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Effects of Iso-Nutrient Fertilization on Plankton Production in Earthen Ponds of Bangladesh

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Abstract: The experiment was conducted to evaluate the effects of iso-nutrients fertilization on fertilizer combinations, containing a similar amount of nitrogen (N) and phosphorus (P) were the production of plankton in earthen ponds for a period of eight weeks. Two different were tested in triplicate using six earthen ponds of 100 m^2 each. The fertilizer combinations of cow manure, urea and Triple Super Phosphate (TSP) at the rate 5000, 125 and 100 kg ha^{-1}, respectively, containing approximately 102 kg N and 65 kg P was used for treatment-1 (T-1). Another combination of poultry-manure, urea and TSP at the rate of 2000, 125 and 100 kg ha^{-1}, respectively, was considered as the treatment-2 (T-2). The application rate of poultry manure was adjusted to make the nutrient (N and P) content of fertilizer combination in T-2 similar to that in T-1. Four groups of phytoplankton namely, Bacillariophyceae, Chlorophyceae, Cyanophyceae and Euglenophyceae and two groups of zooplankton namely, Crustacea and Rotifera were identified. The mean abundance of both phytoplankton ($78.25\pm6.33\times10^4$ cells L^{-1}) and zooplankton ($57.63\pm4.59\times10^4$ cells L^{-1}), were significantly higher ($p<0.05$) in earthen ponds which treated with poultry manure. The result showed that despite iso-nutrients content, the nutrient status of poultry manure proved to be superior to cow manure.

Key words: Fertilizers, iso-nutrients, phytoplankton, zooplankton, earthen ponds, Bangladesh

INTRODUCTION

Both the qualitative and quantitative abundance of plankton in a fish pond are of great importance in managing the successful aquaculture operations, as these vary from location to location and pond to pond within the same location even with similar ecological conditions (Boyd, 1982). Of the primary factors limiting the productive capacity of a fish pond, the most important is the quantity of available nutrients, which form basic materials for structure and growth of living organisms. Fertilization is so far the most useful technique to make up or provide the essential needed nutrients to enhance the natural productivity through production of aquatic biota, which serve either directly or indirectly as the food of fishes (Olah *et al*., 1986; Knud-Hansen, 1998).

In Bangladesh, the most common fertilizer regimes involve monthly application of cow manure, urea and triple super phosphate (TSP) at the rate of 5000, 125 and 100 kg ha^{-1}, respectively. Supplementary feeding is also commonly practiced in fish culture, using agricultural by products such as rice bran and mustard oil-cake (Haq *et al*., 1994; Wahab and Ahmed, 1992; Ahmed *et al*., 1997).

The overall objective of fertilizer application is to increase the productivity of the fish pond and both organic and inorganic fertilizers are used. While the inorganic fertilizers mainly increase the quantity of primary producers, organic fertilizers such as dung of cattle, pig and poultry, biomass slurry, compost and other livestock wastes serve as a class or composite for stimulating abundant growth of zooplankton, insect larvae and other forms of fish food organisms (Jhingran, 1983; Olah *et al*., 1986; Akand, 1986). Therefore, to maintain the required food chain equilibrium in fish ponds, combinations of various types of fertilizers is often used

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to ensure a balance in the amount of both plant and animal matter in the pond ecosystem (Moav *et al*., 1977). Besides, the prevailing hydrological conditions, which determine the character and quality of biological production of a fish pond, provide an important tool for successful fish culture operations (Alam *et al*., 1996).

December 1, 2006Numerous studies have been conducted on the effects of fertilizer on plankton production (Wahab *et al*., 1994; Ahmed *et al*., 1997, Hossain *et al*., 2006, Hossain *et al*., 2007). However, comparative studies on the effect of two different fertilizer combinations are still very scanty and studies on the commonly used fertilizer combination in Bangladesh, of cow dung-urea-TSP and poultry manure-urea-TSP combinations containing a similar amount of nitrogen (N) and phosphorus (P), are virtually non existent. Therefore, the present experiment was aimed at assessing the comparative effects of iso-nutrients fertilization on the productivity of plankton in earthen ponds without stocking of any fish species.

MATERIALS AND METHODS

Ponds description and design of experiment: The experiment was carried out for a period of eight weeks in six earthen ponds situated at the Field Laboratory of the Faculty of Fisheries, Bangladesh Agricultural University, Mymensingh, Bangladesh. Rectangular shaped ponds, of 100 m^2 each, with average depths of about 1.5 m, well exposed to sunlight and free from aquatic vegetation were used. The pond were initially dried out, pond bottom was ploughed and kept exposed to sunlight for three days. Then ponds were further treated with lime at the rate of 250 kg ha^{-1} and filled-up with underground water up to a depth of 1 m.

The commonly used fertilizer combinations of cow manure, urea and TSP at the rate 5000, 125 and 100 kg ha^{-1}, respectively, was applied for treatment-1 (T-1). This combination contained approximately 102 kg N and 65 kg P. Another combination of poultry-manure, urea and TSP at the rate of 2000, 125 and 100 kg ha^{-1}, respectively, was used for treatment-2 (T-2) and the application rate of poultry manure was adjusted to make the nutrient (N and P) content of fertilizer combination in T-2 similar to that in T-1. The nutrient contents of manure (Table 1) and inorganic fertilizers (Das and Jana, 1996) were used to calculate the amount of cow and poultry manure in making up a similar rate nutrient application. Experimental ponds were randomly selected for two fertilizer treatments with three replicates for each. Fertilization of ponds was started on the 5th day after liming and filling of the ponds and the same applications repeated fortnightly for the entire period of the study.

Table 1: Chemical composition (on oven dry basis) of cow and poultry manure used in the experiment

Chemical component (%)	Cow manure	Poultry manure
Moisture	75.30	58.20
Organic matter	24.20	18.65
Total nitrogen (N)	0.90	2.25
Total phosphorus (P_2O_5)	0.40	0.95
Available potassium (K)	0.35	0.80
Available calcium (Ca)	0.70	1.10

Plankton analysis

Collection of plankton samples: Sampling for plankton was done on a weekly basis from each of the experimental ponds using a column sampler. Two litre water samples were taken from different points and depths using the flexible and uniform plastic tube sampler (diameter 8 cm) and the samples properly labeled in plastic jars.

Preservation of plankton sample: The samples were fixed with 2 mL of Lugol's iodine (1:1000) for sedimentation and preservation of the plankton, pending laboratory analysis followed by settling for 2 to 3 days. The supernatant from the sedimentation was then carefully siphoned out and the volume made up to 50 mL. The concentrated samples were then preserved into small, properly labeled and sealed plastic bottles for microscopy counts.

Enumeration and identification of plankton: The concentrated preserved plankton samples were analysed on a Sedgewick-Rafter counting cell (SR-cell) under a compound binocular microscope (SWIFT M 4000-D). From each sample, 1 mL sub-sample was transferred to the cell and all planktonic organisms 10 randomly selected squares of the cell enumerated. The plankton abundance in the original volume was then computed using the formula by Stirling (1985):

$$N=\frac{A\times 100\times C}{V\times F\times L}$$

Where,

N = Number of plankton cells or units per liter of original;
A = Total number of plankton counted;
C = Volume of final concentrate of the samples in mL;
V = Volume of a field in cubic mm;
F = Number of fields countednd
L = Volume of original water in liter.

This was repeated for all the pond samples and the plankton density in each pond expressed as the means of the pond samples in Number of plankton cells per liter of water (No.s/L). The plankters were further identified up to genus level following the guidelines of APHA (1992) and Bellinger (1992).

Statistical analysis: Data were analyzed for one-way ANOVA and any differences at 5% level of significance were noted using the statistical package, Statgraphics *Version 7*. Graphs were done using Microsoft Excel ®, 2002.

RESULTS

Plankton abundance: Plankton population in the experimental ponds comprised of six groups consisting of 50 genera (Table 2). The total planktonic organism mainly composed of 4 groups of phytoplankton and 2 groups of zooplankton. Some 37 genera of phytoplankton belonging to Bacillariophyceae (7), Chlorophyceae (19), Cyanophyceae (8) and Euglenophyceae (3) were identified. Thirteen genera of zooplankton were also identified belonging to Crustacea (5), including *Crustacean naupli* and Rotifera (8). Average abundance of plankton in experimental ponds and the comparison of mean values of different groups of plankton between T-1 and T-2 are shown in Table 3 and 4, respectively.

Table 2: Generic status of plankton (phytoplankton and zooplankton) available in treatment ponds water during experimental period

Data	Phytoplankton	Zooplankton
Bacillariophyceae	**Cyanophyceae**	**Crustacea**
Cocconeis	*Anabaena*	*Cyclops*
Cyclotella	*Aphanocapsa*	*Daphnia*
Frustularia	*Chrococcus*	*Diaphanosoma*
Fragillaria	*Gomphospheria*	*Diaptomus*
Navicula	*Merismopedia*	Nauplius
Synedra	*Microcystis*	
Melosira	*Nostoc*	
	Oscillatoria	
Chlorophyceae	**Euglenophyceae**	**Rotifera**
Actinaustrum	*Euglena*	*Asplanchna*
Ankistrodesmus	*Phacus*	*Brachionus*
Botryococcus	*Trachelomonas*	*Filinia*
Ceratium		*Keratella*
Chlorella		*Lecane*
Characium		*Notholca*
Cladophora		*Polyarthra*
Closterium		*Trichocerca*
Chaetophora		
Cosmarium		
Gonatozygon		
Oocystis		
Pediastrum		
Scenedesmus		
Sphaerocystis		
Tetraedron		
Teubaria		
Ulothrix		
Volvox		
Zygnema		

Phytoplankton: The phytoplankton population of the ponds was composed of 4 major groups, such as Bacillariophyceae, Chlorophyceae, Cyanophyceae and Euglenophyceae.

Bacillariophyceae: Bacillariophyceae comprised of 7 genera and ranked third in respect of both abundance and number of genera (Table 2). Among 7 genera, *Cyclotella, Navicula, Cocconeis and Fragillaria* were found dominant genera. In T-1, average abundance of Bacillariophyceae was found to vary from 3 to 20×10^4 cells L^{-1} (Table 3) with a mean value of $7.50\pm0.97\times10^4$ cells L^{-1} (Table 4). On the contrary, it ranged from 4 to 20 $\times10^4$ cells L^{-1} with a mean value of 12.13 ± 0.85 in T-2. The abundance of this group of phytoplankton was significantly different ($p<0.05$) between T-1 and T-2 (Table 4).

Chlorophyceae: Chlorophyceae was the dominant group of phytoplankton with a large number of genera in all treatment ponds followed by Cyanophyceae, Bacillariophyceae and Euglenophyceae (Table 2). Among 19 genera, *Chlorella*, *Oocystis*, *Scenesdesmus* were the dominant ones. The abundance of Chlorophyceae was found to vary from 8 to 72×10^4 cells L^{-1} with a mean value of 26.33 ± 3.58 in T-1 and from 10 to 76×10^4 cells L^{-1} with a mean value of 36.75 ± 4.21 in T-2 (Tables 3 and 4). There was no significant difference ($p>0.05$) in abundance of Chlorophyceae between two treatments (Table 4).

Cyanophyceae : Cyanophyceae comprised of 8 genera and ranked second in respect of both abundance and number of genera (Table 2.). Among 8 genera, *Microcystis* formed the main bulk of population followed by *Anabaena, Aphanocapsaand Chrococcus.* The abundance of Cyanophyceae ranged from $2\text{-}30\times10^4$/L (Table 3.) and the mean value was 15.71 ± 1.64 in T-1 (Table 4). On the other hand, in T-2, it varied from 11 to 34×10^4 L^{-1} with a mean abundance of $18.88\pm1.53\times10^4$ L^{-1}. Cyanophyceae group of phytoplankton did not vary significantly ($p>0.05$) between T-1 and T-2 (Table 4).

Euglenophyceae: Among the phytoplankton groups identified, Euglenophyceae ranked fourth in respect of both abundance and number of genera. There were three genera of Euglenophyceae of which *Euglena* was the most dominant (Table 2). The abundance of Euglenophyceae was found to range from $2\text{-}8\times10^4$ L^{-1} with a mean value of 5.25 ± 0.40 and from 4 to 20×10^4 L^{-1} with a mean value of $11.08\pm0.92\times10^4$ L^{-1} in T-1 and T-2, respectively (Table 3 and 4). The difference in abundance of phytoplankton under Euglenophyceae was found significant ($p<0.05$) between two treatments.

Total phytoplankton: The abundance of phytoplankton was found to range from $52.70\text{-}55.90\times10^4$ cells L^{-1} with a

Table 3: Mean±SD values of plankton (×10^4 cells L^{-1}) and ranges (in parenthesis) in ponds under two treatments

	Cow manure-urea-TSP (T-1)			Poultry manure-urea-TSP (T-2)		
Plankton group	Pond-1	Pond-3	Pond-6	Pond-2	Pond-4	Pond-5
Bacillariophyceae	7.68±4.68	7.65±3.55	6.90±4.27	11.20±4.50	13.20±3.21	12.12±5.14
	(3-18)	(2-20)	(2.-14)	(4-8)	(6-16)	(4-20)
Chlorophyceae	26.35±12.92	27.25±21.95	25.35±19.50	36.80±22.92	38.95±20.26	39.86±12.83
	(10-42)	(8-72)	(12-70)	(15-68)	(16-68)	
Cyanophyceae	14.60±9.95	16.50±6.92	14.30±8.86	18.50±6.72	19.26±8.34	18.82±8.42
	(2-30)	(8-26)	(6--30)	(11-32)	(12-32)	(12-34)
Euglenophyceae	5.25±1.60	4.50±2.20	6.15±2.03	11.65±3.82	10.85±5.59	10.75±4.52
	(2-6)	(2-8)	(3-8)	(4-16)	(5-20)	(4-16)
Total phytoplankton	53.88	55.90	52.70	78.62	82.13	81.89
Crustacea	23.46±8.52	23.20±7.08	21.40±5.52	30.20±13.09	32.50±12.19	34.18±12.78
	(4-40)	(6-40)	(8-46)	(16-62)	(18-66)	(18-50)
Rotifera	13.21±10.52	15.10±6.54	12.30±5.29	20.38±7.56	24.40±6.56	22.80±5.29
	(8-28)	(6-25)	(5-20)	(10-30)	(12-29)	(8-44)
Total zooplankton	36.67	38.30	33.70	51.58	55.90	56.98
Total plankton	90.55	94.20	86.40	130.20	138.03	138.87

Table 4: Mean (±SD) abundance of plankton (×10^4cells L^{-1}) and comparison in variations of different groups of plankton

Plankton group	Treatment 1 (T-1)	Treatment 2 (T-2)	F-value	Level of significance
Bacillariophyceae	7.50±0.97	12.13±0.85	12.91	*
	(6.90-7.68)	(11.20-13.20)		
Chlorophyceae	26.33±3.58	36.75±4.21	3.55	ns
	(25.35-27.25)	(36.88-39.85)		
Cyanophyceae	15.17±1.64	18.88 ±1.53	2.72	ns
	(14.30-16.50)	(18.50-19.26)		
Euglenophyceae	5.25±0.40	11.08±0.92	33.52	*
	(4.50-6.15)	(10.75-11.65)		
Total phytoplankton	54.54 ±5.60	78.25±6.33	7.86	*
	(52.70-55.90)	(78.62-82.13)		
Crustacea	22.67±2.61	32.29±2.60	6.78	*
	(21.40-23.46)	(30.20-34.18)		
Rotifera	13.50±1.22	22.50±1.62	19.71	*
	(12.30-15.10)	(20.35-24.40)		
Total zooplankton	37.08±3.54	57.63±4.59	12.54	*
	(33.70-38.30)	(51.55-56.98)		
Total plankton	95.08±10.14	135.88±10.62	7.72	*
	(86.40-94.20)	(129.03-139.03)		

ns represents non-significance ($p>0.05$); *represents significance ($p<0.05$); Values in the parentheses are the range

mean value of 54.54±5.60 in T-1, while in T-2 it varied from 78.62-82.13 ×10^4 L^{-1} with a mean value of 78.25±6.33 × 10^4 cells L^{-1} (Table 3 and 4). Statistical analysis showed a significant difference ($p<0.05$) in average abundance of total phytoplankton between two treatments (Table 4). The phytoplankton growth increased in T-2 gradually with the highest rate of 230×10^4 cells L^{-1} at the 7th week of experimental period (Fig. 1). Each of the groups of phytoplankton was also abundant in T-2 in higher percentage. The percent composition of different phytoplankton groups in two treatments is shown in Fig. 2.

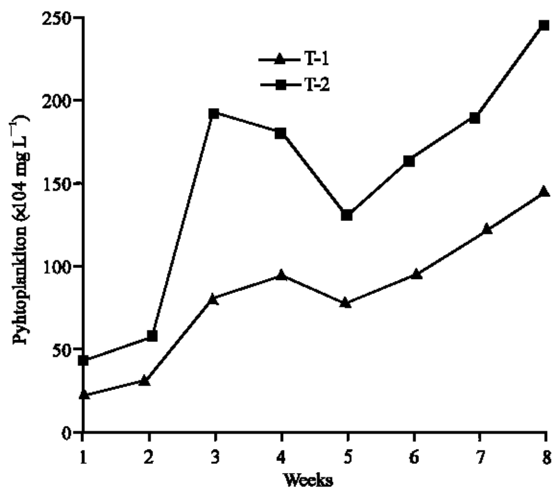

Fig. 1: Weekly variations in abundance of phytoplankton in pond water under different treatments

Zooplankton abundance: Mean abundance of zooplankton in different treatments are shown in Table 3. Two major groups, viz., Crustacea and Rotifera, represented the zooplankton population of the ponds.

Crustacea: Crustacea was the most dominant zooplankton group comprising of 5 genera (Table 2). Its abundanceranged from 4 to 46×10^4cells L^{-1} with a mean value of 22.67±2.61×10^4 cells L^{-1} in T-1 and from 16

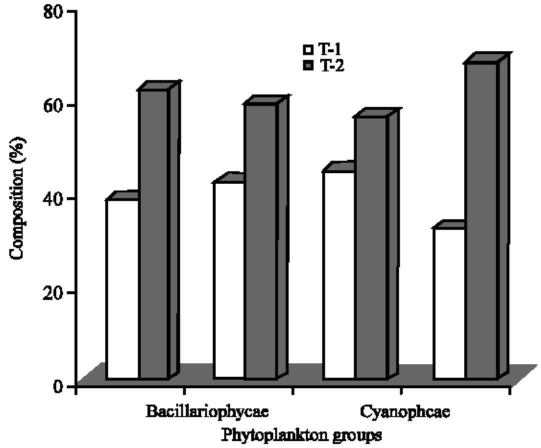

Fig. 2: Percent composition of phytoplankton groups in pond water under different treatments

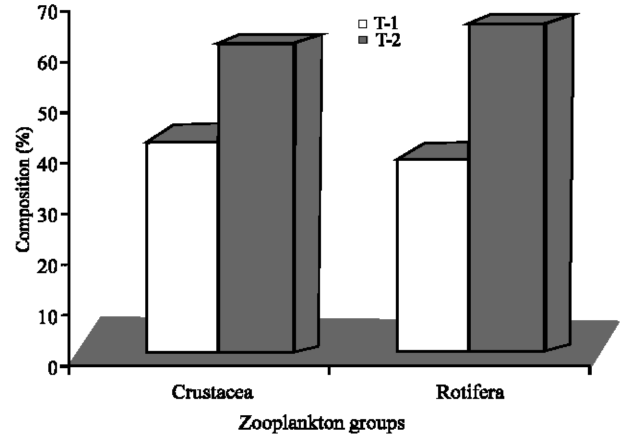

Fig. 4: Percent composition of zooplankton groups in pond water under two different treatments

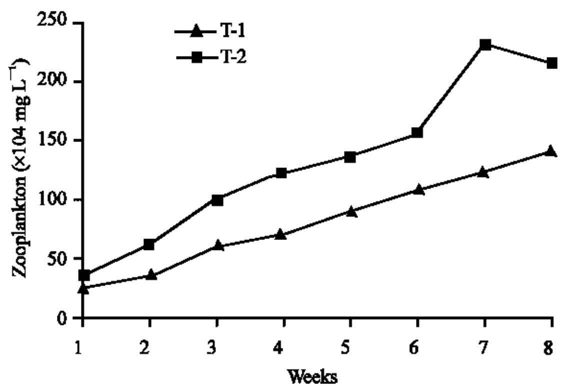

Fig. 3: Weekly variation in abundance of zooplankton in pond water under two different treatments

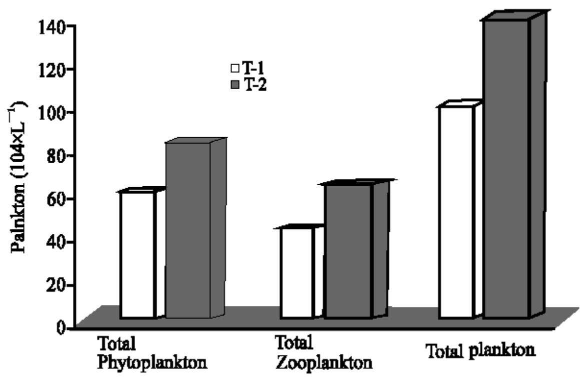

Fig. 5: Mean abundance in plankton content of pond water under two different treatments

to 66×0^4 cells L^{-1} with a mean value of $32.29\pm2.61\times10^4$cells L^{-1} in T-2 (Table 3 and 4). Crustacean abundance was significantly different ($p<0.05$) between two treatments (Table 4).

Rotifera: Rotifera were found in relatively low quantities. *Brachionus* and *Polyarthra* were the most commonly found genera. This group of zooplankton was observed to range from 5 to 28×10^4 cells L^{-1} and 8 to 44×10^4 cells L^{-1} in T-1 and T-2 (Table 3), respectively, with the corresponding treatment means of 13.50 ± 1.22 and $22.50\pm1.62\times10^4$ cells L^{-1} (Table 4). A significant difference ($p<0.05$) was observed in abundance of Rotifera between the two treatments (Table 4).

Total zooplankton: Total zooplankton abundance was found to range from 33.70 to 38.30×10^4 cells L^{-1} (Table 3) with a mean value of $37.08\pm3.54\times10^4$ cells L^{-1} in T-1 (Table 4) and from 51.55 to 56.98×10^4 cells L^{-1} (Table 3) with a mean value of $57.63\pm4.59\times10^4$ cells L^{-1} in T-2 (Table 4). These values were significantly different ($p<0.05$) between the treatment (Table 4). The zooplankton growth increased gradually with the highest rate of 84×10^4 cells L^{-1} at the 7th week of experimental period (Fig. 3). Each of the groups of zooplankton was abundant in T-2 in higher percentage. Percent composition of different zooplankton groups in two treatments is shown in Fig. 4.

Total plankton: The average abundance of plankton population varied from 86.40 to 94.20×10^4 L^{-1} with a mean abundance of $89.74\pm10.09\times10^4$ L^{-1} in T-1. On the contrary, it ranged from 129.03 to 139.03×10^4 L^{-1} with a mean value 154.76 ± 3.03 in T-2 (Table 3 and 4). The treatment means were significantly different ($p<0.05$) between the two treatments (Table 4). Mean abundance in plankton content of pond water under two different treatments is shown in Fig. 5.

DISCUSSION

Production of an unpredictable mixture of algae is greatly caused by application of both inorganic and organic fertilizers and is of great importance in managing the biological productivity in a fishpond. The number of phytoplankton in fertilized pond may be found more than 10 times higher than in unfertilized pond (Boyd, 1982). It is evident from the phytoplankton data obtained during the present experiment that the average abundance of total phytoplankton was significantly higher in treatment ponds receiving poultry manure-urea-TSP (T-2) than that in ponds receiving cow manure-urea-TSP (T-1) (Table 3). Mean variations in phytoplankton production was higher in pond water under T-2 throughout the experimental period, suggesting that the fertilization effects of poultry manure in supplying nutrients in water column is better than that of cow manure. Dhawan and Toor (1989) reported that total phytoplankton were significantly higher in the ponds treated with poultry droppings alone and in combination with cow dung than in the ponds with cow dung alone and in combination with supplementary diet, indicating the fertilization superiority of poultry manure over the cow manure. Total phytoplankton population growth in the ponds treated with poultry manure alone has been higher due to the presence of sufficient PO_4-P and NO_3-N release from the manure in water (Varghese and Shanker, 1981; Sood, 1984)

Among phytoplankton population, Chlorophyceae was found to be the most dominant planktonic group both in terms of number of genera (19) and percentage (47-49%), followed by Cyanophyceae (8 and 24-28%) and Bacillariophyceae (7 and 14-15%). Euglenophyceae showed the poorest abundance in both treatments. However, between the treatments and phytoplankton groups, Euglenophyceae was observed in higher percentage of 68%, followed by Bacillariophyceae of 62%, Chlorophyceae of 58% and Cyanophyceae of 55% in T-2 (Fig. 1). Almost similar order of dominance in different groups of phytoplankton has been reported in ponds treated with poultry and cow manure treated ponds (Dhawan and Toor, 1989) and also in both organic and inorganic fertilized fish ponds in the vicinity of BAU (Dewan, 1973; Ahmed *et al*., 1997; Wahab *et al*., 1994). Dissimilar to the findings of the present study and above authors, diversity among the phytoplankton in cow manure treated ponds was found least dominated by Chlorophyceae and Cyanophyceae (Noriega-Curtis, 1979).

Among phytoplankton genera, *Fragillaria*, *Navicula*, *Synedra*, *Actnestrum*, *Chlorella*, *Pediastrum*, *Tetraedron*, *Chlorococcus*, *Chroococcus*, *Merismopedia*, *Oscillatoria*, *Euglena*, *Phacus* and *Trachelomonas* were persistently present in all ponds during the present study period. While *Scenedesmus*, *Spirulina*, *Anabaena*, *Chaetoceros*, *Spirogyra* and *Microcystis* were the representative phytoplankton genera throughout the observation period in cow manure treated pond (Noriega-Curtis, 1979), *Microcystis*, *Anabaena*, *Oscillatoria*, *Pondarina*, *Volvox*, *Euglena*, *Pediastrum*, *Melosira*, *Scenedesmus* and *Closterium* were the major genera all the year round in poultry manure fertilized pond water (Das, 1986). Though the phytoplankton groups were more or less common in order to their abundance in the vicinity of present study area, the generic representation differs either in quality and quantity (Dewan, 1973; Ahmed *et al*., 1997; Wahab *et al*., 1994; Azim *et al*., 2001). It has been observed that phytoplankton abundance both in quantity and quality varies from location to location, pond to pond even within the same location with similar ecological conditions (Boyd, 1982).

Fertilization (both inorganic and organic) has of great implications in increasing primary productivity that usually follows in greater zooplankton production in ponds (Boyd, 1982; Shandhu *et al*., 1985) though the abundance and composition of zooplankton are often strikingly different, i.e., fertilization had little effect upon community composition. The poultry manure with inorganic fertilizer (T-2) resulted in significantly higher zooplankton production, both in total number and in group-wise variations. Of the crustacean, *Daphnia*, *Diaphanosoma*, *Diaptomus*, *Cyclops* and of the rotifers, *Brachionus*, *Asplanchna* and *Keratella* were the dominant genera found consistently in all ponds during the study period. Though Crustacea was the dominant zooplankton group in both types of manure treated pond, rotifers have been reported as the common and dominant group in manure-rich waters (Noriega-Curtis, 1979; Shadhu *et al*., 1985) the crustaceans (copepods, cladocerans) and rotifers may also occur as equally abundant in manure treated ponds (Ghosh *et al*., 1974). Hasan (1990) observed that zooplankton biomass varied from 0.12 to 9.48 mg L^{-1} in cow manure treated ponds, where nauplii were the dominant (59.3%) group among zooplankton, followed by rotifers (24.8%), copepods (11.9%) and cladocerans (4.0%). The plankton production in pond under both fertilization treatments increased rapidly in around the 3rd week of fertilization and afterwards the production was stabilized, though apparently in a increasing rate. The type of quick dissolution of organic manure might have given rise to high phytoplankton abundance during the first 21-28 days after fertilization. Later on towards the end of the experimental period, the release of nutrients by decomposition of solid portions of manure might have produced the larger bloom of plankton. It is to note here that despite a similar amount of nitrogen and phosphorus loading in ponds under two treatments (poultry manure-urea-TSP and cow manure-urea-TSP), poultry manure treated ponds resulted in high production of plankton. This might be due to that besides nitrogen and phosphorus; poultry manure might have released plankton growth promoting soluble salts in water column at a higher rate than cow manure, as has been observed by Banerjee *et al*. (1979). Further, the experiment give credence to conclude that the favorable water and sediment qualities helped considerably to mineralize the organic manure and release of nutrients like nitrates and phosphates, causing and maintaining the high plankton production throughout the experimental period.

Though the experiment was conducted without any fish in ponds, there might be phytoplankton grazing by zooplankton, resulting in the fluctuations in phytoplankton abundance. However, the phytoplankton production was more or less steady throughout the experimental period. The one way of justifying this is that in manure treated pond, the phytoplankton link is bypassed in that the zooplankters feed directly on small solid pieces of the manure, possibly digesting the bacteria from outer surfaces, or absorb the dissolved organic matter present in the water (Schroeder, 1980). The food chain activity in manure treated pond possibly reduced the zooplankton grazing on phytoplankton and provided additional food source for zooplankton production, resulting in plankton production in high magnitude.

CONCLUSIONS

It can be concluded that poultry manure is more efficient than the cow manure for plankton production in earthen ponds. Poultry manure can be recommended as substitute of cow manure for its high quality and quantity plankton production capacity. Therefore, fish farmers in rural areas in tropical developing country like Bangladesh, where poultry manure is easily available and underutilized, may be suggested to use of poultry manure for maintaining biological productivity in earthen ponds for fish culture.

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