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Evaluation of the effects of fertilizers on the abundance of plankton population

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Abstract: The experiment was conducted for a period of four months during August to November, 2004 to evaluate the effects of fertilizers on the abundance of plankton population. Three treatments namely T_1 (urea: 100 kg/ha + TSP: 50 kg/ha), T_2 (chicken manure: 2000 kg/ha + urea: 100 kg/ha + TSP: 50 kg/ha) and T_3 (cowdung: 4000 kg/ha + urea: 100 kg/ha + TSP: 50 kg/ha) were applied with duplicates for each of the treatment. Fertilizers were applied fortnightly. Four groups of phytoplankton such as Cyanophyceae, Chlorophyceae, Bacillariophyceae and Euglenophyceae and four groups of zooplankton viz. Rotifer, copepod, cladoceran and Nauplius were recorded in the present experiment. Cyanophyceae and Rotifer were found to be the most dominant groups over different groups of phytoplankton and zooplankton, respectively. The maximum abundance of phytoplankton was noted in T_2 whereas; the maximum abundance of zooplankton was recorded in T_1. On an average, the maximum abundance of different groups of phytoplankton was recorded in T_2; the maximum abundance of zooplankton was recorded in T_3. The physicochemical factors such as temperature, transparency, dissolved oxygen and pH were considered in the present experiment and found within the productive range. Therefore, chicken manure is very much effective for higher biological production in a waterbody.

Key words: Plankton, Cyanophyceae, Chlorophyceae, Bacillariophyceae and Euglenophyceae

Introduction

The production of fish per ha in Bangladesh is much lower than the other fish producing countries of the world. This is due to the lack of sufficient knowledge regarding scientific culture and management practices. Intensive fish culture depends on use of costly artificial fish feeds along with other modern scientific techniques. Semi-intensive culture is considerably less expensive by using fertilizers and supplementary feeds.

Fertilization is an important technique to increase the pond productivity. Fertilization in the pond enhances the growth of primary producers which are consumed by fish. Locally available organic manures as well as in combined with the inorganic fertilizers can play an important role for plankton production and fish culture. Farmers can get the organic manures at little or no cost. It also helps in improving aquatic ecosystem. Chemical fertilizers enhanced the growth of phytoplankton and zooplankton (Saha, 1978).

Quantitative and qualitative study of plankton by applying chicken manure and cowdung along with the inorganic fertilizers in our country is still very limited or scanty. Therefore, this work was initiated to study the effect of different treatments of cowdung, chicken manure, urea & TSP on plankton production in fish ponds with the objective of evaluation of effectiveness of fertilizers on the quantitative and qualitative production of plankton and physico -chemical conditions of the experimental ponds.

Materials and Methods

Study area and period: The present experiment was conducted for a period of four months from August to November, 2004 in ponds, situated at the South-West corner of the Faculty of Fisheries, Bangladesh Agricultural University, Mymensingh. All these ponds were rectangular in shape having a surface area of 0.004 hectare. The average water depth was one meter.

Experimental design: Three treatments namely T_1, T_2 and T_3 were randomly assigned in each block with two replications. Where T_1, represents ponds treated with inorganic fertilizer (Urea 100 Kg/ha + TSP 50 Kg/ha), T_2 represents ponds treated with a combination organic and inorganic fertilizers (chicken manure 2000 Kg/ha + Urea 100 Kg/ha + TSP 50 Kg/ha) and T_3 represents with a combination of organic and inorganic fertilizer (cowdung 4000 Kg/ha + urea 100 Kg/ha + TSP 50 Kg/ha. Fertilizers were applied fortnightly. All the manures were applied into the ponds as slurry on wet weight basis and applied by spreading uniformly all over the pond water.

Pond preparation: Before fertilization, all the ponds were made ready by taking some appropriate measures. Aquatic vegetations were cleared off manually, all the predatory and weed fishes were removed by repeated netting and then by using rotenone at a dose of 3 ppm. Liming was done at a rate of 1 Kg/decimal.

Study of physico-chemical factors: The important factors such as water temperature, transparency, pH and dissolved oxygen content of the treated ponds were measured fortnightly at 10.00 - 11.00 A.M. during the study period. The temperature and dissolved oxygen of the ponds were determined by DO meter (YSI, model 58, made in USA.) pH changes were recorded by pH meter Wenway, model 3020, made in UK).

Plankton study: Ten liters water samples were collected from the ponds for the quantitative and qualitative study of both phytoplankton and zooplankton from each pond just before successive fertilizations and then passed through plankton net of 55 blotting silk of 100 micron mesh size. The collected samples were concentrated to a volume of 25 ml and preserved in plastic vials with 5% formalin for further analysis.

The numerical enumeration of both phytoplankton and zooplankton was done by Sedgewick-Rafter (S-R) counting cell which is 55 mm long, 20 mm wide and I mm deep. The volume of the chamber is I ml (1000 MM3 or I cc). The counting chamber is equally divided into 1000 fields. Each of the fields were having with a capacity of I microlitre. From the concentrated volume of the plankton samples, I ml was taken by a dropper and then put on the S-R cell. The counting chamber was covered with a cover slip so as to eliminate the air bubbles and left to stand for a few minutes to allow the plankton settle down and then it was placed under a microscope (magnification: I0X10) and both phytoplankton and zooplankton were counted from 10 random fields (units) out of 1000 units. The quantitative analysis of both phytoplankton and zooplankton were expressed as cells or units/litre according Stirling (1985). The qualitative analysis of plankton was done up to genus level according to Needham and Needham (1962), Pennak (1953), Ward and Whipple (1959).

Statistical analysis: For statistical analysis of data, a one-way ANOVA (Analysis of Variance) and DMRT (Duncan's Multiple Range Test) were done by using the SPSS (Statistical Package for Social Science) version-11.5. Significance was assigned at the 5% level. Duncan's tests were used to test the results of multiple ranges for comparisons of averages.

Results and Discussion

Plankton production: The plankton population showed an increasing tendency due to fertilizer application in the ponds. The fluctuations in abundance of both phytoplankton and zooplankton were found to vary from treatment to treatment.

Table 1. Mean (±SE) values of abundance (cells l^{-1}) in different treatments during study period

Plankton group	T_1	T_2	T_3	P value
		Phytoplankton		
Bacillariophyceae	12,7778 ± 585 ^{b}	14,700 ± 658 ^{a}	7,078 ± 386 ^{c}	0.00
Chlorophyceae	18,100 ± 57 ^{b}	21,767 ± 966 ^{a}	9,178 ± 565 ^{c}	0.00
Cyanophyceae	12,878 ± 409 ^{b}	16,189 ± 470 ^{a}	6,644 ± 382 ^{c}	0.00
Euglenophyceae	5,156 ±199 ^{b}	6,611 ± 308 ^{a}	2,478 ± 229 ^{c}	0.00
Total phytoplankton	49,000 ±1,560 ^{b}	59,444 ±2,178 ^{a}	25,422 ±1,245 ^{c}	
		Zooplankton		
Copepoda	4,219 ± 3,714	289 ± 67	633.33 ± 121	0.36
Rotifera	6022 ± 390 ^{b}	4,5667 ± 356 ^{c}	7211 ± 391 ^{a}	0.00
Cladocera	1989 ± 166 ^{b}	1,433 ± 134 ^{c}	2,533 ± 115 ^{a}	0.00
Crustaceae	1444 ±104 ^{b}	1,133 ± 6 9 ^{c}	2,144 ± 114 ^{a}	0.00
Total zooplankton	9,944 ± 560 ^{b}	7,422 ± 483 ^{c}	12,511 ± 496 ^{a}	0.00
Total plankton	58,944 ±1878 ^{b}	45,844 ± 1,629 ^{c}	71,956 ± 2,599 ^{a}	0.00

Means with different superscript in each row indicates significant (P<.05) difference based on Tukey test

Phytoplankton: The mean values of different phytoplankton groups are presented in Table 1. Four major groups of phytoplankton viz, Cyanophyceae, Chlorophyceae, Bacillariophyceae and Euglenophyceae were observed in the ponds under different treatments during the study period. The different genera of Cyanophyceae were Aphanocapsa, Microcystis, Aphanotheca, and 0scillatorla, Nostoc, Anabaena, Chroococcus, Gloeocapsa, Coelespharlum and Merismopedla. The group Chlorophyceae was represented by15 genera such as Scenedesmus, Chlorella, Closterlum, pediastrum, Gloeocystis, Spirogyra, Ulothrix, Volvox, Tetredron, Oocystis, Gonatozjygon, SpIrulina, Cosmarlum, Ankistrodesmus and Botryococcus. Six genera such as Navicula, Fragilaria, Asterlonella, Synedra, Diatoma and Tabellarla were found in the group Bacillariophyceae. Three genera such as Phacus, Euglena and Trachelomonas were counted belong to group Euglenophyceae.

A fortnightly variation in the abundance of different groups of phytoplankton among all the treatments was recorded in the present study. The maximum number (40,383 units/litre) of Cyanophyceae was counted in T_2 at sixth fortnight and minimum (8,080 units/litre) in T_1, at third fortnight. Whereas, the highest number of Chlorophyceae (15,416 units/litre) was found in T_3 at 4th fortnight and minimum number (5,794 units/litre) was observed with the treatment T_2 at second fortnight. The maximum number of Bacillariophyceae (5,160 units/litre) was found in T_1 at third fortnight and minimum number (3,283 units/litre) with the same treatment at 5th fortnight. Euglenophyceae showed its maximum number (25,472 units/litre) in T_3 at third fortnight and minimum number (1,266 units/litre) with the treatment T_2 at first fortnight. Although a significant variation in the number of different groups of phytoplankton were recorded in the present experiment, but significantly a higher number of all the groups of phytoplankton were recorded in T_2 (urea, TSP and chicken manure) than rest of the treatments among all fortnight..

Alikunhi *et al*. (1957) and Bhimachar (1971) stated that organic fertilizers enhance the production of phytoplankton. Nandeesha *et al*. (1984) evaluated the effect of three organic manures, silkworm fecal matter, poultry manure and a combination of both in fish pond and stated that poultry manure treatment had the highest number of phytoplankton than others. The above findings are in compliment with the present finding. Among the different groups of phytoplankton, Cyanophyceae was found to be the most dominant group followed by Chlorophyceae, Euglenophyceae and Bacillariophyceae in respect of numerical abundanc that is supported by Bhimachar (1971). Inorganic fertilizer (urea) treated ponds gave comparatively higher production of phytoplankton. Ghosh (1973) also found higher phytoplankton production by applying urea in pond.

Zooplankton: The mean values of zooplankton concentration in different treatments are in Table 1. Four groups of zooplankton such as Rotifer, Copepod, Cladoceran and Nanp lius were encountered in the present experiment. A total of seven genera viz. Brachlonas, Keratella, Poliarthra, Filinia, Lecane, Asplanchna and Notholca were noted in the Rotifer group. The group Copepod was represented by two genera such as Qyclops and Diaptomus. Two genera namely Daphnia and Diaphanosoma were found in the group Cladoceran. Fortnightly variations in the number of different groups of zooplankton among all the treatments were recorded in the present study. The maximum number of Rotifer (33,166 units/litre) was noted in T_1 at 6th fortnight and minimum number (1,249 units/litre) in T_1, at 2nd fortnight. The maximum number (10,500 units/litre) of Copepod was encountered with the treatment T_3 at 7th fortnight and' the minimum was (556 units/litre) with the treatment T_1 at 2nd fortnight. The maximum number (3,405 units/litre) and the minimum (266 units/litre) of Cladoceran was found with the same treatment T_3 at 4th and fifth fortnights, respectively. The highest number of Nauplius was enumerated (12,279 units/litre) with the treatment T_3 at 7th fortnight and the lowest number (1,172 units/litre) in T_2 at 2nd fortnight. Although a significant variation in the number of different groups of zooplankton was observed but significantly a higher number of more or less all the groups of zooplankton was recorded with the treatment T_3 (combination of inorganic and cowdung treated ponds) than rest of the treatments among all fortnights.

Variations in the abundance of different groups of zooplankton were observed in almost all the treatments. The abundance of Rotifer was higher foloowed by Nauplius, copepod and Cladoceran which is supported by Rappaport *et al*. (1977) and Banerjee *et al*. (1979). Ponds treated with a combination of both inorganic plus organic fertilizers gave a moderate production of both phytopankton and zooplankton which are similar to the findings of Chattopadhay and Mandal (1969) and Chakraborti (1984). The ponds treated with organic fertilizers gave comparatively high production of zooplantkton which is more or less similar to the finding of Alikunhi *et al*. (1957). Banerjee (1967) also stated that organic fertilizers are especially efficient in increasing the abundance of zooplankton.

Physico-chemical factors

Water temperature: The mean values of water temperature in different treatments did not differ significantly (P>0.05) among the treatments (Table 1). During the observation period, the water temperature of the treated ponds varied from 20.1^{o} C to 30.8 ^{o} C. The highest water temperature 30.8 ^{0} C) was recorded at first fortnight with the treatments T, and T_3 and the lowest water temperature (20.1 ^{0} C) in treatment T_2. The highest and lowest value of water temperature might be due to summer season and cold weather respectively, during the observation period. The water temperature was within the suitable range over the study period.

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

Parameters	N	T_1	T_2	T_3
Temperature (ºC)	72	27.21± 4.21	28.21± 4.21	28.21± 4.21
Transparency (cm)	72	34.26 ± 8.58^{c}	39.46 ± 12.41^{b}	43.77 ± 11.51^{a}
Dissolved oxygen (mg l^{-1})	72	5.73 ± 0.07	5.76 ± 0.07	5.81 ± 0.07
pH range	72	7.2 - 9.3	6.5 – 8.8	6.3 – 8.6

Transparency: The mean values of water transparency in different treatments were significantly (P<0.05) different during the observation period. The transparency of the treated ponds varied from 35 cm to 17 cm. The highest value of transparency was 35 cm with the treatments T_1, T_2 and T_3 at 4th, 2nd and 6th fortnights, respectively and the lowest value of transparency was 17 cm in T_3 at 5th fortnight. The transparency was within in the productive range but exceeding the optimum range over the study period.

Dissolved Oxygen (DO): The mean values of dissolved oxygen content in different treatment were found to vary at different fortnights in different treatments significantly (P<0.05). Dissolved oxygen content varied from 5 to 8.5 mg/l. The minimum value of dissolved oxygen concentration was recorded in T_2 at 2nd fortnight whereas the maximum value of the same was recorded in T_1 at 3rd fortnight. During the present observation period it was found that the dissolved oxygen contents of water under different treatments were within the suitable productive range. The dissolved oxygen was comparatively lower in T_2 where combination of inorganic and organic fertilizer was applied and the higher growth of plankton observed. The finding is in agreement with those reported by Rao (1955). This might be due to the decomposition of organic matter and intake of DO by Zooplankton. Ellis (1937) concluded that dissolved oxygen concentration below 3.0 ppm may lead to asphyxia to fish and 5 ppm of dissolved oxygen was required to maintain a favorable condition of fish fauna. Alikunhi (1957) stated that good pond water for fish cultivation should have a fair amount of dissolved oxygen of the order of 5.0 to 7.0 ppm. Considering the physico-chemical factors the experimental ponds were with in the suitable range for fish culture.

pH: Ranges of pH value varied from 6.3 to 9.3 (Table 1). The minimum pH value was recorded in T_3 at 7th fortnight and the maximum pH value was recorded in T_1 at first fortnight. Significant variation was observed among the treatments. The pH values of the treated ponds were near neutral. The range of pH values obtained during the observation period indicated that the treated ponds were productive. Swingle (1957) stated that waters having a pH range of 6.5 to 9.0 are the most suitable for pond fish culture. He also observed that water with pH more than 9.5 was unproductive and pH 11.0 was lethal for fish. Ellis (1937) reported that pH values ranged between 6.5 and 8.5

are required to maintain the productivity of water for aquatic life.

The physico-chemical condition was with in the suitable range and biological production was higher in T_2 where chicken manure was used as organic fertilizer. Therefore, it may be recommended for higher productivity of a waterbody.

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