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Effect of Supplementary Feed, Fertilizer and Physico-Chemical Parameters on Pond Productivity Stocked With Indian Major Carps in Monoculture System

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Abstract.- A study was conducted to evaluate the effect of supplementary feed, fertilizers and physico-chemical parameters on the primary and secondary productivity of earthen ponds stocked with Indian major carps (*Catla catla, Labeo rohita* and *Cirrhinus mrigala*) under monoculture system. Three fish species (350±15 g) were stocked at 70fish/pond for 90 days. Each species had three treated and one control pond. The control ponds received only organic and inorganic fertilizers, while treated ponds of all the fish species received organic and inorganic fertilizers along with supplementary feed. Pond productivity in terms of chlorophyll-*a* estimation, phytoplankton and zooplankton abundance were studied on daily as well as on weekly basis. Results of the study revealed that chlorophyll-*a* concentration significantly varied in fish ponds (*Cirrhinus mrigala,* F = 52.91, *Labeo rohita,* F = 20.00 and *Catla catla,* F = 11.73) and higher in treated than control ponds on daily basis. Whereas chlorophyll-*a* concentration on weekly basis was found significantly higher in ponds containing *Cirrhinus mrigala* (F = 40.14) and non-significant in *Labeo rohita* (F = 2.98) and *Catla catla* (F = 0.75). The diversity indices (diversity, equitability and Simpson index) of phytoplankton and zooplankton were significantly higher in treated versus control ponds. The order of abundance among 23 species of phytoplankton recorded during the study period were; Cyanophyceae > Englenophyceae > Bacillariophyceae. In conclusion, supplementary feed along with fertilizers and higher temperature significantly enhanced natural productivity of ponds compared to fertilizers alone.

Keywords: Indian major carps, artificial feed, chlorophyll-*a*, pond productivity.

INTRODUCTION

Pond productivity both in marine and freshwater ecosystems is basically controlled by three factors: nutrients availability, light and response of the algae to nutrients and light (Kelly and Naguib, 1984). The direct effect of nutrient enrichment results in blooming of phytoplankton. The dynamic feature of water bodies (colors, clarity, trophic state, zooplankton and fish production) depends on the availability of phytoplankton (Goldman and Horne, 1983). Since plankton population vary greatly in their size distribution but numbers alone do not give adequate picture of population dynamics or diversity and structure of the ecosystem (APHA, 1980). The use of photosynthetic pigments as forecasters of algal biomass is widely known due to pigments specificity of certain plants (Fogg, 1975; Moses, 1979). Among all the pigments, chlorophyll-*a* is the most widely used measure of phytoplankton biomass. The most important reason for preferring chlorophyll-*a* in phytoplankton biomass determination is due to a main photosynthetic pigment in all photosynthetic organisms while other algal pigments (chlorophyll *b* and *c*, carotenoids and phycobillins), have limited distribution and are, therefore, considered as secondary pigments (Akpan, 1994).

Phytoplankton populations are generally controlled by physical and chemical variables which are responsible for their abundance, composition and heterogeneity (El-Ayouty *et al*., 1999; Ahmad *et al*., 2001; Ibrahim *et al*., 2003). Increase in fish production in fertilized ponds is directly attributed to the increase in pond primary productivity which in turn, increases secondary productivity (zooplankton); thereby producing greater yields of fish (Seymour, 1980; Diana *et al*., 1991; Ahmad *et*

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al., 2001; Abdel-Tawwab *et al*., 2002a,b). Indian major carps are basically herbivorous in nature and prefer to feed on planktons (Khan *et al.*, 2011). The availability of natural planktonic food and ecological conditions in the pond are the basic need for best production (Jena *et al.*, 2001). The natural productivity of pond is increased with the application of organic and inorganic fertilizers and increasing the essential nutrients available to the lower portion of food chain, the bacteria and phytoplankton. This in turn provides maximum food for higher trophic levels resulting finally in higher fish production per unit area in the water. Artificial feed increases the carrying capacity of the culture systems and can increase fish production by many fold (Hepher, 1975; Devaraj *et al.*, 1986). Artificial feed benefits fish not only through direct utilization but also indirectly through increased plankton productivity (Javed *et al.*, 1993). Keeping in view the above mentioned facts present study is, therefore, planned with a view to evaluate the effect of supplementary feed, fertilizers and physcio-chemical parameters on pond productivity stocked with Indian major carps.

MATERIALS AND METHODS

Experimental site

The experiment was conducted at Fisheries Research and Training Facilities, Department of Fisheries and Aquaculture, UVAS Ravi Campus, Pattoki. Experimental fish Indian major carps (*Catla catla*, *Labeo rohita* and *Cirrhinus mrigala*) average weight (350±15g) were stocked at 70fish/pond having an area of 0.03 ha. Each species had three treated and one control pond. Organic manure (cow dung and poultry manure was applied at 90kg/pond and 45 kg/pond and inorganic 2.5 kg single super phosphate (SSP) and 1.5 kg Urea/pond) as initial dose and same was repeated fortnightly both in treated and control ponds. Supplementary feed 35% crude protein was applied at 3% fish body weight/ day twice 9:00 a.m. and 4:00 p.m. in the treated ponds only.

*Determination of chlorophyll-*a

The primary productivity in terms of chlorophyll-*a* concentration and phytoplankton counts was done. Chlorophyll-*a* concentration was determined on daily and weekly basis. Estimation of chlorophyll-*a* was carried out on weekly basis from September to November and on daily basis for fifteen days to check the fluctuations continually. For this purpose subsurface water samples (0.3m depth) were collected randomly from the experimental ponds with the help of plastic sample bottles. Subsurface water samples (100 ml) were used for filtration within one hour of collection. After filtration, the filtrate blotted with absorbent paper placed in centrifuging tube containing 10ml acetone (90%) and placed in dark chilled environment for 48 hours. After complete chlorophyll extraction the sample extract was mixed with vortex mixer for 5 min. The extract was then centrifuged for 5 min at 5000rpm. The supernatant was poured into the spectrophotometer cuvette carefully for measuring the absorbance of chlorophyll-*a* at 664nm, 647nm and 630nm. However, secondary productivity was observed to identify and count different species of zooplankton. Planktons were collected, fixed, identified and counted with the help of Sedgwick rafter cell counter up to the highest taxonomic unit under the microscope (Micros Austria AC230V, Austria) at low and high power. For this purpose subsurface water samples were collected and filtered by using glass-fiber membrane filter paper (Whatman GF/C type, 47 mm in diameter) at a pressure of 0.7 bars. Filter paper was placed in chilled environment in 10 ml acetone (90%) until complete extraction of chlorophyll. Extract was mixed with the help of vortex mixer and centrifuged at 5000 rpm for five minutes. The absorbance of supernatant was recorded at 664 nm, 647 nm and 630 nm by spectrophotometer.

Concentration of chlorophyll-*a* (CHL) was measured by following formula:

$$\text{Chlorophyll-}a = E664\text{-}E647\text{-}E630$$

Biological diversity

Taxonomic diversity indices of phytoplankton and zooplankton were estimated by most common Shannon-Weinner diversity index, equitability, and Simpson index (Gao and Song, 2005).

Diversity index (H)

Shannon-Weiner diversity index was determined by using formula:

$$H' = \sum p_i * \log_2 p_i$$

Where p_i is equal to n_i/N

Equitability (E)

$H_{max} = -S\ (1/s \log_2 1/s) = S$

Where S is number of species

Equitability can be defined as the ratio.

$E = H'/H_{max}$

Simpson's index (D)

Simpson's index is calculated as follows:

$D = \sum (n_i/N)^2$

Water quality parameters

Water quality variables were determined by following APHA (1998). Temperature and dissolved oxygen was measured with DO meter YSI 58 Oxygen meter (Yellow Spring Instrument Co., Yellow Springs, Ohio, USA), pH with pH meter (LT-Lutron), electrical conductivity (Condi 330i WTW 82362 Weilheim Germany) and light penetration with Secchi disk were monitored on daily basis.

Statistical analysis

Data was analyzed by using Minitab 13.2 version statistical package. The data of planktons were statistically analyzed using completely randomized design (CRD) and analysis of variance (ANOVA) technique (Steel *et al.*, 1997). Pearson correlation was used to find out relationship among various parameters.

RESULTS

*Comparison of chlorophyll-*a *estimation in different ponds*

Chlorophyll-*a* concentration observed on weekly basis in ponds treated with supplemented feed and fertilizers containing *C. catla* was 0.769 µg/L compared to control 0.669µg/L, while in *L. rohita* ponds receiving supplemented feed and fertilizers (0.738 µg/L) compared to control (0.596 µg/L) and were found non-significantly different (F = 0.78 and F = 2.98). The amount of chlorophyll-*a* in *C. mrigala* ponds treated supplemented feed and fertilizers (2.513 µg/L) was found significantly higher (F = 40.14) than control pond (0.704 µg/L) (Fig. 1). However, results of chlorophyll-*a* concentration on daily basis revealed a significant difference (F = 93.91) among the treated and control ponds of *C. catla, C. mrigala* and *L. rohita* (Fig. 2).

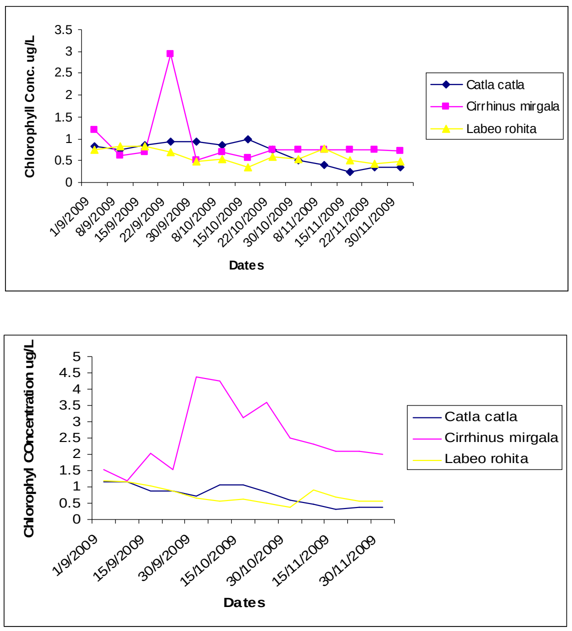
Abundance of phytoplankton and zooplankton

The main phytoplankton groups recorded were Bacillariophyceae (diatoms), Cyanophyceae (blue-green algae) and Euglenophyceae (euglenophytes). Phytoplankton abundance followed the order of Cyanophyceae > Euglenophyceae > Bacillariophyceae. A total of 23 species were recorded during the study period. The percentage distribution of species of algae was highest in treated pond of *C. mrigala* followed by *L. rohita* (Table I). The blue-green algae was observed the most diversified algae, the least being Euglenophytes.

The recorded zooplanktonic organisms were rotifers, copepods, cladocerans and crustacean larvae. There was marked difference in the density of total zooplankton in the eight ponds. Highest numbers of copepods were observed in September, and the lowest in November. The average values of diversity index, equitability and Simpson index of current study revealed highest in ponds containing *C. mrigala* followed by *C. catla* and *L. rohita,* respectively (Table I).

*Correlation of physico-chemical parameters and chlorophyll-*a *concentration*

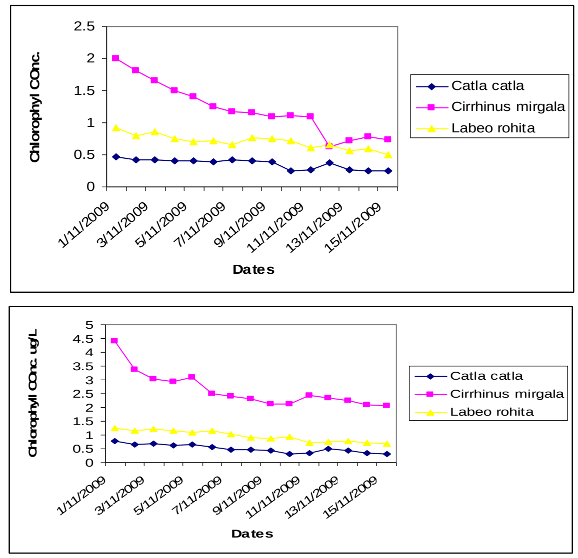
In current study, chlorophyll-*a* showed a positive and highly significant correlation with temperature while, a positive non-significant correlation with salinity, total dissolved solid (TDS), electrical conductivity (EC), dissolved oxygen (DO), pH and light penetration (LP) in *C. catla* ponds (Table II). In *C. mrigala* ponds the chlorophyll-*a* concentration revealed a significant positive correlation with salinity, TDS, EC and pH and non-significant negative correlation with temperature, DO, and LP (Table II). In *L. rohita* ponds the concentration of chlorophyll-*a* indicated positive significant correlation with temperature and TDS but it has significant negative correlation with LP. Chlorophyll showed positive non-significant



A

B

Fig. 1. Weekly variation of chlorophyll-*a* concentration in *Catla catla, Cirrhinus mrigala* and *Labeo rohita* control (A) and treated ponds (B).



A

B

Fig. 2. Daily variation of chlorophyll-*a* concentration in *Catla catla, Cirrhinus mrigala* and *Labeo rohita* in control (A) and treated ponds (B).

correlation with pH but it has negative non-significant correlation with salinity, EC and DO (Table II).

Table I.- Comparison of phytoplankton and zooplankton abundance in experimental fish ponds.

Species	Pond	Diversity (H)	Equitability (E)	Simpson index (D)
Phytoplankton				
Catla catla	Treated	4.0629	0.971	0.0354
	Control	3.8418	0.9622	0.0355
Cirrhinus mrigala	Treated	4.3162	0.9779	0.0222
	Control	3.9003	0.8483	0.0214
Labeo rohita	Treated	4.366	0.9782	0.0241
	Control	4.1442	0.98	0.0201
Zooplankton				
Catla catla	Treated	4.0474	0.9746	0.0233
	Control	3.6446	0.9655	0.0323
Cirrhinus mrigala	Treated	4.3157	0.9812	0.0204
	Control	3.8773	0.9798	0.0193
Labeo rohita	Treated	4.0779	0.9377	0.0336
	Control	3.9593	0.9679	0.0283

Table III.- Pearson correlations co-efficient relationship of chlorophyll-*a* with physico-chemical parameters in pond stocked with *Catla catla, Cirrhinus mrigala* and *Labeo rohita*.

Parameters	Salinity	Temperature	TDS	EC	DO	pH	LP
Catla catla							
Temperature	0.300						
	0.137						
TDS	**0.406**	0.274					
	0.040	0.175					
EC	**0.387**	-0.001	**0.418**				
	0.051	0.998	**0.033**				
DO	0.339	0.103	-0.035	-0.020			
	0.091	0.617	0.866	0.921			
pH	-0.191	0.007	**0.389**	-0.013	-0.379		
	0.350	0.975	**0.050**	0.951	0.056		
LP	**-0.405**	0.210	-0.326	**-0.652**	-0.158	-0.045	
	0.040	0.303	0.104	**0.000**	0.442	0.829	
CHL	0.239	**0.837**	0.678	0.111	-0.051	0.143	0.103
	0.239	**0.000**	0.085	0.589	0.805	0.485	0.618
Cirrhinus mrigala							
Temperature	0.060						
	0.771						
TDS	0.193	0.255					
	0.344	0.209					
EC	0.278	0.011	**0.591**				
	0.169	0.957	**0.001**				
DO	0.206	0.118	0.333	-0.081			
	0.313	0.565	0.097	0.696			
pH	**0.582**	-0.034	0.127	0.145	-0.104		
	0.002	0.871	0.536	0.480	0.615		
LP	-0.060	-0.034	0.072	0.343	-0.103	-0.361	
	0.772	0.871	0.726	0.086	0.616	0.070	
CHL	**0.554**	-0.049	0.393	**0.540**	0.026	**0.594**	-0.097
	0.003	0.811	0.047	**0.004**	0.899	**0.001**	0.638
Labeo rohita							
Temperature	-0.326						
	0.104						
TDS	-0.063	0.480					
	0.759	0.013					
EC	-0.056	0.086	-0.209				
	0.787	0.674	0.306				
DO	0.257	0.115	-0.024	0.064			
	0.205	0.577	0.906	0.756			
pH	0.057	0.241	0.128	0.049	**0.642**		
	0.783	0.236	0.534	0.812	**0.000**		
LP	0.187	-0.442	**-0.623**	0.303	0.438	-0.083	
	0.360	0.024	**0.001**	0.133	0.025	0.688	
CHL	-0.029	**0.597**	**0.572**	-0.135	-0.108	0.150	**-0.660**
	0.889	**0.001**	**0.002**	0.511	0.600	0.465	**0.000**

Cell Contents: Pearson correlation P-Value

DISCUSSION

The amount of chlorophyll-*a* in *C. catla* ponds during current study was lower compared to *C. mrigala* and *L. rohita*. Due to lesser production of phytoplankton in *C. catla* ponds the numbers of zooplankton were also very low. According to Turker *et al*. (2003) the impact of planktonic filter feeding fish, rate of growth and zooplanktonic predation significantly affected planktonic abundance. The higher amount of chlorophyll-*a* in *C. mrigala* pond is due to its bottom feeding habit which mostly consumes organic matter/detritus and might allowed an increased bloom of phytoplankton, zooplankton and chlorophyll-*a* concentration. During this three month study period from September to November a high value of chlorophyll-*a* was determined in the month of September compared to October and November. Positive significant correlation of chlorophyll-*a* concentration with temperature revealed this fact that temperature has greatly affected the abundance of phytoplankton, zooplankton and chlorophyll-*a* concentration in the experimental ponds. Contrary to our results, Abdel-Tawwab *et al.* (2005) reported that stripped mullet ponds receiving organic and inorganic manures (control) and fertilizers along with supplementary feed (treated) were found significantly higher in abundance of phytoplankton and zooplankton. They recorded maximum numbers in November in control and T1 while the minimum in September and October in T2. The higher amount of chlorophyll-*a* and planktonic abundance on daily basis in present study in treated ponds might be related to the availability of higher amount of nutrients such as nitrogen and phosphorous (supplementary feed) along with organic and inorganic manures (Kelly and Naguib, 1984).

Results of the current study regarding group dominancy are in harmony with the findings of Abdel-Tawwab *et al.* (2005) who reported Bacillariophyceae, Chlorophyceae, Cyanobacteria, and Euglenophyceae in treated and control groups. The recorded zooplanktonic organisms were rotifers, copepods, cladocerans and crustacean larvae. There was marked difference in the density of total zooplankton in the eight ponds. Highest numbers of the copepods were observed in September, and the lowest in November. *Cyclops* were the most dominant group in all ponds during study period while Abdel-Tawwab *et al.* (2005) reported that cyclops were dominant in December. Similar pattern of zooplankton groups, cladocera, copepods and rotifers were observed by Abdel-Tawwab *et al.* (2005) with cladocera as the dominant zooplankton compared to copepods and rotifers which exhibited lower abundance in all treatments. Jeppesen *et al*. (2004) relate low zooplankton biomass during winter season with low turnover, low fecundity, food shortage and low hatchability from resting eggs.

During this study due to higher temperature in September an increased amount of planktonic abundance was observed while subsequent reduction was noticed during low temperature in the month of November. A similar trend of planktonic abundance with relation to temperature fluctuation was reported by Ahmad *et al*. (2001), Ibrahim *et al*. (2003) and Abdel-Tawwab *et al.* (2005). The correlation studies of physico-chemical parameters and chlorophyll-*a* concentration during current study are in harmony with Hutchinson (1967) and Wetzel (1983) who reported that light, temperature and nutrients play a significant role in phytoplankton productivity in aquatic environments.

CONCLUSION

It has been concluded that application of supplementary feed along with organic and inorganic fertilizers during higher temperature significantly enhanced ponds natural productivity compared to organic and inorganic fertilizers alone. However, higher temperature also plays an important role in increasing pond productivity that in turn results higher fish production.

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