponds. The pelleted feed was provided at the rate of 5% of fish biomass up to 30 days, 3% up to 60 days, 2% up to 160 days, 1% up to the rest of the culture period. The experimental results showed that the survival rates of Indian major carps were similar in three culture systems (NCS, CCS and OCS). However, feed conversion ratio (FCR), specific growth rate (SGR) and total production of Indian Major Carps were significantly higher in organic culture system compared to conventional and normal culture systems. Further, water quality parameters were also found to lie in the desirable range in case of organic culture system. This study clearly proved that fish farming in organic culture system will not only improve the fish production but will also maintain good water quality throughout the culture period.

KEYWORDS: Indian Major Carps, Organic fish feed, Organic fish culture, Growth performance.

INTRODUCTION

Aquaculture has been remarkably successful in expanding production in the recent years, mainly due to the increasing demand for aquaculture products and the need for new food supplies (Demirak *et al.*, 2006). The major fish production systems in India and its neighboring countries mainly constitute Indian major carps viz. *catla* (*Catla catla*, Hamilton), Rohu (*Labeo rohita*, Hamilton), Mrigal (*Cirrhinus mrigala*, Hamilton). In India, Indian major carps are cultured mostly in extensive manner involving stocking and fertilization as the inputs. With the adoption of commercial farming method in recent years, fish production has been increased two to three folds. However, commercial fish farming is characterized by high stocking density of fish, heavy use of commercial formulated feed containing synthetic product, antibiotic and other harmful pharmaceuticals products. This has led to imbalance in pond ecosystem, resulting in degradation of aquatic environment (Holmer *et al.*, 2008), leading to increased risk to human health (Tacon and Metian, 2008).

Organic fish production has been the current trend for maintaining sustainability in fish production. Many studies have been carried out in organic fish farming utilizing organic manures as fertilizers (Behrends *et al.*, 1983; Mims *et al.*, 1991). A wide variety of organic manures such as grass, leaves, sewage, livestock manure, domestic wastes, night soil, dried blood meal have been used as a nutrient for growth of phytoplankton and zooplankton (Hickling, 1962; Steinberg *et al.*, 2006). Many researchers used organic fertilizers to increase the fish production. Yadava and Garg (1992) showed that an application of cow dung along with supplemental feed can increase the fish production to a substantial amount compared to cow dung treated ponds only or supplemental feed alone. Balasubramanian and Bai (1994) utilized biogas-plant effluent in fish polyculture. Total fish production was 6653 kg ha⁻¹ year⁻¹ without any supplementary fish-feed. Sahu *et al.* (2002) studied the use of water hyacinth compost as manure in nursery ponds for larval rearing of *Labeo rohita*. Better performance with regard to growth

and survivability of the larvae was recorded in the ponds treated with water hyacinth compost than in either the ponds treated with inorganic fertilizers or the ponds where no treatment was applied. Ghosh (2004) used three separate cemented tanks (6 m³ each) as control tank, vermicompost fertilized tank and inorganic fertilizer manured tank. Monoculture of fish was carried out with cat fish, *Clarias batrachus*. The produced earthworms were used as fish feed. Carter and Hauler (2000) reported that substitution of up to 33% soybean meal for fishmeal does not reduce growth rates of fish. It has also been suggested that substantial replacement of fishmeal with vegetable oil in fish diets is feasible in terms of growth performance (Thomassen and Røsjø, 1989; Greene and Selivonchek, 1990; Dosanjh *et al.*, 1998; Glencross, 2003). Pelletier and Tyedmers (2007) suggested that environmental impacts could be considerably lowered by reducing the proportions of fish and poultry derived ingredients in fish feed. Nandeeshha *et al.* (1988) used dried earthworm meal as a replacement for fish meal in a culture trial with common carp for a period of 84 days. It was found that fish meal partially replaced by earthworm meal and enriched with 5% sardine oil induced the best growth of fish. Nandeeshha *et al.* (2001) found that the replacement of fish meal by more than 25% Spirulina resulted in significantly superior growth of Rohu.

It can be noticed from the above discussion that most of the studies on organic farming of fish were conducted in laboratory scale. However, till date no study is reported on organic culture of Indian Major Carp in a large scale. The present study was conducted in nine earthen ponds, each measuring 0.015 ha, for a period of 280 days to evaluate and compare the growth parameters of Indian Major Carps (*Catla catla*, *Labeo rohita* and *Cirrhinus mrigala*) in Normal Culture System (NCS) (with cow dung as fertilizer and without any supplementary feed and aeration); Conventional Culture System (CCS) (with commercial fish feed and organic and inorganic fertilizer and without aeration) and Organic Culture System (OCS) (with organic fertilizer and organic fish feed and without aeration).

MATERIALS & METHODS

Experimental design

In the present study, Indian major carps were cultured for a period of 280 days following three different management practices - (a) Normal Culture System (NCS) (with cow dung as fertilizer and without any supplementary feed and aeration,) (b) Conventional Culture System (CCS) (with commercial fish feed and organic and inorganic fertilizer and without aeration) and (c) Organic Culture System (OCS) (with organic fertilizer and organic fish feed and without aeration). Each of the above culture practices was replicated thrice. Nine ponds each measuring 0.015 ha situated in the experimental farm of Agricultural and Food Engineering Department, IIT Kharagpur were used in the study. The ponds were made free of weeds; sun dried for about 15 days and then lime was applied at the rate of 200 kg ha⁻¹. All the culture ponds were filled with mini deep tube well water to a maximum depth of 1.5 m, and the same level was maintained throughout the study period by compensating the daily losses. Conventional ponds were

fertilized with cow dung (15450 kg ha⁻¹), urea (31 kg ha⁻¹) and triple super phosphate (TSP) (16 kg ha⁻¹) (Rahman *et al.*, 2006); while the organic ponds were fertilized with vermin compost (12443 kg ha⁻¹) and vermiwash (93.33 L ha⁻¹) (Chakraborty *et al.*, 2009). Fertilization was done one week before stocking, and supplemented by fortnightly application of the same amount for the duration of the study period.

Culture of Indian Major Carps

The fingerlings of three Indian major carps, Catla (*Catla catla*, Hamilton), Rohu (*Labeo rohita*, Hamilton,) and Mrigal (*Cirrhinus mrigala*, Hamilton) were stocked at the rate of 10,000 fingerlings ha⁻¹ with a ratio of 1:1:1. Seed stocks of equal size, good quality and disease free with good growth rate potential were selected for stocking (Xie *et al.*, 2011). The fish fingerlings were genetic modified organism (GMO) free and genetic engineering free (European Union, 2008; IFOAM, 2010). Fingerlings of the three species (catla, rohu and mrigal) were obtained from a tested local fish hatchery. Stocking was done in the early morning, generally, before 9.30 a.m. when the temperature of water was low. Before stocking, the fish seeds were kept in a 2% NaCl solution bath for 1-2 minutes and were then well acclimatized to pond water. The mean initial weights of catla, rohu and mrigal species were 25.5 ± 1.09 g, 22.5 ± 1.08 g and 21.3 ± 1.06 g respectively. In NCS, no feed was applied. In CCS, commercial feed and antibiotics were used. The commercial fish feed was pelleted feed (2 - 4 mm diameter) manufactured by a local commercial Fish Feed Company. The main ingredients were Fish meal, Soybean Meal, Mustard oil cake, Wheat flour and Vitamins and minerals with crude protein content at 32%. In OCS, organic fish feed was used. The organic fish feed contained earth worm meal, maize meal and soybean meal with crude protein content at 32%. The feed was applied at different water depths (0.7 m, 1.0 m and 1.13 m) using nylon rope and nylon bag for feeding of surface, column and bottom feeders. This procedure increased access for the different feeders to feed and it also minimized energy loss. No feeding was done during sampling time or in rainy days. Pelleted feed was fed twice a day (9.30 a.m. and 3.00 p.m.) in both conventional and organic ponds. The pelleted feed was provided at the rate of 5% of fish biomass up to 30 days, 3% up to 60 days, 2% up to 160 days, 1% up to the rest of the culture period.

Monitoring of Water quality Parameters

To monitor the physico-chemical parameters of water like water temperature, pH, dissolved oxygen (DO), water samples were collected at 09.00AM and 03.00 PM at alternate days. Dissolved oxygen and temperature were measured with the multi-parameter DO meter (YSI Dissolved Oxygen Meter) and pH with PCS Testr 35, the multi parameter (OAKTON). Total ammonia nitrogen (TAN), nitrite nitrogen, nitrate nitrogen, orthophosphate, BOD were analyzed once in a week according to the Standard Methods for Examination of Water and Wastewater (APHA, 2002) using a UV spectrophotometer (UV-1700 Spectrophotometer, SHIMADZU).

Determination of fish growth parameters

More than 50% of the fish of all the tanks were sampled fortnightly and individual measurements were taken to

determine the fish yield parameters. The major fish growth parameters included: i) specific growth rate (SGR), ii) feed conversion ratio (FCR), iii) protein efficiency ratio

(PER). These parameters were calculated using the following equations:

$$SGR (\% \text{ body weight / day}) = 100 \times \frac{\ln(\text{final weight} - \text{initial weight})}{\text{culture period (days)}} \dots (2.1)$$

$$FCR = \frac{\text{amount of fed (dry weight basis)}}{\text{net weight gain (wet weight basis)}} \dots (2.2)$$

$$PER = \frac{\text{net weight gain (wet weight basis)}}{\text{amount of protein dosed (dry weight basis)}} \dots (2.3)$$

Statistical analysis

Data of different water quality and fish growth parameters were analyzed by one-way ANOVA with different culture systems as the factor. Post-hoc comparisons were made using Duncan’s new multiple range test (Duncan, 1955) to detail the significant differences among the treatments (p < 0.05). All statistical analyses were performed using SPSS version 17.

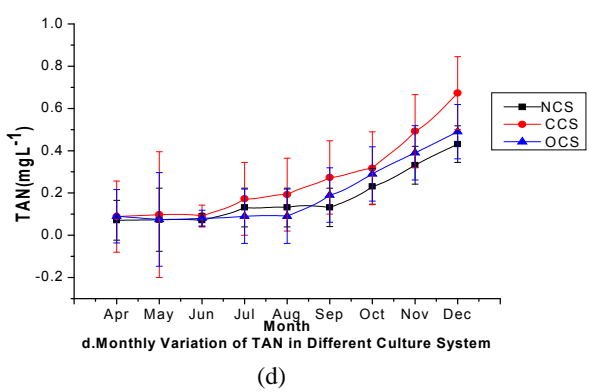
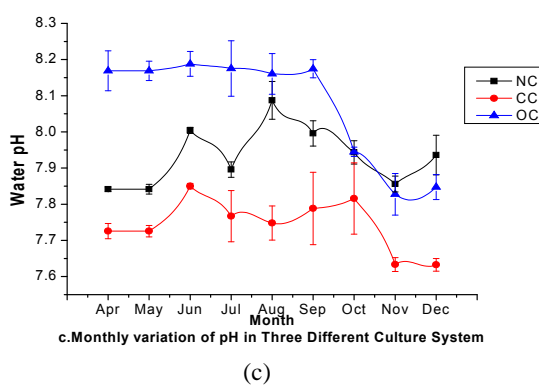
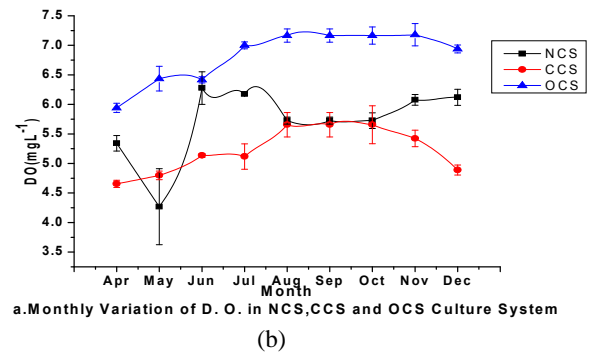
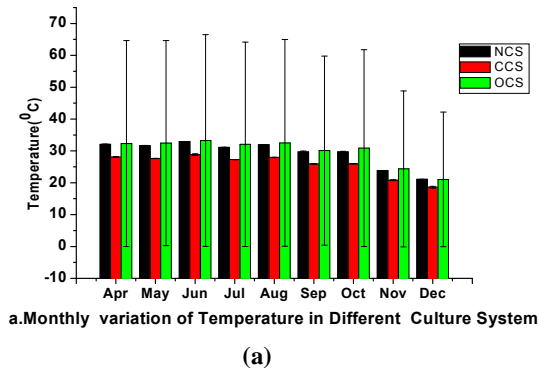
RESULTS & DISCUSSION

The results obtained by conducting experiments and analyzing the data are presented and discussed in this section.

Water quality parameters

The mean (± standard deviation) values of various water quality parameters, as stated in Section 2.3, are presented in Table 1, whereas their monthly variations are shown in Fig 1(a-h). The temperature remained almost same for all

the culture systems. In case of dissolved oxygen (DO), the ranges were found to be 4.56 – 6.78, 4.59 – 5.86 and 5.88 – 7.78 for NCS, CCS and OCS respectively. The higher concentration of DO in case of OCS was due to presence of natural hydrilla (*Hydrilla* sp.) plant which produced enough amount of dissolved oxygen in organic fish pond during photosynthesis. The pH in all the culture systems followed almost the same pattern. In case of total ammonia nitrogen (TAN), the concentrations in all the cases were well within the acceptable limit of 1.0 mg/L. In case of CCS, the maximum recorded value of TAN was 0.672 mg/L, followed by 0.490 mg/L for OCS and 0.431 mg/L for NCS. In case of nitrate-nitrogen, nitrite-nitrogen and orthophosphate, the maximum values for all the culture systems were well within the desirable ranges probably due to low stocking density of 10,000 numbers of fish per hectare.



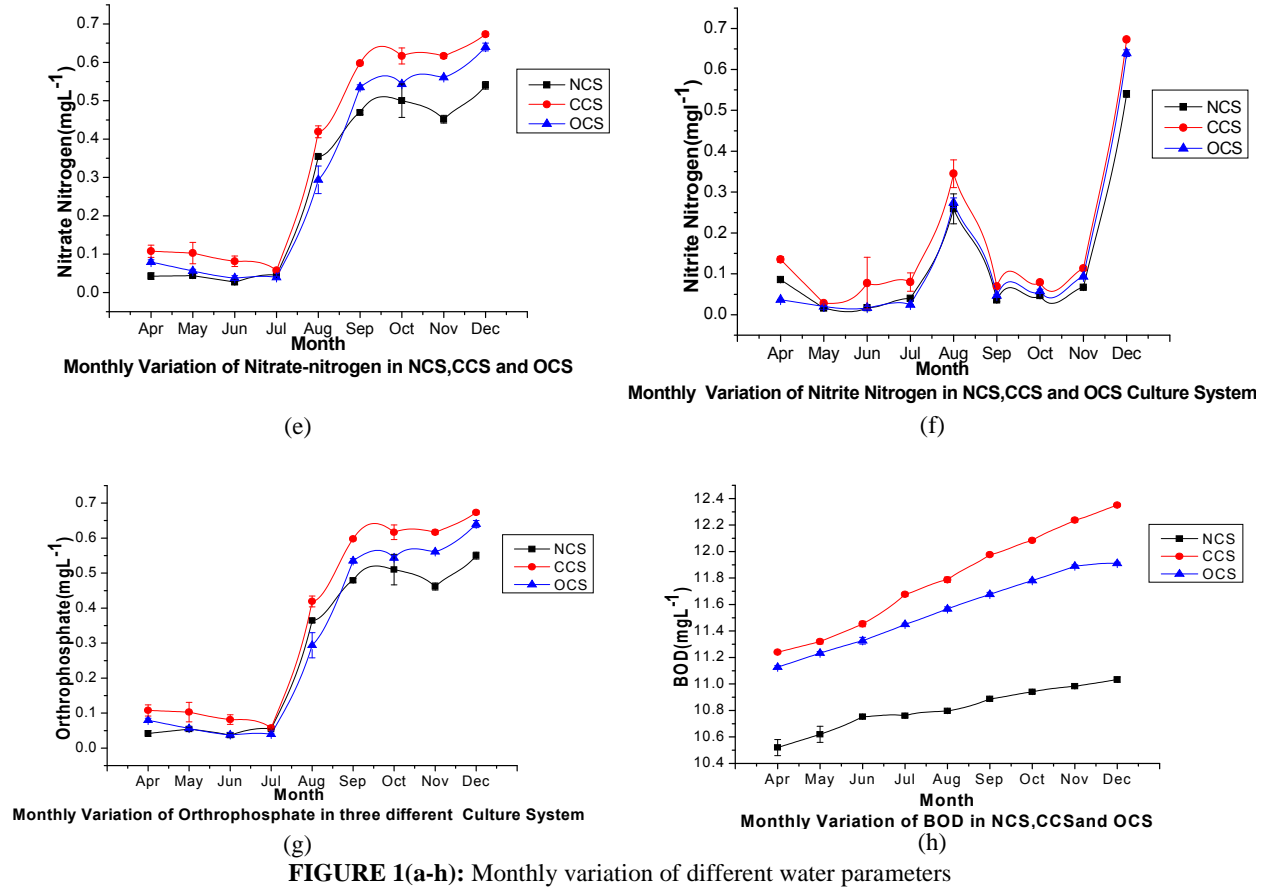


FIGURE 1(a-h): Monthly variation of different water parameters

TABLE 1: Mean (\pm SD) water quality values recorded for NCS, CCS and OCS culture systems

Parameters	NCS	CCS	OCS
Temperature (C^0)	29.32 \pm 0.032 ^a	29.32 \pm 0.058 ^a	29.82 \pm 0.076 ^a
Dissolved Oxygen ($mg L^{-1}$)	5.93 \pm 0.06 ^b	5.22 \pm 0.11 ^a	6.87 \pm 0.35 ^c
pH	8.64 \pm 0.11 ^a	7.77 \pm 0.21 ^a	8.08 \pm 0.27 ^a
TAN (mgL^{-1})	0.089 \pm 0.029 ^a	0.172 \pm 0.059 ^c	0.130 \pm 0.044 ^b
Nitrate Nitrogen (mgL^{-1})	0.274 \pm 0.21 ^a	0.363 \pm 0.25 ^c	0.309 \pm 0.26 ^b
Nitrite Nitrogen (mgL^{-1})	0.1264 \pm 0.16 ^a	0.1778 \pm 0.20 ^b	0.1344 \pm 0.20 ^a
Orthophosphate (mgL^{-1})	0.42 \pm 0.016	0.52 \pm 0.0350	0.49 \pm 0.028
BOD (mgL^{-1})	10.81 \pm 0.16 ^a	11.79 \pm 0.40 ^b	11.55 \pm 0.28 ^b

Note-Mean water quality values for of NCS, CCS and OCS culture systems (mean \pm SD). Mean values followed by different letters in the same row are different by Tukey HSD^a test, Turkey B^a ($p < 0.05$)

TABLE 2: Mean (\pm SD) values of initial and final weights of fish (g) for different treatments

Fish Species	Culture System	Survival	Initial Weight (g)	Final weight (g)	Weight gain (g)
Catla	NCS	100%	25.22 \pm 0.95	112.75 \pm 3.56	87.53
	CCS	100%	25.18 \pm 0.98	629.7 \pm 5.66	604.52
	OCS	100%	25.25 \pm 0.98	709.55 \pm 4.32	684.3
Rohu	NCS	100%	21.23 \pm 0.93	253.2 \pm 3.03	231.97
	CCS	100%	21.18 \pm 0.97	669.7 \pm 5.52	648.52
	OCS	100%	21.27 \pm 0.98	708.41 \pm 4.23	687.14
Mrigal	NCS	100%	20.1 \pm 0.91	221.67 \pm 3.04	201.57
	CCS	100%	20.03 \pm 0.96	503.73 \pm 5.32	483.7
	OCS	100%	20.13 \pm 0.95	547.73 \pm 4.21	527.6

Initial and final harvested size of fish

The initial stocking weight (g) of fish and final harvested weight (g) for different culture system of NCS, CCS and OCS are presented in Table 2. It can be seen from the table that the organic culture system (OCS) contributed greater individual weight gain and net fish production compared to the corresponding CCS and NCS treatments. The individual fish growth is more in CCS culture compared to control treatment confirming the utilization of fish feed for growth of fish in both the treatments. Fishes stocked in the experimental ponds were selected to have the same mean initial weight for different treatments. However, at harvest the highest individual fish weight was recorded in OCS culture followed by CCS and NCS.

The harvested weight of fish in all the culture systems with different types of fish species were significantly different from each other ($p < 0.05$). The growth of Catla, Rohu and Mrigal in three different culture systems varied significantly. Growth of different species of fish is

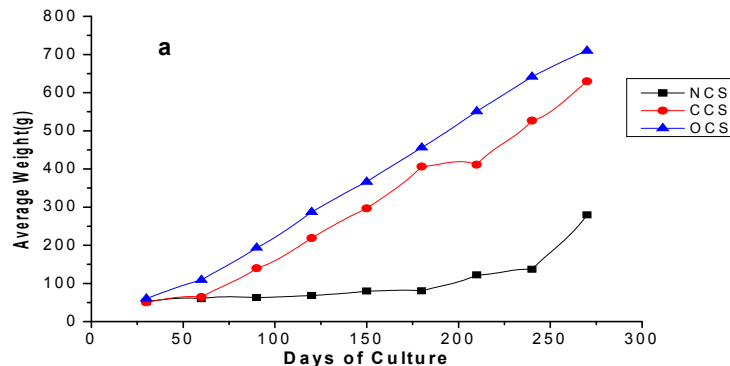
presented in Fig. 2 (a-c). In OCS, parameters like dissolved oxygen (DO), total ammonia nitrogen (TAN), nitrite nitrogen, nitrate nitrogen, orthophosphate etc. were of better quality than CCS. Studies conducted at China (Xie *et al.*, 2011b; Xie *et al.*, 2005) with organic shrimp culture, indicated similar trends. The harvested organic shrimp had a higher mean body length, mean fresh body weight and mean dry body weight compared to that of conventional culture.

Specific growth rate

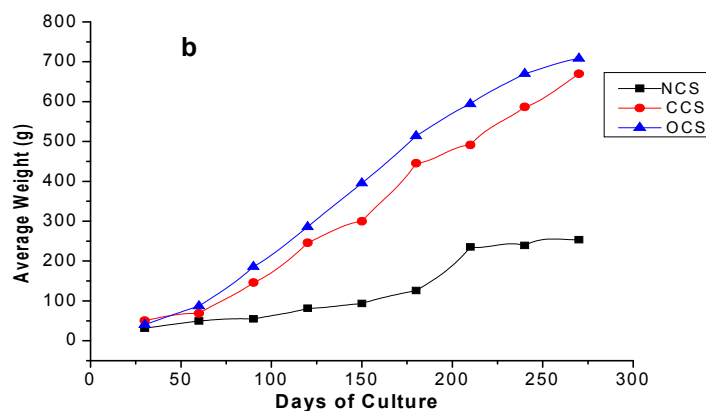
The specific growth rate (SGR) of Indian major carps in different treatments is presented in Table 3. The highest value of SGR (1.29% day⁻¹) was obtained in Rohu with OCS treatment. Specific growth rate trend is presented in Fig. 3 (a-c). These results clearly show that organic culture of fish will not only improve the water quality of the culture ponds, but also will increase the growth rate as well as the production rate.

TABLE 3: Observed mean (\pm SD) values of specific growth rate (%day⁻¹) in different treatments

Fish Species	SGR (%day ⁻¹)					
	Culture System					
	NCS		CCS		OCS	
	Mean \pm SD	Range	Mean \pm SD	Range	Mean \pm SD	Range
Catla	0.891 \pm 0.93	0.053-2.08	1.19 \pm 0.81	0.041-2.59	1.235 \pm 0.86	0.334-2.899
Rohu	0.918 \pm 0.69	0.053-2.080	1.279 \pm 0.92	0.328-2.875	1.298 \pm 0.91	0.185-2.544
Mrigal	0.889 \pm 0.58	0.126-1.893	1.194 \pm 1.01	0.121-3.284	1.224 \pm 1.80	0.012-3.724



a. Growth Performance of Catla in NCS, CCS and OCS Culture System



b. Growth Performance of Rohu in three different Culture System

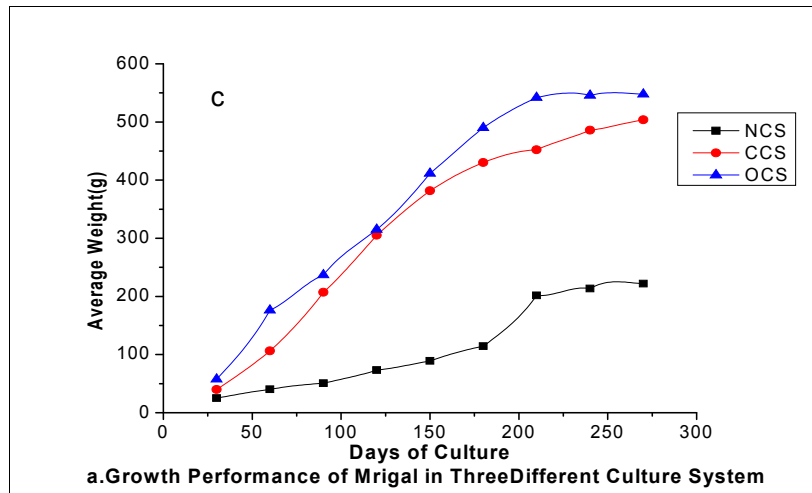
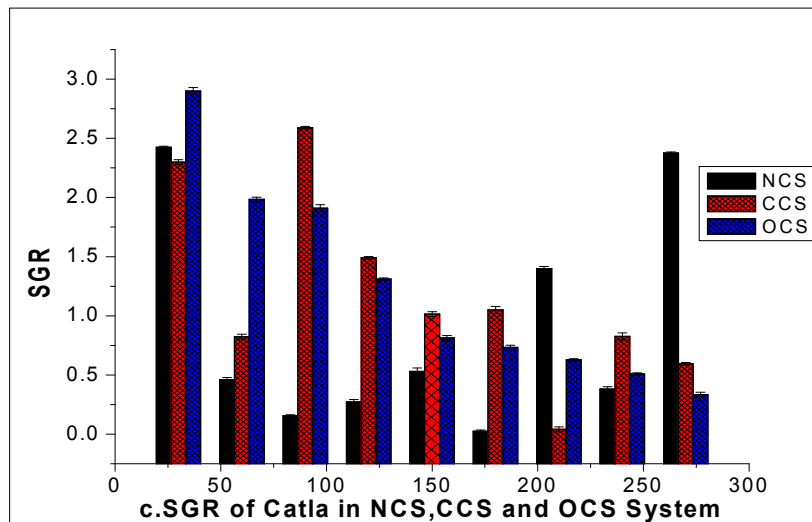
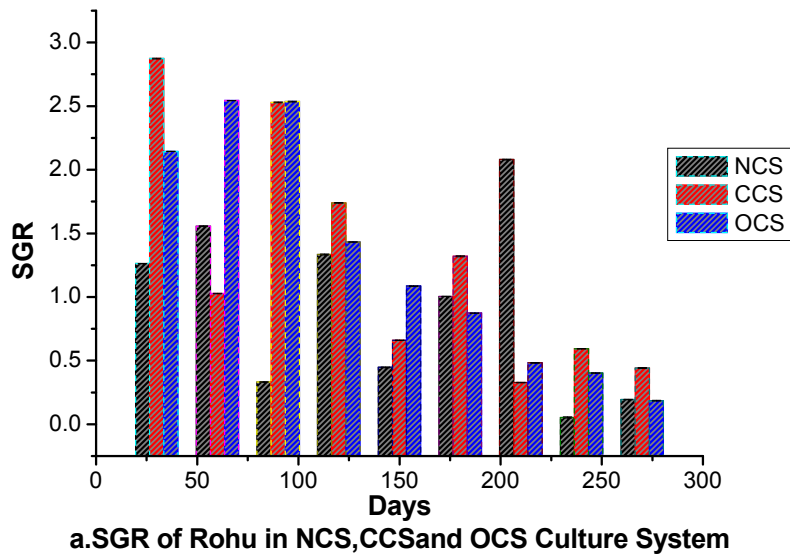


FIGURE 2 (a-c): Growth Performance of Catla, Rohu and Mrig in Different Culture Systems



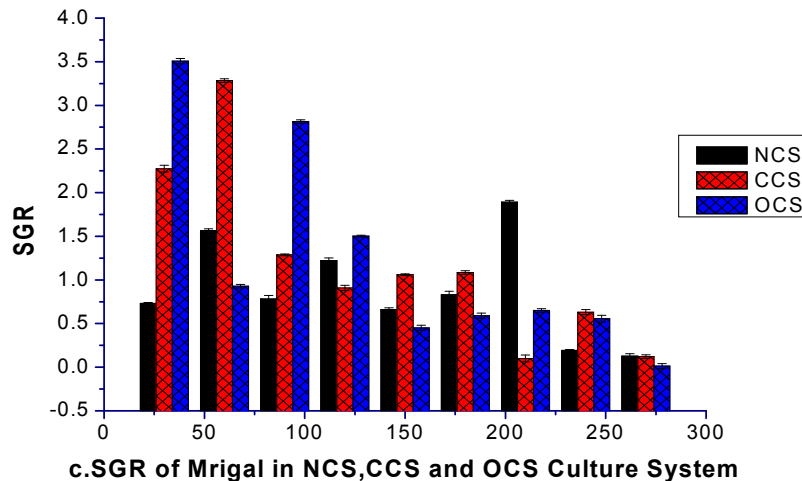


FIGURE 3(a-c): Specific growth rate of Calta, Rohu and Mrigal fish in different culture systems

CONCLUSION

The efficacy of input management practices (organic, conventional, and natural) on Indian major carp culture could be established through the study. Based on the study, the following conclusions can be drawn:

1. Organic culture system helps to maintain better pond water quality compared to the traditional and commercial culture system.
2. The fish biomass produced using organic fish feed is significantly higher than that of other culture systems.
3. The fish produced using organic earth worm meal, organic soybean meal, and other ingredients following organic guidelines provides a balanced nutritional value and there is no detrimental effect on fish health and aquatic environment.
4. On the basis of the study, organic culture practice for IMC is strongly recommended for long term benefit in terms of quality product, human health and protection of environment.

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Abbreviations

- NCS Natural Culture System
 CCS Conventional Culture System
 OCS Organic Culture System
 D O Dissolved Oxygen
 FCR Feed Conversion Ratio
 SGR Specific Growth Rate