EFFECTS OF DIFFERENT TYPES OF FERTILIZERS ON PLANKTON PRODUCTIVITY IN EARTHEN PONDS.

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ABSTRACT

Three fertilizer types (NPK, Super-phosphate and cow dung) were applied at two levels (Low, $0.3kg/25m^2/$ 2weeks and High, $0.7kg/25m^2/2weeks$) to 12 ponds with two ponds serving as control. Each pond had an area of $25m^2$. Application of fertilizers and monitoring of plankton productivity and water quality parameters continued fortnightly for 52 days. Results obtained were subjected to Analysis of Variance statistical analysis. The abundance of phytoplankton was in the order *Chlorophyceae* > *Bacillariophyceae* > *Cyanophyceae* > *Desmideaceae.* While that of Zooplankton followed the order *Crustacean* > *Rotifer* > *Protozoan.* Primary productivity showed a variation between treatments with lowest value of $5592mg/O_2/m^3/day$ obtained in the control and cow dung low application rates ($1.5kg/25m^2/2weeks$). The highest value for primary productivity was obtained at M_2($0.7kg/25m^2/2weeks$, N.P.K) with primary productivity value of $7200mgO_2/m^3/day$, closely followed by M_4($0.7kg/25m^2/2weeks$, super phosphate) with $6792mgO_2/m^3/day$.

INTRODUCTION

Fertilizer application, among other things has been used to achieve an increase in the productivity of ponds. Biological productivity in any given water body is a function of nutrients in it. These nutrients are used up for primary productivity by nanoplankton, which are subsequently eaten by megazooplankton, that serve as food to planktivores and finally they too are eaten by piscivores. Fertilizers are known to supply these nutrients, since they have been shown to stimulate the growth of plankton, the natural fish food. Fertilizers have been observed to increase fish yield three to four times (Moses, 1983; Westly, 1984). Chemical fertilizers are more readily soluble and have an immediate effect on plankton growth, since nutrient concentrations is readily released (Westly, 1984). However, comparing three types of fertilizers, Rappaport et al, (1976) reported that chicken droppings were most effective in aquaculture. It increased growth (yield) by about 30 %, liquid cattle manure was second, increasing yield by about 24 %, while chemical fertilizer increased yield by only 10 %. The high performance shown by chicken droppings is believed to be due to its high crude protein (about 33.2 % in some cases), compared to about 19 % in cattle manure (Keins and Reolof, 1977; Collins and Smitherman, 1978; Boyd, 1979).The amount of nutrient in a pond play a major role in determining the quantity and quality of plankton (Pearson et àl, 1984), usually measured either in mg/l, mg/m^2, g/m^3. The relative availability of nutrient in aquatic environments is believed to play.an important role in the structuring of phytoplanktonic communities (Harris, 1986). Nitrogen was found to be more of a limiting factor in pond productivity in the tropics (Henry et al, 1984) compared to temperate regions. It has also been observed that when nitrogen fertilizer was applied in ponds, there may be an initial lag in productivity, but the appearance of nitrogen fixing cyanobacteria usually raises the level (Levine and Levine, 1999). They were of the opinion that increase in nitrogen produces phytoplankton communities dominated by cryptophytes, chlorophytes and non-heterocystous cyanobacteria and in some cases chrysophytes. Lowkman and Jones (1999) found that increase in phosphates leads to increase in chlorophyll 'a' in streams by stimulating the growth column and thus stimulating the growth of benthic algae. Works on freshwater zooplankton have shown that the rotifers are the most abundant group (Hutchinson, 1967). These organisms are important as intermediates in aquatic food webs, since most rotifers are primary consumers. The protozoans are also of immense importance among the zooplankton.

The use of fertilizers in earthen ponds will therefore translate to the availability of nutrients for planktonic productivity. This will in turn mean more food availability for fish and consequently good fish yield, under proper water quality management. The aim of this study is therefore to obtain the best fertilizer type and level (among the three) that can be used for qualitative and quantitative plankton production in earthen ponds.

MATERIALS AND METHODS

Experimental site.

The study was conducted in 14 earthen ponds of an area of $25m^2$ each, and 0.5m average depths. The ponds were fed by an annual stream during the rainy season.

The earthen ponds were cleared manually to get rid of submerged weeds in July 2000 in such a way that the bottom soil was not disturbed. Water inlets and spillways were subsequently reconstructed. Three types of fertilizers were used for the study; NPK (15: 15: 15); super-phosphate (0 : 20: 0) and liquid cattle manure. The rates of application were 0.3kg/25m^2/2weeks for NPK and super-phosphate (as low rate) and 0.7kg/25m^2/2weeks as high rate based on the application rate recommended by Kumar, (1962). Cattle manure was applied at a rate of 1.5kg/25m^2/2weeks and 3.5kg/25m^2/2weeks as low and high rates respectively (based on the work of Kumar, (1962).

NPK and super-phosphate fertilizers were applied by broadcasting, while cattle liquid manure was in liquid form. The experiment lasted for 52 days.

Measuring primary productivity.

Primary productivity was determined by light and dark bottle technique. These bottles containing pond water taken at about 10cm from the surface were allowed to incubate in the pond water for a period of 6 hours before they were removed. Their oxygen contents were then determined using the modified Azide – Winkler's method. The difference in the amount of oxygen between the light and dark bottles is believed to be due to photosynthetic activities of the phytoplankton, from where gross productivity was calculated.

$$\text{Gross productivity} = \frac{O_L - O_D}{T\ (hrs)} \times \frac{0.375 \times 1000}{PQ\ (1.2)}\ mgL/m^3/h$$

$$\text{Net productivity} = \frac{O_L - O_I}{T\ (hrs)} \times \frac{0.375 \times 1000}{PQ\ (1.2)}\ mgL/m^3/h$$

O_I = Initial dissolved oxygen

O_L = Dissolved oxygen in light bottle

O_D = Dissolved oxygen in dark bottle

PQ = Photosynthesis Quotient given as 1.2

Planktonic sampling and identification

Plankton net of 70μm mesh size and 20cm diameter was used in the planktonic sampling. At the end of the net is attached a 60ml plastic container. Sampling took place before fertilization, three days after fertilization (completion of mineralization) and every fort-nightly for the remaining days. The procedure involved immersing the net in the pond and trawling backward and forward through a distance of about 1 meter. Sampled water was then transferred into a 60ml plastic container. In the case of phytoplankton, Lugol's iodine solution was the fixative used, while 4 % formalin was used for zooplankton. Estimation of plankton population was as recommended by APHA, (1985) using the formula,

$$N = \frac{(a\ 1000)\ C}{L}$$

N = number of plankton per liter

a = the average number of plankton in 1 ml of the sample

C = concentrated volume of sample

L = the volume of the original water sampled.

Identification of plankton was by the use of keys and monographs (Needham and Needham, 1962)

Experimental design

Complete Randomized Design was used with the three fertilizers at two (2) levels, with two replications, the 2 extra ponds serving as control.

For easy identification the ponds were designated thus:

M_1 = NPK at 0.3kg/25m^2/2weeks

M_2 = NPK at 0.7kg/25m^2/2weeks

M_3 = super phosphate at 0.3kg/25m^2/2weeks

M_4 = super phosphate at 0.7kg/25m^2/2weeks

M_5 = cow dung at 1.5kg/25m^2/2weeks

M_6 = cow dung at 3.5kg/25m^2/2weeks

M_7 = control (without fertilizer)

Initial selection of ponds was by random sampling (balloting), this is to reduce systematic sampling error. The balloting was done by random picking of pre-numbered pieces of papers as one goes through the ponds systematically.

Statistical analysis

One way analysis of variance was used to analyze the data obtained and Stat graphic was also used to draw the graphs.

RESULTS

The main phytoplankton groups recorded were baccillariophyceae, chlorophyceae, cyanophyceae and desmideaceae. Phytoplankton abundance followed the order chlorophyceae > bacillariophyceae>cyanophyceae > desmideaceae. A total of 44 species of phytoplankton was recorded during the study period. The percentage composition of each phytoplankton group were as follows: Baccillariophyceae 9 species (20.45%); Chlorophyceae 19 species (43.27%); Cyanophyceae 9 species (20.45%) and Desmideaceae 7 species (15.91%). The mean population of each phytoplankton group when compared were as shown in table 1.

It is evident that treatment M_1 (NPK at 0.3kg/25m^2/2weeks) had more chlorophyceae and bacillariophyceae, with high population of desmideaceae, even though there was an initial lag in desmideaceae population (table 1). M_7 (control) generally had the least phytoplankton population in respect of bacillariophyceace and cyanophyceace compared to the other treatments.

Main groups of zooplankton recorded during the study period were, rotifers, crustaceans and protozoans. These groups were found in almost all treatments (ponds). However with the exception of M_5 (cow dung at 1.5kg/25m^2/2weeks) where rotifers were not recorded; M_3 (super phosphate at 0.3kg/25m^2/2weeks) no crustaceans and M_2 (NPK at 0.7kg/25m^2/2weeks) there was no protozoan seen. The distribution of rotifers did not show any significant difference between the ponds, at $P < 0.05$ (table 2).

Except for the treatments where zooplankton was not recorded, M_6 (cow dung at 3.5kg/25m²/2weeks) and M_7 (control) had the least population of rotifers and protozoa - in this study, while M_4 (super phosphate at 0.7kg/25m²/2weeks) had the least population of crustaceans.

A total of 28 species of zooplankton were recorded with Rotifers 9 species (32.14%); Crustaceans 13 species (46.43%) and Protozoans 6 species (21.43%).

Discussion

This study revealed that M_4 (0.7kg/25m²/2 weeks super phosphate) had the highest primary productivity value of 7200mg 0_2/m³/day, closely followed by M_3 (0.3mg/25m²/2 weeks super phosphate) of 6792mg 0_2/m³/day. Cattle manure and control had lower values. The results obtained indicated that ponds that received super phosphate fertilizers did better, which is in agreement with Lowkman and Jones, (1999). They stated that increased phosphorous lead to a increase in chlorophyll'a' which stimulate algal growth in the water column.

The relative abundance of plankton in treatments (ponds) other than control could be attributed to the presence of more nutrients as a result of the fertilizer added to the water (Moses, 1983; Westly, 1984).

The present study revealed that the chlorophyceae were more abundant and were also found in all treatments, which is in agreement with the findings of Pervin, et al, (1987). In their study, they concluded that the proliferation of benthic filamentous chlorophy has been commonly associated with nutrient enrichment. This was why their abundance was mostly recorded in M_1 (NPK at 0.3kg/25m²/2weeks) and M_2 (NPK at 0.7kg/25m²/2weeks). The difference between M_1 (0.3mg/25m²/2 weeks and M_2 (0.7mg/25m²/2 weeks); which was higher for M_1 as opposed to M_2 could probably be due to sampling error or some inhibition effect of NPK with increasing concentration. This is despite the fact that the variation was insignificant, P>0.05. N.P.K. fertilizers are more balanced in terms of nutrient contents, especially in terms of chlorophy; and as such they will definitely produce better plankton communities compared to other treatments. This is evident from the fact that, M_1 (NPK at 0.3kg/25m²/2weeks) also gave higher population of bacillariophyceae and was closely followed by M_4 (super phosphate at 0.7kg/25m²/2weeks) in agreement with, Wong and Chung, (1976). They reported that the bacillariophyceae have a relatively high phosphorous requirements for optimal growth. Highest population of cyanophyceae recorded in M_3 (super phosphate at 0.3kg/25m²/2weeks) appears to be in agreement with the works of Schindler, (1977). According to Schindler, (1977), cyanophyceae are favoured by low Nitrogen – phosphorous ratio because of their ability to fix atmospheric Nitrogen, during periods of dissolved inorganic N_2 scarcity. It was for this reason that Levine and Levine, (1999), recommended the addition of nitrogen fertilizers to scum in water bodies formed by cyanophyceae.

The liquid cattle manure treatments generally had higher values of desmideaceae especially M_6 (3.5kg of maure/25m²/2 weeks). This appears to be in agreement with Jacoby et al (1991), who is of the opinion that the desmids are commonly associated with nutrients enrichment in lentic environments. Nitrogen fertilization has also been shown to lead to an initial lag in phytoplankton production (Levine and Levine, 1999). This was only evident in this study in respect of the desmids.

Results of this study revealed that the crustacean were the most abundant, even though Hutchinson, (1967) stated that in freshwater among zooplankton, the rotifers are more abundant. But this might have been in natural conditions. Also, the nitrogen fertilizers produced more rotifers and crustaceans compared to the other treatments. The low population of rotifers associated with liquid cattle manure might be due to their sensitivity to pollution in water bodies.

In conclusion, the use of fertilizer increased the plankton population by providing more nutrients, especially the NPK fertilizers in terms of chlorophyceae and bacillariophyceae. These are main food organism for intermediate consumers. And they are to be recommended for use in ponds.

To achieve maximum plankton production, it is recommended that the inclusion of liquid cattle manure will improve the plankton dynamics of the water body.

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Table 1: Mean phytoplankton population in ponds treated with different types of fertilizers.

Treatments	Bacillariophyceae	Chlorophyceae	Cyanophyceae	Desmideaceae	Row mean ± S.E
M_1	6800 ± 5271	12200 ± 5074	1000 ± 503	2800 ± 1803	5700 ± 2021a
M_2	3800 ± 3017	11200 ± 7742	400 ± 230	200 ± 20	3900 ± 2185a
M_3	2400 ± 565	4000 ± 979	7800 ± 3189	1000 ± 382	3800 ± 1005a
M_4	11800 ± 5954	15400 ± 6251	1200 ± 954	3150 ± 3150	7887 ± 2564a
M_5	2600 ± 1612	7400 ± 5809	1400 ± 886	1800 ± 1280	3300 ± 1524a
M_6	1600 ± 326	5100 ± 2462	2400 ± 2141	3000 ± 2495	2025 ± 980a
M_7	1000 ± 382	5700 ± 2334	600 ± 200	600 ± 382	1975 ± 774a
Column mean ± S.E	4285 ± 1208ab	8714 ± 1814b	2114 ± 692a	1792 ± 621a	

Mean data in the same row or column carrying different subscripts differ significantly from each other at $P < 0.05$.

M_1 = 0.3 kg NPK/25m²/2weeks M_2 = 0.7 kg NPK/25m²/2weeks
M_3 = 0.3 kg Superphosphate/25m²/2weeks
M_4 = 0.7 kg Superphosphate/25m²/2weeks M_5 = 1.5 kg Cattle manure/25m²/2weeks
M_6 = 3.5 kg Cattle manure/25m²/2weeks M_7 = Control

Table 2: Mean zooplankton population in ponds treated with different types of fertilizers.

Treatments	Rotifers	Crustaceans	Protozoans	Row mean ± S.E
M_1	1800 ± 1051	1800 ± 503	800 ± 565	1466 ± 415a
M_2	1200 ± 230	1800 ± 600	600 ± 600	1200 ± 303
M_3	400 ± 230	200 ± 200	1400 ± 600	1066 ± 257a
M_4	600 ± 200	800 ± 326	600 ± 200	166 ± 133a
M_5		1600 ± 565	1400 ± 683	1000 ± 342a
M_6	400 ± 230	600 ± 200	600 ± 200	533 ± 113a
M_7	400 ± 230	1000 ± 382	400 ± 230	600 ± 200a
Column mean ± E.E	685 ± 187a	1114 ± 180a	828 ± 175a	

Mean data in the same row or column carrying different subscripts differ significantly from each other at $P < 0.05$.

M_1 = 0.3 kg NPK/25m²/2weeks M_2 = 0.7 kg NPK/25m²/2weeks
M_3 = 0.3 kg Superphosphate/25m²/2weeks
M_4 = 0.7 kg Superphosphate/25m²/2weeks M_5 = 1.5 kg Cattle manure/25m²/2weeks
M_6 = 3.5 kg Cattle manure/25m²/2weeks M_7 = Control