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Effect of fertilizers and supplementary feeding on water quality and plankton productivity in fish ponds under uniform fish stocking density

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Abstract

Studies were conducted to investigate the effects of different fertilizers and supplementary feed on water quality parameters. Dissolved oxygen levels were higher in nutrient rich and plankton dense ponds. There were quite minor variations in water quality parameters among treatments and different seasons of the year. Values of alkalinity and hardness remained same irrespective of the type of input. Total solids were much higher in those ponds with both types of fertilizers and supplementary feed. Differences were more prominent in the levels of plankton productivity which was always higher in nutrient dense ponds where all the proposed inputs were present. During the winter months this difference however totally mitigated indicating low metabolic and decomposition activities. So it can be concluded that water quality can be maintained within acceptable ranges if all the inputs are added in well measured and managed way. Haphazard and poorly managed activities always lead to deleterious effects.

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Introduction

In present fish culture practices both organic and inorganic fertilizers are used to enhance plankton production (Green 1990, Morissens *et al.*, 1996, Yaro *et al.*, 2005). Efficiency of their fertilization varies from type and nature of fertilizer which ultimately affects plankton density and their nutritional value for fish. This variation in fertilizers and their subsequent effects has bearing on fish health and production. Therefore to improve the pond environment and to get maximum yield it is imperative to fertilize the pond water with quality inorganic as well as organic fertilizers (Chattopadhyay and Dev 2000).

From the last several decades animal manures have been used in fish ponds as a source of soluble phosphorus, nitrogen and carbon to maximize the algal growth and natural food production (Ali 1993, Njoku 1997, Knud-Hansen 1998, Abbas *et al.*, 2004). Manure input and fish yield are directly related with each other (Ansa and Jiya 2002). Excessive application of organic manure and nitrogen fertilizer @ 200 to 400 kg/ha have increased the microbial activity, nitrates and phosphates ultimately plankton productivity (Boyd 2003). Conversion efficiency of organic manure protein (chicken, duck, pig and cow manure) to a fish protein through plankton was about 40% on a dry weight basis in fish ponds (Fang *et al.*, 1994). However, more than the optimum dosage of manure reduces the plankton population, fish biomass, specific growth rate (Garg and Bhatnagar 1996; 1999) and induces high mortality in fish due to eutrophication and resultant oxygen depletion (Zoccarato *et al.*, 1995, Bhakta *et al.*, 2004).

Qualitative and quantitative applications of fertilizers and frequency of applications manipulate water quality parameters (Garg and Bhatnagar, 1999, Garg, 1996, Bhakta *et al.*, 2006). The fertilization twice a month raises the alkalinity and calcium level in pond water (Garg and Bhatnagar 2000). Inorganic fertilizers are more effective in improving plankton productivity, dissolved oxygen, pH than organic ones (Qin *et al.*, 1995b, Tabinda and Ayub 2009). Pond fertilized with manure @ 36 ton ha^{-1} yr^{-1} during winter and summer season predominantly lowered the pH value in summer while increment in plankton population is reported during both winter and summer seasons (Dhawan and Kaur, 2002a; 2002b). This study is conducted to observe the effects on water quality and plankton production by using fertilizers and supplementary feed when used alone or in combination with each other.

Materials and methods

Experimental site and Design

Studies were performed in research ponds of Zoology and Fisheries Department in University of Agriculture Faisalabad Pakistan. There were 5 treatments and a control (Table 1). Each treatment including control had two replicate earthen ponds with an area of 0.02 ha each. Studies were conducted following Completely Randomized Design (CRD). All the ponds were randomly allotted to each treatment and control group maintaining complete homogeneity during pond distribution.

Table 1. Detail of different treatment groups.

Treatment	Source of Nitrogen	Nitrogen %
Control	Cow manure	100%
T_1	Nitrophos	100%
T_2	Cow manure	50%
	Nitrophos	50%
T_3	Cow manure	50%
	Supplementary feed	50%
T_4	Nitrophos	50%
	Supplementary feed	50%
T_5	Cow manure	25%
	Nitrophos	25%
	Supplementary feed	50%

Experimental Fish species

Labeo rohita, *Catla catla* and *Cyprinus carpio* were procured from Government Fish Hatchery Satyana Road Faisalabad and housed in circular cemented tanks available in the above referred department building for acclimatization. All the ponds were then stocked with *Labeo rohita, Catla catla* and *Cyprinus carpio* in the ratio of 20:15:15, respectively. Experimental ponds were disinfected with CaO applied @ 2.5 kg $pond^{-1}$(Wahab *et al.*, 2002) and then fertilized with cow manure @ 66.66kg (3333.33kg ha^{-1}) to induce pond productivity (Javed *et al.*, 1995). After proper acclimatization 10 fish of each species were randomly collected from bulk stock, weighed and measured for initial data for future growth comparisons, then all the three species were stocked in each replicate pond maintaining species combination ratio of (*Labeo rohita* 20; *Catla catla* 15 and *Cyprinus carpio* 15) following standard stocking density (825 fish ha^{-1}).

Physico-Chemical Parameters

Water temperature was recorded with the help of Dissolved Oxygen Meter (HI-9146) and plankton level by "Secchi Disc". Total alkalinity, total hardness, total dissolved solids and planktonic biomass were determined on monthly basis following methods described by Boyd (1981) and American Public Health Association (A.P.H.A., 1998). pH was determined by pH meter (HANNA-HI-8520) and dissolved oxygen by Dissolved Oxygen Meter (HI-9146).

Total hardness

A 50ml of water sample was taken in an Erlenmeyer's flask and pH was maintained (12-13) by adding appropriate volume of the buffer solution. The reaction mixture was stirred and 0.1 ml of Eriochrome Black T (EBT) indicator was added to it and titrated against Ethylene Diamine Tetra Acetic acid (EDTA) (0.01 N) to reach the end point which is blue color. Then the total hardness was calculated by following formula.

$$\text{Total hardness (mgL}^{-1}) = \frac{\text{(Volume of EDTA used)}}{\text{Volume of sample (ml)}} \times 1000$$

Total solids

Total water solids were estimated by evaporation method. A 100 ml of water sample was taken in a pre-weighed beaker and evaporated in an oven at 103°C. After evaporation, beaker was weighed again and the total solids were calculated by the following equation:

$$\text{Total solids (mgL}^{-1}) = \frac{\text{Increase in weight}}{\text{Volume of sample (ml)}} \times 100{,}000$$

Planktonic biomass

The planktonic biomass was calculated indirectly from total solids and total dissolved solids by the following equation (Mahboob and Sheri, 2002).

Planktonic biomass (mgL^{-1}) = Total solids – Total dissolved solids

Statistical Analysis

The data thus obtained was subjected to statistical analysis (Steel *et al.*, 1997). The variation among various parameters, their significance and their interaction among the different treatments for the growth data (effect of fertilization and supplementary feed on growth and yield) were tested by using Analysis of Variance (ANOVA) by a Micro-Computer: IBM-PC. Differences among treatment means was determined by Duncan's Multiple Range Test (Duncan, 1955). MSTAT and MICROSTAT packages were used for the statistical analysis of the data.

Results

Dissolved Oxygen and pH

DO concentrations remained similar when compared among treatments or among various months of the year. Slightly higher concentrations were observed in control in the months of January and February. Similarly little higher concentrations were present in treatment 3 to 5 in June and July. Values of pH were uniform either compared among treatments or among different months of the year (Table 2).

Alkalinity and Hardness

There were no differences in the concentrations of alkalinity and hardness. Though there were some ups and downs in the values, when we moved from control to different treatments or from one month to other but there was no regular trend in these increments or reductions (Table 3). Comparative values of these two parameters were on the higher side when we moved from T_3 onward.

Table 2. Seasonal variations in dissolved oxygen and pH of pond water under different treatments.

Months	Dissolved oxygen (mg L-1)						pH					
	Control	T1	T2	T3	T4	T5	Control	T1	T2	T3	T4	T5
August	5.5± 0.3Aa	5.8± 0.2Aa	5.1± 0.3Aa	5.3± 0.3Aa	5.4± 0.3Aa	5.5± 0.3Aa	8.0± 0.4Aa	8.1± 0.3Aa	8.4± 0.3Aa	8.0± 0.2Aa	8.5± 0.2Aa	8.4± 0.3Aa
September	5.6± 0.3Aa	5.8± 0.3Aa	5.4± 0.3Aa	5.4± 0.3Aa	5.9± 0.3Aa	6.2± 0.3Aa	8.1± 0.3Aa	8.1± 0.3Aa	8.2± 0.2Aa	8.5± 0.3Aa	8.3± 0.2Aa	8.5± 0.3Aa
October	6.2± 0.2Aa	6.9± 0.3Aa	6.8± 0.2Aa	6.1± 0.3Aa	6.8± 0.3Aa	6.9± 0.2Aa	8.5± 0.3Aa	7.9± 0.2Aa	8.5± 0.2Aa	8.3± 0.3Aa	8.5± 0.2Aa	7.9± 0.3Aa
November	8.1± 0.3Ba	7.9± 0.3Ba	7.6± 0.3Aa	7.3± 0.3Aa	6.8± 0.2Aa	7.3± 0.3Aa	8.3± 0.2Aa	8.2± 0.2Aa	8.5± 0.3Aa	8.3± 0.3Aa	8.5± 0.3Aa	7.8± 0.2Aa
December	7.9± 0.3Ba	8.4± 0.2Ba	7.9± 0.3Ba	8.1± 0.2Aa	7.9± 0.3Ba	7.9± 0.4Ba	8.2± 0.3Aa	8.1± 0.3Aa	8.5± 0.4Aa	8.1± 0.3Aa	8.5± 0.1Aa	8.1± 0.2Aa
January	8.5± 0.3Ba	8.5± 0.4Ba	8.5± 0.3Ba	8.0± 0.4Aa	8.3± 0.3Ba	7.9± 0.3Ba	8.0± 0.2Aa	8.3± 0.3Aa	8.0± 0.3Aa	8.3± 0.1Aa	7.8± 0.3Aa	8.2± 0.0Aa
February	8.5± 0.4Ba	8.1± 0.3Ba	8.0± 0.3Ba	7.9± 0.4Aa	8.0± 0.3Ba	8.1± 0.3Ba	8.5± 0.4Aa	8.3± 0.3Aa	8.0± 0.3Aa	8.5± 0.3Aa	8.3± 0.4Aa	8.4± 0.3Aa
March	6.3± 0.1Aa	7.1± 0.3Ba	7.3± 0.3Ba	7.8± 0.3Aa	7.2± 0.3Ba	7.5± 0.4Ba	8.5± 0.4Aa	8.0± 0.3Aa	8.4± 0.3Aa	8.1± 0.4Aa	8.0± 0.3Aa	8.1± 0.3Aa
April	5.2± 0.3Aa	6.5± 0.2Aa	6.8± 0.4Aa	7.2± 0.4Aa	7.0± 0.3Ba	7.0± 0.4Ba	8.1± 0.3Aa	8.2± 0.3Aa	8.3± 0.2Aa	8.2± 0.3Aa	8.5± 0.4Aa	8.5± 0.3Aa
May	6.5± 0.4Aa	6.6± 0.3Aa	6.5± 0.3Aa	6.9± 0.3Aa	6.9± 0.4Aa	6.3± 0.3Aa	8.4± 0.3Aa	8.3± 0.2Aa	8.5± 0.2Aa	8.5± 0.2Aa	8.2± 0.3Aa	8.3± 0.3Aa
June	5.5± 0.2Aa	6.1± 0.3Aa	6.5± 0.3Aa	6.3± 0.3Aa	6.2± 0.3Aa	6.5± 0.2Aa	8.4± 0.3Aa	8.4± 0.4Aa	8.2± 0.4Aa	8.0± 0.3Aa	8.2± 0.3Aa	8.5± 0.4Aa
July	5.1± 0.2Aa	5.8± 0.3Aa	5.9± 0.3Aa	5.9± 0.4Aa	6.0± 0.3Aa	6.1± 0.3Aa	8.5± 0.4Aa	8.4± 0.3Aa	8.1± 0.3Aa	7.8± 0.3Aa	8.5± 0.3Aa	8.3± 0.3Aa

Table 3. Seasonal variations in total alkalinity and hardness of pond water under different treatments.

Months	Total alkalinity (mg L-1)						Hardness(mg L-1)					
	Control	T1	T2	T3	T4	T5	Control	T1	T2	T3	T4	T5
August	465.0 ±50Aa	502.5 ±39aA	475.5 ±40aA	425.0 ±40aA	510.5 ±50aA	475.0 ±35aA	215 ±20a	212 ±15aA	220 ±23aA	223 ±24aA	203 ±20aA	245 ±24aA
September	460.0 ±53aa	463.5 ±54aA	470.5 ±55aA	581.0 ±49aA	431.5 ±47aA	500.5 ±56aA	228 ±21a	246 ±23aA	212 ±20aA	210 ±25aA	210 ±24aA	205 ±21aA
October	486.5 ±49Aa	490.0 ±47aA	520.0 ±51aA	485.5 ±52aA	510.0 ±47aA	499.0 ±49aA	190 ±20a	193 ±20aA	203 ±25aA	202 ±30aA	225 ±24aA	235 ±23aA
November	406.5 ±49Aa	405.5 ±52aA	441.0 ±51aA	500.5 ±41aA	502.5 ±48aA	475.5 ±51aA	202 ±20a	245 ±23aA	202 ±23aA	190 ±20aA	218 ±21aA	221 ±25aA
December	490.5 ±49Aa	529.5 ±53aA	450.5 ±51aA	399.5 ±35aA	540.5 ±52aA	425.5 ±51aA	245 ±20a	215 ±23aA	248 ±24aA	215 ±21aA	220 ±22aA	221 ±23aA
January	480.0 ±49a	482.0 ±46a	502.0 ±47aA	400.0 ±53aA	560.5 ±51a	485.0 ±52aA	236 ±46a	213 ±19aA	255 ±22aA	235 ±21aA	241 ±23aA	200 ±20aA
February	425.5 ±43Aa	502.5 ±45aA	430.5 ±47aA	485.0 ±41aA	470.5 ±46aA	475.5 ±43aA	230 ±25a	218 ±22aA	249 ±21aA	218 ±20aA	220 ±21aA	205 ±20aA
March	410.5 ±49aA	423.5 ±53aA	470.5 ±52aA	475.5 ±49aA	501.0 ±45aA	475.5 ±52aA	220 ±15a	203 ±15aA	245 ±12aA	240 ±21aA	215 ±19aA	230 ±17aA
April	403.0 ±50aA	462.5 ±43aA	480.0 ±54aA	482.5 ±45aA	500.5 ±40aA	485.0 ±42aA	201 ±21a	202 ±23aA	210 ±20aA	209 ±21aA	212 ±19aA	215 ±18aA
May	405.0 ±47aA	460.0 ±45aA	480.5 ±47aA	435.0 ±51aA	510.5 ±45aA	475.0 ±43aA	200 ±23a	204 ±21aA	210 ±17aA	209 ±21aA	203 ±21aA	210 ±20aA
June	465.0 ±53aA	462.0 ±47aA	400.5 ±50aA	510.5 ±42aA	501.0 ±45aA	455.0 ±46aA	240 ±21a	242 ±19aA	215 ±18aA	236 ±21aA	250 ±17aA	230 ±23A
July	425.5 ±47aA	480.0a ±45aA	500.5 ±41aA	455.0 ±40aA	430.5 ±43aA	501.5 ±44aA	211 ±21a	200 ±20aA	218 ±18aA	221 ±21aA	230 ±19aA	215 ±20aA

Total solids

Values of total solids were significantly higher in T_4 and T_5 than control and T_1-T_3 higher. Differences in concentrations of total solids were more prominent when compared among different months of the year. Total solids were higher in winter months than those of summer months. Like total solids concentrations of total dissolved solids was also higher in winter months when compared with summer months (Table 4).

Table 4. Seasonal variations in total solids pond water under different treatments.

Months	Total solids (mg L⁻¹)					
	Control	T_1	T_2	T_3	T_4	T_5
August	1394.38 ±213aA	1398.50 ±247aA	1370.00 ±234aA	1478.25 ±217aA	1480.50 ±219aA	1466.37 ±220aA
September	1428.37 ±231aA	1432.76 ±243aA	1415.47 ±241aA	1470.35 ±228aA	1491.55 ±225aA	1480.75 ±221aA
October	1429.81 ±250aA	1433.62 ±229aA	1445.39 ±239aA	1480.65 ±245aA	1502.25 ±251aB	1495.30 ±255aA
November	1530.20 ±240aB	1515.55 ±229aB	1496.50 ±223a	1489.25 ±243aA	1565.30 ±225aB	1558.20 ±244aB
December	1458.25 ±251aB	1390.50 ±250aA	1392.20 ±190aA	1334.25 ±199aA	1413.50 ±201aB	1460.20 ±241aA
January	1444.20 ±244aB	1561.50 ±251aB	1383.25 ±244aA	1514.30 ±234aB	1612.20 ±243aB	1523.20 ±24aB
February	1578.20 ±254aB	1555.80 ±255aB	1544.20 ±256aB	1550.80 ±247aB	1568.90 ±231aB	1521.20 ±225aB
March	1595.20 ±257aB	1570.20 ±256aB	1568.20 ±243aB	1546.20 ±241aB	1530.20 ±240aB	1548.20 ±243aB
April	1605.00 ±247aB	1573.20 ±248aB	1539.20 ±257aB	1608.50 ±256aB	1547.20 ±234aB	1548.20 ±250aB
May	1492.20 ±243aA	1490.20 ±239a	1468.30 ±223aA	1465.20 ±225aB	1541.20 ±229aB	1470.20 ±241aA
June	1525.50 ±241aA	1522.20 ±240aB	1508.20 ±245aB	1495.20 ±198aB	1478.25 ±256aA	1485.80 ±243aA
July	1472.20 ±243aA	1448.20 ±244aA	1452.30 ±245aA	1486.50 ±246aB	1468.30 ±245aA	1475.20 ±256aA

Planktonic biomass

Plankton productivity levels in treatment 2 and 3 were similar to control but were significantly higher in treatment 3 to 5 where supplementary feed was provided. Plankton productivity levels in treatment 3 to 5 did not differ when compared among themselves irrespective of the type of fertilizer added- inorganic or organic. This difference was more prominent from August to October and then gradually diminished in the following months. In coming year, July plankton productivity equaled among all the treatments and control rather it was comparatively higher in control than all the treatments (Table 5).

Table 5. Seasonal variations in planktonic biomass of pond water under different treatments.

Months	Planktonic biomass (mg L⁻¹)					
	Control	T_1	T_2	T_3	T_4	T_5
August	54.38 ±8aA	58.50 ±7aA	60.00 ±5aA	128.25 ±6aA	130.50 ±9bA	126.37 ±10bA
September	78.37 ±9aB	72.76 ±5aA	75.47 ±7aA	130.35 ±10bA	131.55 ±11bA	130.75 ±11bA
October	89.81 ±10aB	93.62 ±9aB	85.39 ±10aB	120.65 ±12bA	122.25 ±11bA	125.30 ±9bA
November	100.20 ±8aB	105.55 ±9aB	106.50 ±10aB	109.25 ±8aA	105.30 ±9aA	108.20 ±10aA
December	98.25 ±9aB	100.50 ±11aB	102.20 ±10aB	104.25 ±12aA	103.50 ±12aA	110.20 ±11aA
January	64.20 ±11aA	101.50 ±10bB	103.25 ±11bB	104.30 ±13b	102.20 ±12bA	103.20 ±10bA
February	108.20 ±12aB	105.80 ±13aB	104.20 ±14aB	100.80 ±12aA	98.90 ±10aA	101.20 ±11aA
March	115.20 ±11aB	120.20 ±13aB	118.20 ±10aB	116.20 ±13aA	110.20 ±12aA	108.20 ±11aA
April	125.00 ±10aB	123.20 ±12aB	119.20 ±11aB	118.50 ±9aA	117.20 ±8aA	118.20 ±10aA
May	132.20 ±11aB	130.20 ±12aB	128.30 ±11aC	125.20 ±10aA	121.20 ±8aA	120.20 ±9aA
June	135.50 ±10aB	132.20 ±11aB	138.20 ±12aC	125.20 ±10aA	128.25 ±11aA	125.80 ±12aA
July	132.20 ±10aB	128.20a ±12B	122.30 ±11aB	126.50 ±10aA	128.30 ±9aA	125.20 ±10aA

Discussion

In semi-intensive poly-culture system, the frequent applications of organic manure, inorganic fertilizers and supplementary feed are direct and indirect source of fish food and have both positive and negative impact on water quality. Water quality parameters like pH, alkalinity and hardness and their subsequent interactions exhibit profound effects on pond productivity, availability of oxygen, the level of stress which ultimately affects fish health. The physico-chemical characteristics of both soil and water are not static, but are dynamic and change with the introduction of fish species, provision of supplementary feeds, manures and fertilizers and other inputs. Both the soil and water quality parameters of pond ecosystem undergo complex changes consequently disrupting the aquatic life in pond (Ali *et al*., 2006). During this study, Plankton productivity was same in control, T1 and T2 but significantly higher in T3 to T5 though they were not different among themselves (Table 5). Light penetration is another motivator of plankton productivity. In the presence of sufficient nutrients both light and temperature promote pond productivity which has been observed in current(Table 5) as well as in previous studies (Mahboob *et al*., 1993; Singh *et al*., 2000; Rafique *et al*., 2003; Pramila *et al*., 2004; Liti *et al*., 2006).

The dissolved oxygen is the important factor for the growth and survival of fish. Dissolved oxygen concentration of pond water remained within suitable range (5.1-8.5 mg L^{-1}) during current studies and encouraged fish growth in all the treatments. It showed the seasonal variation due to temperature fluctuations and photosynthetic and respiratory activities (Table 2). During present studies, dissolved oxygen did not differ significantly among treatments though slightly higher in more nutrient rich treatments like T_3, T_4 and T_5 which are verified by Mahboob and Sheri (2002) and Tahir (2008) who observed positive correlation of DO level with plankton productivity and negative with temperature. pH which indicates level of acidity and basicity in fish ponds was also observed and was tried to investigate if there were any relationship with phytoplankton productivity. As there was no variation among treatments neither among various months of the year so any relationship cannot be expected (Table 2). Findings of Mahboob and Sheri (2002) corroborate with ours.

The pond water remained alkaline throughout the experimental duration in all the treatments. Presence of carbonates and bicarbonates make the pond water slightly alkaline which proves to be suitable for aquatic organism (Pandey and Lal 1995, Terziyski *et al*., 2007, El-Saidy and Gaber 2003, Swelium *et al*., 2005). Uniformity in alkalinity and hardness further reveals that all the nutrients were in balanced amount which provided a conductive environment for water quality parameters and plankton production (Table 3). Similar results were observed by Mahboob and Sheri (2002) who reported the positive correlation among the total alkalinity and total hardness under the effect of fertilization and supplementary feed in carp poly-culture system. Tahir (2008) showed the negative and non-significant correlation in different treatments with supplementary feed. During this investigation, total solids remained maximum in the month of January and minimum in August at the start of the experiment. The minimum value (1370 mg L^{-1}) was noted in treatment T_2 in August while the maximum value (1612 mg L^{-1}) was observed in treatment T_4 in January. There was a highly significant difference among months as well as among treatments (Table 4). It may be concluded that the presence of total solids in pond water stimulated the growth of planktonic biomass and contributed towards the primary productivity of pond ecosystem. The planktonic biomass was found to be highest in T_3 (June) in which cow-dung and nitrophos were used. These results substantiate the findings of (Sayeed *et al*., 2007, Afzal *et al*., 2007, Anetikhai *et al*., 2005) who suggested that basic macro and micro nutrients in pond sediments can be enhanced by the application of combined applications of organic and inorganic fertilization. Cattle manure and nitrophos caused a marked increase in planktonic biomass in T_3 which is an indication of sufficient plankton productivity. Lane (2000) had the similar findings which further support our results.

Cow dung is found to be an effective source of organic fertilization, which positively influences the growth performance of major carps (Sughra *et al.*, 2003; Kanwal *et al.*, 2003). High doses of cow dung and poultry manuring reduces the value of dissolved oxygen (DO), while optimum dose i-e 0.26 kg m^{-3} maintains the better water quality and abundance of planktonic biomass, which improves the growth of carps (Jha *et al.*, 2004). Ponds manured with cattle dung show higher production by encouraging plankton metabolism (Terziyski *et al.*, 2007). The common carp attained the maximum fish growth in poultry manure as compared to duck and cattle manure treatment in monoculture system (Garg, 1996). Nile tilapia gave the high fish biomass in fertilized earthen ponds with the cattle manure and supplementary feed as compared to unfertilized ponds (Middendrop and Huisman, 1995).

Organic manure like cow dung and poultry droppings in combination with inorganic fertilizers like NPK have provided conducive environment for *Clarias gariepinus* fry that showed the best weight increment with a condition factor (K) under the influence of organic manure and NPK combination (Anetekhai *et al.*, 2005). Combination of organic and inorganic fertilizer is encouraging in poly-culture of bighead carp with major carp and Chinese carps (Afzal *et al.*, 2007). Application of cow dung, urea and TSP@ 4500, 150 and 150 kg/ha is found to be the best for the optimum production of major carps (Azim *et al.*, 2001). Therefore it can be concluded that moderate applications of fertilizers and feed help in maintaining proper water quality and plankton productivity which ultimately enhance fish growth and overall production of the fish per unit of area. Excessive use of these inputs deteriorates water quality, induce eutrophication and stress the fish eventually affecting pond production.

Conclusion

The induction of nutrients, rise in temperature and sufficient light boosted plankton production and this trend continued even throughout the winter where productivity normally shows depression. These studies further revealed that only organic or inorganic fertilizers cannot meet the requirements but both in combination or supplemented with artificial feed are the best hyper for plankton productivity.

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