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A Study on the Effects of Iso-Phosphorus Fertilizers on Plankton Production in Fish Ponds

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Abstract

This study was conducted to evaluate the effects of iso-phosphorus organic and inorganic fertilizers on plankton production in fish ponds for a period of three months. Three types of fertilizers viz., poultry manure (PM), cow manure (CM) and urea plus triple-super phosphate (UT) were tested in triplicate using nine man-made earthen ponds of 100 m^2 each. The application rate of PM, CM and UT, was 3,300 kg/ha, 9,200 kg/ha, and 100 kg urea plus 100 kg TSP/ha, respectively in treatments T_1, T_2 and T_3 to have a similar content of 46 kg P_2O_5. Four groups of phytoplankton such as Bacillariophyceae, Chlorophyceae, Cyanophyceae, Euglenophyceae and two groups of zooplankton namely; Crustacea and Rotifera were encountered. The mean abundance of both phytoplankton ($72.00 \pm 6.6 \times 10^4$ cells/l), and zooplankton ($33.14 \pm 3.81 \times 10^4$ cells/l), were significantly higher ($p<0.05$) in fish ponds which received PM. The results of the present study show that despite iso-phosphorus content, the nutrient status of poultry manure is significantly superior to cow manure or inorganic fertilizers when these are used alone.
Key words: fertilizers, fish pond, iso-phosphorus, phytoplankton, zooplankton.

Introduction

Fertilization is an essential step or procedure in efficient farm management to increase pond productivity. Pond fertilization enhances the growth of primary producers, which are consumed by fish, thus ultimately augmenting the fish crop. Pond fertilization is the cheapest and simplest means of increasing aquatic productivity.

Pond fertilization practices using animal wastes are widely used in many countries to sustain pond productivity at a low cost (PEKER and OLAH 1990). The employability of different kinds of manures, such as poultry manure, dung from cows, sheep, goats or pigs, has been established in biological production and these are known suitable substi-

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tutes for the costly feeds and fertilizers currently in use (BANERJEE *et al.* 1979, JHINGRAN and SHARMA 1980). Though both organic and inorganic fertilizers are used in fishponds, but manures from the organic sources are the most readily available in Bangladesh, and are thus far used most commonly in fish and shrimp culture practices at little or no cost. Among the types of organic manures, poultry manure is considered to be the best since it contains more N and P, which play a vital role for plankton production (DHAWAN 1986).

Phosphorus, though required in small quantities for aquatic biota, is the single most important element in waters. In lake studies, dissolved phosphorus is normally regarded as the most important factor affecting water quality, because this factor is most necessary for phytoplankton growth. However, phosphorus has been targeted because it is the limiting nutrient in many lakes and excessive phosphorus fertilization can result in eutrophication, with associated water quality problems for users (CLARKE *et al.* 1988). The availability of phosphorus from phosphatic fertilizers is strongly related to pond productivity. Triple-super phosphate (TSP) (40% P_2O_5) has been found to be the most efficient in maintaining a higher level of soluble phosphorus in the water phase, while single super phosphate (16% P_2O_5) maintains a higher level of available phosphorus in the soil phase (SHAH and CHATTERJEE 1979).

Although a number of studies have been performed on the effect of fertilizers on plankton production (WAHAB *et al.* 1994, AHMED *et al.* 1997), comparative studies on the effect of poultry manure, cow manure and that of inorganic fertilizer, i.e., urea and TSP, containing similar quantities of phosphorus, are still very limited. Therefore, the present study was undertaken with the aim of determining the effect of organic and inorganic iso-phosphorus fertilizers on plankton production.

Materials and Methods

Description of Ponds and design of experiment

This experiment was carried out for a period of three months from March to May 2000, in nine experimental ponds situated at the Field Laboratory of the Faculty of Fisheries, Bangladesh Agricultural University, Mymensingh, Bangladesh. The area of each pond was 100 m^2 with an average depth of 1.5 m. All the experimental ponds were

Table1. Chemical composition of different organic manures.

Chemical component (%)	Poultry manure	Cow manure
Moisture	60	65
Organic matter	16	22
Total nitrogen	1.6	0.8
Total phosphorus	1.5	0.5
Total potassium	0.80	0.35

dried, re-excavated to a depth of 0.3 m and then ploughed. The pond bottoms were treated with lime at a rate of 250 kg/ha. After 5 days of liming, the ponds were filled up to a depth of 1 meter with water from the hatchery deep tube-well.

The experiment was conducted using completely randomized design (CRD). Three treatments with two replicates each were tested in this experiment. Three levels of iso-phosphorus organic and inorganic fertilizers, viz. poultry manure (PM), cow manure (CM), and urea plus triple-superphosphate (UT), were used as treatments in the experiment. The content of 46 kg of P_2O_5 in 100 kg TSP, a usual application rate of phosphatic fertilizer per hectare being used prevailing conditions in Bangladesh, was used to determine the amount of test manures containing 46 kg of P_2O_5 along with the nutrient content of poultry and cow manure, which was analyzed on wet basis (Table 1) following the procedures given by AOAC (1980). The doses of PM, CM, and UT were 3,300 kg/ha (46 kg P_2O_5), 9,200 kg/ha (46 kg P_2O_5), and urea 100 kg/ha plus TSP 100 kg/ha (46 kg P_2O_5), respectively in the treatments T_1, T_2 and T_3.

Plankton Enumeration

Collection of Plankton samples

Ten-liter water samples were collected from different areas and depths of the ponds, and passed through a 25 μmesh plankton net. The collected plankton samples were preserved in 5% buffered formalin in small plastic bottles.

Qualitative and quantitative study of plankton

The preserved plankton samples were studied by using a Sedgewick-Rafter counting cell, under a compound binocular microscope (Swift M 4000-D). A 1 ml sub-sample from each of the samples was transferred to the cell, after which all planktonic organisms, present on 10 squares of the cells chosen randomly, were counted and later were used for quantitative estimation using the following the method and following formula given by STIRLING (1985).

$$N = (A \times 1000 \times C) / (V \times F \times L);$$

where,

N = No. of plankton cells or units per litre of original water.

A = Total no. of plankton counted.

C = Volume of final concentrate of the samples in ml.

V = Volume of a field in cubic mm.

F = No. of fields counted.

L = Volume of original water in liters.

Plankton were identified up to the category of genus and enumerated by the following [APHA (1992) and BELLINGER (1992)]. The mean number of plankton was recorded and expressed numerically per litre of water for each pond.

Statistical analysis

Data were analyzed for one-way ANOVA, and any differences at 5 % level of significance were noted using the statistical software package of Statgraphics verson 7.

Results

Plankton population of pond water

Plankton population were identified to be composed of six planktonic groups consisting of 51 genera (Table.2). Planktonic organisms mainly consist of 4 groups of phytoplankton, and 2 groups of zooplankton. Some 38 genera of phytoplankton belonging to Bacillariophyceae (7), Chlorophyceae (2), Cyanophyceae (8), and Euglenophyceae (3) were identified. Thirteen genera of zooplankton identified belonging to Crustacea (5), including Crustacean Nauplius and Rotifera (8) were also identified.

Comparison of mean values of different groups of Plankton among the treatments were made by using ANOVA to observe the difference among the treatments, as presented in Table 3. The comparative abundance of different phytoplankton and zooplankton groups under three treatments are shown in Fig 1, 2 respectively.

Phytoplankton

Mean abundance of phytoplankton with their different groups are shown in Table 2. The phytoplankton population of the fish ponds was composed of four major groups, such as Bacillariophyceae, Chlorophyceae, Cyanophyceae and Euglenophyceae.

Table 2.Generic status of phytoplankton and zooplankton available in pond waters during experimental period.

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

Table 3. Mean ± SD abundance of plankton (x10^4 cells/l) in pond waters under three different treatments.

Plankton groups	Treatment PM (T1)	Treatment CM (T2)	Treatment UT (T3)
Bacillariophyceae	13.79 ± 2.38a	3.86 ± 0.73b	6.71 ± 1.48b
Chlorophyceae	32.50 ± 4.02a	11.64 ± 1.61b	28.21 ± 3.89a
Cyanophyceae	20.79 ± 2.79a	10.21 ± 1.33b	18.29 ± 3.23b
Euglenophyceae	5.36 ± 0.84a	1.71 ± 0.33b	4.57 ± 0.95a
Total phytoplankton	72.00 ± 6.6a	27.43 ± 2.35b	61.50 ± 6.82a
Crustacea	24.21 ± 3.31a	13.71 ± 2.22b	17.14 ± 2.03ab
Rotifera	8.93 ± 1.60a	5.50 ± 0.79b	8.00 ± 1.37a
Total zooplankton	33.14 ± 3.81a	19.07 ± 2.59b	24.43 ± 2.40b
Total plankton	105.57 ± 10.09a	45.76 ± 3.03c	82.21 ± 7.37b

Values sharing similar superscript indicate non-significant difference at 5% level.

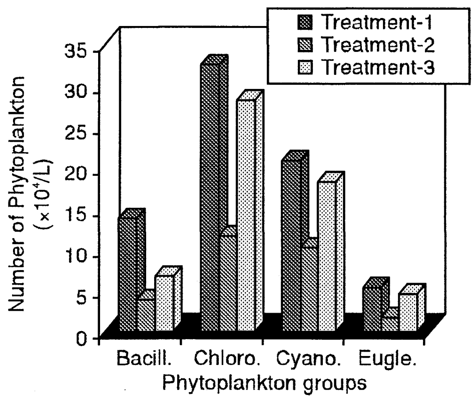

Fig. 1. Comparison of abundance of different phytoplankton groups under three different treatments.

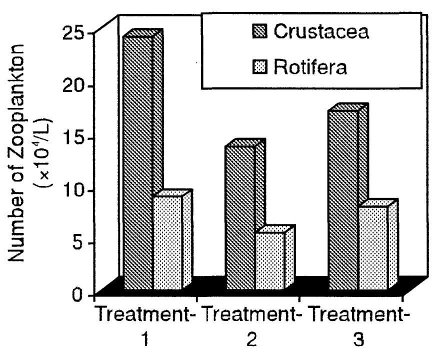

Fig. 2. Comparison of abundance of different zooplankton groups under three different treatments.

Bacillariophyceae

Bacillariophyceae is comprised of seven genera of which *Cyclotella, Frustularia, Melosira, Navicula, Surirella* were always present *Cocconeis, Synedra* were occasionally present. Mean abundance (×10^4 cells/l) of Bacillariophyceae was 13.79 ± 2.38 in T_1, 3.86 ± 0.73 in T_2, and 6.71 ± 1.84 in T_3. When compared using ANOVA, significant difference was found between treatment T_1 and T_2. Conversely, T_1 and T_3 were not significantly different.

Chlorophyceae

Chlorophyceae was the most dominant groups with a large number of genera in all the treatments. Among 20 genera most the dominant were *Chlorella, Oocystis, Scenedesmus*. Others genera were *Actinaustrum, Ankistrodesmus, Botryococcus, Ceratium, Characium, Cladophora, Closterium, Chaetophora, Cosmarium, Gonatozygon, Pediastrum, Sphaerocystis, Tetraedron, Teubaria, Ulothrix, Volvox,* and *Zygnema*. Mean abundance (×10^4 cells/l) of Chlorophyceae was 32.50 ± 4.02 in T_1, 11.64 ± 1.61 in T_2, and 28.21

± 3.89 in T_3. When compared using ANOVA, significant difference was found between T_1 and T_2. On the contrary, $T_1$and T_3 were not significantly different.

Cyanophyceae

Cyanophyceae are comprised of 8 genera viz. *Anabaena, Aphanocapsa, Chrococcus, Gomphospheria, Merismopedia, Microcystis, Nostoc*, and *Oscillatoria* were ranked second in respect to both abundance and number of genera. Among the 8 genera, *Anabaena, Aphanocapsa, Chrococcus, Microcystis* were the most dominant.

Mean abundance ($\times 10^4$ cells/l) of Cyanophyceae was 20.79 ± 2.79 in T_1, 10.21 ± 1.33 in T_2, and 18.29 ± 3.23 in T_3. When compared using ANOVA, significant difference was found between T_1, T_2, and T_3. On the contrary, T_1 and T_3 were not significantly different.

Euglenophyceae

Among phytoplankton, Euglenophyceae ranked fourth in respect to both abundance and number of genera. There were three genera of Euglenophyceae, *Euglena, Phacus,* and *Trachelomonas*. Mean abundance ($\times 10^4$ cells/l) of Euglenophyceae was 5.36 ± 0.84 in T_1, 1.71 ± 0.33 in T_2, and 4.37 ± 0.95 in T_3.When compared using ANOVA, significant differences were found between T_1, and T_2 and T_3. However there was no significant difference between T_1 and T_3.

Total Phytoplankton

The mean abundances ($\times 10^4$ cells/l) of total phytoplankton were 72.00 ± 6.6 in T_1, 27.43 ± 2.35 in T_2, and 61.50 ± 6.82 in T_3. When compared using ANOVA, significant differences were found between T_1 and T_2 and between T_2 and T_3, while T_1 and T_3 were not significantly different. Among phytoplankton groups, Chlorophyceae was the most dominant group, and Euglenophyceae was the least abundant planktonic group during the period of study (Table 2).

The dominant genera of phytoplankton were *Actinaustrum, Botryococcus, Chlorella, Ceratium, Characium, Closterium, Cosmarium, Gonatozygon, Oocystis, Scenedesmus, Pediastrum, Tetraedron, Ulothrix,* and *Volvox.*

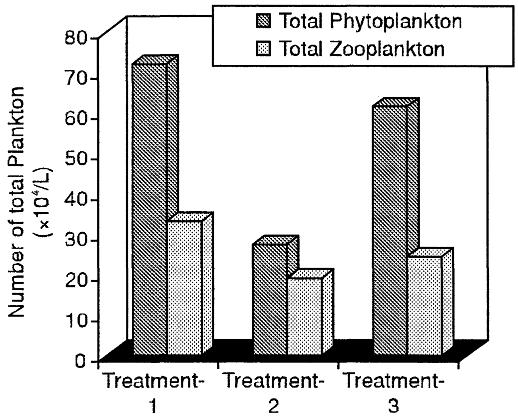

Fig. 3. Comparison of abundance of phytoplankton and zooplankton under three treatments.

Zooplankton

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 fish ponds.

Crustacea

Crustacea was the most dominant zooplanktonic group, where the mean abundances ($\times 10^4$ cells/l) were 24.21 ± 3.31 in T_1, 13.71 ± 2.22 in T_2, and 17.14 ± 2.03 in T_3, respectively. The abundance of crustacean was not significantly different among the treatments when compared using ANOVA.

Rotifera

Rotifera were found in relatively low numbers. The mean abundance ($\times 10^4$ cells/l) of rotifera was 8.90 ± 1.60 in T_1, 5.50 ± 0.79 in T_2, and 8.00 ± 1.37 in T_3, respectively. When compared using ANOVA, significant differences were found between T_1 and T_2, and between T_2 and T_3, while T_1 and T_3 were not significantly different.

Total Zooplankton

The mean abundance ($\times 10^4$ cells/l) of total zooplankton was 33.14 ± 3.81 in T_1, 19.07 ± 2.59 in T_2, and 24.43 ± 2.40 in T_3. These values were, when compared using ANOVA, significantly different between T_1 and T_3, and between T_1 and T_2, while T_2 and T_3 did not show any difference. Among zooplankton, the available genera were *Cyclops, Daphina, Diaphanosoma, Diaptomus, Nauplius, Asplanchna, Brachinus, Filinia, Keratella, Lecane, Notholca, Polyarthara*, and *Trichocerca*.

Total Plankton

The mean abundance ($\times 10^4$ cells/l) of total plankton ranged from 105.57 ± 10.09, 45.76 ± 3.03, and 82.21 ± 7.37 in T_1, T_2, and T_3, respectively. When compared using ANOVA, significant differences were found among T_1, T_2, and T_3 (Table 3). Comparison of abundance of phytoplankton and zooplankton under three treatments are shown in Fig 3.

Discussion

A total of 38 genera of phytoplankton, and 13 genera of zooplankton were recorded during the period of study. Phytoplankton densities of the ponds were 72.00 ± 6.6 in T_1, 27.43 ± 2.35 in T_2, and 61.50 ± 6.82 in T_3. The zooplankton densities were 105.57 ± 10.09, 45.76 ± 3.03, and 82.21 ± 7.37 in T_1, T_2, and T_3, respectively. RAY and DAVID (1969), conducted an experiment by using cow, poultry, goat, sheep, pig and horse manure for plankton production and they reported that the poultry manure gave the quickest and best results for plankton production. DINESH *et al.* (1986) reported that poultry manure is the best among the commonly used organic manures in India. FANG *et al.* (1986) carried out an experiment with chicken and pig manure in ponds and they reported that chicken manure was suitable for plankton production. ROSY (1993) conducted an experiment for a period of eight weeks to compare the effect of cow and chicken manure on the production of plankton. She observed four groups of phytoplankton such as Cyanophyceae, Chlorophyceae, Bacillariophyceae, and Euglenophyceae and four groups of zooplankton such as Rotifera, Copepoda, Cladoceran, and Nauplius in the experiment. BANERJEE (1979) and BHANOT *et al.* (1991) reported that organic fertilizer, especially poultry manure treated ponds, gave a comparatively higher production of zooplankton as the more or less the same results of the present study.

Though the plankton population was identified up to the level of genus level, their abundance is shown in Table 2 categorizing them in respective groups (families). The phytoplankton population was comprised of four major groups, viz., Bacillariophyceae, Chlorophyceae, Cyanophyceae and Euglenophyceae, which reflected the usual phytoplankton composition of tropical fish ponds (DEWAN *et al.* 1991). The Chlorophyceae group was the most dominant, with the highest number of 20 genera in all the treatments, followed by Cyanophyceae (8), Bacillariophyceae (7), and Euglenophyceae (3). All phytoplankton genera were significantly higher ($p<0.05$), with a mean value of 72.00 ± 6.6 x 104 cells/l in T_1 followed by 61.50 ± 6.82 $\times 10^4$ cells/l in T_3, and 27.43 ± 2.35 $\times 10^4$ cells/l in T_2. In addition to higher total plankton, the significantly higher abundance of Chlorophyceae (32.50 ± 4.02 $\times 10^4$ cells/l) in ponds treated with poultry manure (T_1) had a positive correlation to higher productivity.

The zooplankton population was comprised of two major groups: Crustacea having 5, and Rotifera, having 8 genera. Similar to phytoplankton abundance, the total zooplankton (33.14 ± 3.81 $\times 10^4$ cells/l) was significantly higher in T_1 (Table 3), indicating the nutrient superiority of poultry manure over cow manure and inorganic fertilizer.

Conclusions

Phosphorus is considered as an important nutrient for plankton production, as it has been found to result in producing a higher abundance of phytoplankton than nitrogen alone (DANIELS and BOYED 1993). Despite of iso-content the phosphorus of the two organic manures (poultry manure and cow manure), and one inorganic fertilizer combination (N: P), the high abundance of plankton in ponds treated with poultry manure than those ponds treated with other fertilizers (Table 3) suggests that the capacity of phosphorus released from poultry manure might be more efficient than cow manure alone and in combination with mineral fertilizer. It may be concluded that the treatment with poultry manure is better than treatment with cow manure alone and with or without the treatment of mineral fertilizers in combination. Therefore, fish culturists in general, particularly rural fish farmers, may be encouraged to use poultry manure. The fertilization strategy developed in this study has potential for a developing country like Bangladesh where poultry manure is underutilized and the use of synthetic fertilizer is not feasible from economic and environmental points of view.

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