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Impacts of different fertilizers on production of fishes in polyculture system

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Abstract
The experiment was conducted to determine the impacts of different fertilizers on production of fishes in polyculture system for three months. There were 3 treatments with two replications under each treatment and each pond was stocked with a total of 80 fish fry. Pond nos. 2 and 5 were under the treatment-I (TSP-90g per decimal fortnightly), pond nos. 1 and 4 were under the treatment-II (urea-60g and TSP-90g per decimal fortnightly) and pond nos. 3 and 6 were under the treatment-III (urea 60g and cowdung 1kg per decimal fortnightly). During experimental period, the ranges of water temperature (21.82 to 27.69 ºC), transparency (28.00 to 36.00 cm), dissolved oxygen (6.00 to 8.30 mg/L), pH (7.00 to 7.90), total alkalinity (142.00 to 205.00 mg/L), free CO_2 (2.00 to 4.00 mg/L), phosphate-phosphorus (1.20 to 2.30 mg/L), and nitrate-nitrogen (3.20 to 4.00 mg/L) were within the productive range and more or less similar in all the ponds under three treatments. Mean phytoplankton and zooplankton densities under treatment-I, II and III were 73.52±3.12 (× 10^3) cells/L,10.62±0.95 (× 10^3) cells/L and 75.79±2.39 (× 10^3) cells/L, 11.50±1.47 (× 10^3) cells/L and 74.41±7.87 (×10^3) cells/L, 10.17±1.56 (× 10^3) cells/L, respectively. The net productions of fish of the ponds under treatment-I, II and III were 1.041 ton/ha/yr, 1.425 ton/ha/yr and 1.191 ton/ha/yr, respectively. So, the use of urea 60g and TSP 90g per decimal (under treatment-II) might be considered the best among the three treatments.

Keywords: Fertilizers, Production of Fishes, Polyculture System

1. Introduction
Bangladesh is blessed with vast area of innumerable water bodies in the form of ponds, lakes, rivers, haors, baors, beels, tanks and inundated paddy fields. But the production of fish per hectare in our country is low in comparison to our demand. Fish is the major protein source contributing about 60% of total animal protein intake [1]. To increase the fish production, the improved techniques and management practices should be developed. Among different culture techniques, polyculture is the most important cultural technique which is mainly practiced in perennial ponds to get maximum production within a short period (3-4 months). The selection of species for polyculture is important. Rui *(Labeo rohita)*, mrigal *(Cirrhinus cirrhosus)*, common carp (*Cyprinus carpio)* and tilapia *(Oreochromis niloticus)*, four high yielding species for aquaculture were selected for the present experiment because these species are suitable for low input culture system in small ponds and ditches and for their high growth. Fertilization is an important part of fish culture. Through fertilization nutrients are supplied to a pond to increase primary production and increased primary production increases the population density of zooplankton, benthos and other fish-food organisms higher and in these way higher fish-food organisms increase fish yield manifolds (Rahman, 1992) [2]. Some nutrients, especially phosphorus and nitrogen, are naturally present in soil and water in very low concentration but they are highly significant and essential as major plant nutrients for which phosphorus and nitrogen are limiting factors. Phosphorus, nitrogen is limiting factors. Phosphorus, nitrogen and potassium are used as fertilizers in agricultural lands and also in fish ponds. But now-a-days potassium fertilizer is not considered important by many scientists for fish culture ponds. Recently some fishery scientists considering phosphorous as the most important component (Rahman, 1992) [2]. Successful fisheries management and scientific fish culture depends on the various limnological factors of the water bodies. According to Hickling (1968) [3] fish farming is a practical application of limnology and fresh-water biology [3]. According to Reid (1971) [4] the chemical analysis for dissolved gases and solids are highly important for the study of natural waters [4]. He also reported that fish culture can be enhanced by the improvement of substratum by the use of fertilizers along with other pond management measures. The physico-chemical characteristics of pond water are of great importance and essential in case of fish culture and fisheries management. The physico-chemical properties play the most important role in governing the production of phytoplankton i.e. primary production in fishponds (Banerjee, 1967) [5].

Although fertilization increase primary productivity and through which fish production increases manifold, yet many problems appear due to fertilization, for this reason fertilization should be done carefully considering the prevailing physicochemical and biological conditions of the pond and economics of fertilization should be considered for making fish culture profitable. The present research work was undertaken to study and observe the effects of fertilizers on the physico-chemical and biological environment of the ponds under three treatments and to find out the effects of fertilizers application on growth and production of fishes in polyculture system.

2. Materials and Methods

2.1 Study Area and duration

The duration of the experiment was 3 months during the period of February-April, 2015 in six ponds. The ponds were situated at the southeast corner of the Faculty of Fisheries Buildings, Bangladesh Agricultural University, Mymensingh.

2.2 Experimental Design

Six earthen ponds of similar size about 40 m^2 (1 decimal) area each and rectangular in shape, were used for the experiment. The ponds each have an average depth of 0.90 m. All the experimental ponds were arbitrarily numbered as pond no. 1 (P_1), pond no. 2 (P_2)…..and pond no. 6 (P_6). For the convenience of the research work pond 2 and 5 were considered as treatment no-I, pond 1 and 4 as treatment no-II and pond 3 and 6 as treatment no- III.

The experimental layout has been given in the Table 1 below-

Table 1: The layout of the experiment

Treatments	Replications	Fish species and ratio	Application of fertilizers	Fish population density
Treatment-I	2	Carpio:Rui:Mrigal:Tilapia=20:20:20:20	TSP 90g per decimal per 2 weeks	80 per decimal
Treatment-II	2	-do-	Urea 60g and TSP 90g per decimal per 2 weeks	80 per decimal
Treatment-III	2	-do-	Urea 60g and 1kg cowdung per decimal per 2 weeks	80 per decimal

Liming (CaO) was done in all the ponds at the rate of 1 kg/decimal before 7 days of fertilization. Ponds were supplied with water after 7 days of liming from a deep tube-well water supply system; rainfall was also a source of water supply to the ponds.

2.3 Fertilization of the ponds

Use of fertilizer, under treatment-I TSP-90g per decimal, under treatment- II urea-60g and TSP-90g per decimal and treatment- III urea 60g and cowdung 1kg per decimal were applied fortnightly. TSP was dissolved in water for 24 hours in a plastic bucket and then applied by spreading over the pond surface by a mug. Urea was also dissolved in the same plastic bucket before spreading on the water surface of the ponds. Fertilizers were applied at fifteen days interval.

2.4 Stocking of fish

Fingerlings of Rui, Mrigal, Common carp and Tilapia was stocked in the ponds. All the fish fry were collected from BFRI, Freshwater station, Mymensingh. Transportation of fry was done in well oxygenated polythene bags. Stocking was done in the morning and care was taken to acclimatize the fish gradually to pond condition. In all treatments fish population density was 80 fish per decimal. Fish were released after a week of fertilization. The initial average weight *of L. rohita, C. mrigala, C. carpio* and *O. niloticu*s were 5g, 5g, 5.8g and 3.8g and the initial average length of *L. rohita, C. mrigala, C. carpio and niloticu*s were 7.4 cm, 8.43 cm, 7.8 cm and 3.8 cm respectively.

2.5 Study of water quality parameters

Different water quality parameters were estimated and recorded fortnightly throughout the experimental period. Water quality measurement and sample collection were made between 9.00 am to 12.00 noon. Water samples were collected and transported in black plastic bottles having a volume of 250 ml each marked with pond number to the laboratory for chemical analysis. The procedures and methods followed to study water quality parameters have been given below.

2.5.1 Methods for study of physical parameters

2.5.1.1 Water depth (m)

Depth of water of the experimental ponds were measured with the help of a graduated wooden depth meter.

2.5.1.2 Transparency (cm)

Water transparency of the experimental ponds were measured by a Secchi-disk, it was immersed into the water and then the visible and invisible depths under the water to the naked eye were measured in cm.

2.5.1.3 Temperature (ºC)

Data of air and water temperature were collected from 'Weather Yard' of the Dept. of Irrigation and Water Management under the Faculty of Agricultural Engineering and Technology, BAU, Mymensingh.

2.5.2 Methods for study of chemical parameters

2.5.2.1 Dissolved oxygen (mg/L)

Dissolved oxygen of water was measured by a portable digital dissolved oxygen (DO) meter (Milwaukee, SM600 Smart DO Meter).

2.5.2.2 pH (Hydrogen-ion concentration)

pH was determined by a portable digital pH meter (Hanna Instruments).

2.5.2.3 Free carbon dioxide (mg/L)

For determining free carbon dioxide of water and titrated with 0.0227N sodium hydroxide solution using phenolphthalein as indicator (APHA, 1992) [6].

2.5.2.4 Total alkalinity (mg/L)

Total alkalinity of water samples was determined by titrimetric method using methyl orange indicator.

2.5.2.5 Phosphate-phosphorus (PO_4-P)

Phosphate-phosphorus (PO_4-P) of water samples of the ponds was determined by a digital Phosphate Meter (model HI 93717, Hanna Instruments Co.).

2.5.2.6 Nitrate-nitrogen (NO_3-N)

Nitrate-nitrogen (NO_3-N) was determined by a digital Nitrate Meter (model HI 93728, Hanna Instruments Co.).

2.5.3 Methods for study of biological parameters

Water samples in a 500 ml bottle were randomly collected for quantitative and qualitative study of phytoplankton and zooplankton of water from different locations of each of the

ponds and passed through a plankton net (mesh-size 55 µ) and finally concentrated to 100 ml. Then concentrated samples were preserved in small plastic bottles in 5% formalin for study under a compound microscope.

Calculation of planktons

The plankton population was determined by Sedgwick Rafter Counting Cell (S-R Cell) using the following formula (Rahman, 1992) [2]

$$N = \frac{A \times 1000 \times C}{V \times F \times L}$$

Where,

N = No. of plankton cells per liter of original water
A = Total no. of plankton counted
C = Volume of final concentrate of the sample in ml
V = Volume of a field = 1 mm³
F = No. of the fields counted
L = Volume of original water in liter

The number of phytoplankton and zooplankton were expressed as cells/L

2.6 Harvesting of fish

At the end of the experiment the water of the ponds were pumped out and all the fish were harvested. Then the final growth gained by the fish was recorded by measuring the length (cm) and weight (g) of the harvested fish by using a measuring scale and a balance respectively.

Estimation of survival rate, growth and production of fish

(i) The survival rate was estimated by the following formula

$$\text{Survival rate (\%)} = \frac{\text{No.of harvested fishes}}{\text{Initial no.of fishes}} \times 100$$

(ii) Specific growth rate (SGR %) was estimated by the following formula:

$$\text{SGR (\% per day)} = \frac{\log_e W_2 - \log_e W_1}{T_2 - T_1} \times 100$$

Where,

W_1= Initial live body weight (g) at time T_1
W_2= Final live body weight (g) at time T_2

(iii) Calculation of gross fish production (ton/ha/year) =

$$\frac{\text{Gross weight (kg) of fish per decimal per month} \times 250 \times 12}{1000}$$

(iv) Calculation of net fish production (ton/ha/year) =

$$\frac{\text{Net weight (kg) of fish per decimal per month} \times 250 \times 12}{1000}$$

2.7 Statistical analyses

T-test of net fish production of the ponds under three treatments was done by a computer using SPSS package programme.

3. Results

3.1 Physico-chemical parameters

The results of physico-chemical parameters are shown in Table-2. All Physical and chemical parameters were found to be within the acceptable ranges for fish culture in all treatments.

Table 2: Physico-chemical parameters (Mean±SD; n=3) of the ponds during the experimental period

Parameters	Treatment-I	Treatment-II	Treatment-III
Average water depth (m)	0.92±0.02	0.89±0.04	0.90±0.02
Water temperature (ºC)	25.88±2.23	25.88±2.23	25.88±2.23
Air temperature (ºC)	26.63±1.94	26.63±1.94	26.63±1.94
Transparency (cm)	30.91±1.38	31.50±1.00	31.58±1.63
Dissolved oxygen (mg/L)	6.95±0.38	7.33±0.12	7.41±0.45
Free CO_2	3.07±0.45	4.07±0.53	4.40±0.53
pH	7.36±0.15	7.48±0.09	7.42±0.08
PO_4-P (mg/L)	1.75±0.08	1.88±0.06	1.50±0.20
NO_3-N (mg/L)	1.75±0.08	3.52±0.19	3.55±0.16
Total alkalinity (mg/L)	166.71±14.49	167.14±10.68	166.04±11.79

3.2 Plankton

3.2.1 Biological parameters

The results of present experiment regarding the biological parameters such as phytoplankton density (cells/L) and zooplankton density (cells/L), generic status of phytoplankton and zooplankton have been presented in Table-3.

3.2.1.1 Phytoplankton (cells/L)

During the experimental period 21 genera of phytoplankton belonging to 5 different groups of Bacillariophyceae, Chlorophyceae, Cyanophyceae, Dinophyceae, and Euglenophyceae were found in the experimental ponds .Mean phytoplankton densities under treatment-I, II and III were 73.52±3.12 (× 10^3) cells/L, 75.79±2.39 (× 10^3) cells/L and 74.41±7.87 (×10^3) cells/L, respectively.

3.2.1.2 Zooplankton (cells/L)

During the experimental period a total of 9 genera of zooplankton belonging to 3 groups of Crustacea (Cladocera and Copepoda) and Rotifera were found in the experimental ponds. Mean zooplankton densities under treatment-I, II and III were 10.62±0.95 (× 10^3) cells/L, 11.50±1.47 (× 10^3) cells/L and 10.17±1.56 (× 10^3) cells/L, respectively.

Table 3: Generic status of phytoplankton and zooplankton found in the culture ponds under treatments-I, II and III.

Phytoplankton				
Chlorophyceae	**Cyanophyceae**	**Bacillariophyceae**	**Dinophyceae**	**Euglenophyceae**
Actinastrum Chlorella Closterium Pediastrum Scenedesmus Ulothrix Zygnema Volvox	Anabaena Gomphospaeria Microsystis Oscillatoria Aphanizomenon	Asterionella Cyclotella Fragilaria Navicula Tabellaria	Ceratium	Euglena Phacus
Zooplankton				
Crustacea				**Rotifera**
Cladocera		**Copepoda**		Asplanchna Brachionus Filinia Keratella Polyarthra
Daphnia Diaphanosoma Nauplius(Crustacean Larvae)		Cyclops		

Growth and production of fish

The net production of fishes are shown in fig. 01. Significantly highest net productions of fishes were obtained in Treatment - II.

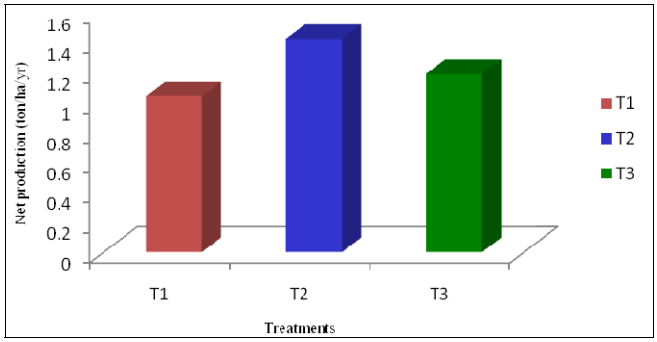

Fig. 1: Net production of fish under treatments I, II, and III.

4. Discussion

The present experiment was conducted to determine the impacts of different fertilizers on production of fishes in polyculture system. The results of the study on various water quality parameters, impacts of different fertilizers on the growth and production of fishes of four species in polyculture system have been discussed below.

Rahman (1992) [2] quoted that pond should not be shallower than 1 m and deeper than 5 m and optimum depth should be 2 m. The mean values of water depth under treatments-I, II and III were 0.92±0.02 m, 0.89±0.04 m and 0.90±0.02 m, respectively [2].

The mean values of water transparency of the ponds under treatment-I, II and III were 30.91±1.38 cm, 31.50±1.00 cm and 31.58±1.63 cm respectively. Rahman (1992) [2] stated that the transparency of productive water bodies should be 40 cm or less (turbidity resulting from plankton) [2].

In the present experiment the water temperature fluctuated from 21.82 to 27.69 ºC. Ali (1998) stated that water temperature of ponds from 20.20 to 36.50 ºC which was favorable to fish [7].

The range of air temperature was 17.09 to 32.36º C.

The mean values of dissolved oxygen content recorded in the present experiment under treatment-I, treatment-II and treatment-III were 6.95±0.38, 7.33±0.12, and 7.41±0.45 mg/L respectively. According to Rahman (1992) [2] dissolved oxygen content of a productive pond should be 5 ppm or more [2].

The mean values of free CO_2 content recorded in the present experiment under treatment-I, treatment-II and treatment-III were 3.07±0.45, 4.07±0.53, and 4.40±0.53 mg/L respectively.

The mean values of pH recorded in the present experiment under treatments-I, II and III were 7.36±0.15, 7.48±0.09, and 7.42±0.08 respectively. Swingle (1967) stated that pH 6.5 to 9.0 is suitable for pond fish culture [8].

The mean values of total alkalinity in the present experiment under treatments-I, II and III were 166.71±14.49, 167.14±10.68, and 166.04±11.79 mg/L respectively. Mairs (1966) stated that water bodies having total alkalinity 40 ppm or more are considered more productive than the water bodies of lower alkalinity [9].

The average values of PO_4-P in the present experiment under treatments-I, II and III were 1.75±0.08, 1.88±0.06, and 1.50±0.20 mg/L respectively. Wahab *et al.* (1995) found the highest concentration of phosphate-phosphorus to vary from 0.09 to 5.20 mg/L in nine experimental ponds of Bangladesh Agricultural University Campus, Mymensingh [10].

The mean values of NO_3-N in the present experiment under treatment-I, II and III were 3.57±0.18, 3.52±0.19, and 3.55±0.16 mg/L respectively. Das (2002) recorded the range of nitrate-nitrogen values from 1.60 to 3.22 mg/L. which is more or less close to the values found in the present experiment [11].

Mean phytoplankton densities under treatment-I, II and III were 73.52±3.12 (× 10^3) cells/L, 75.79±2.39 (× 10^3) cells/L and 74.41±7.87 (×10^3) cells/L, respectively. Mean zooplankton densities under treatment-I, II and III were 10.62±0.95 (× 10^3) cells/L, 11.50±1.47 (× 10^3) cells/L and 10.17±1.56 (× 10^3) cells/L, respectively. Sarker (2007), Chowdhury (2005), Khatun (2004), Kabir (2003) found more or less similar results in their experimental ponds.

The survival rates in treatment-I was 88.7%, in treatment-II was 89.9% and in treatment-III was 89.6% [12, 13, 14, 15].

The specific growth rates in treatment-I, II and III were 1.42%, 1.67% and 1.56% respectively. Milstein *et al.* (2009) who recorded specific growth rate of rohu ranged 0.83 to 1.2% [16].

In the present experiment, calculated net productions of fish of the ponds under treatment-I (use of TSP-90g per decimal)

were 1.041 ton/ha/yr and those of the ponds under treatment-II (use of urea-60g and TSP-90g per decimal) were 1.425 ton/ha/yr and those of the ponds under treatment-III (use of urea 60g and cowdung 1kg per decimal) were 1.191 ton/ha/yr, respectively. The highest production of fish was found under treatment-II. It may be concluded that use of urea and TSP (treatment-II) affected fish growth and production significantly than use of only TSP (Treatment-I) or use of urea and cowdung (Treatment-III).

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