The Journal of Animal & Plant Sciences, 21(4): 2011, Page: 642-645
ISSN: 1018-7081

EFFECT OF LOW LEVEL OF MINERAL PHOSPHORUS AND MEDIUM LEVEL OF NITROGEN ON PLANKTONIC PRODUCTIVITY AND INCREASE IN FISH PRODUCTION

M. Hussain, S. M. Hussain[*], M. Afzal, A. Javid[**], S. Abdullah, S. A. Raza[***] and M. Iqbal[****]

Department of Zoology & Fisheries, University of Agriculture, Faisalabad, Pakistan
[*]Department of Wildlife and Fisheries, Government College University, Faisalabad, Pakistan
[**]Department of Wildlife and Ecology, University of Veterinary and Animal Sciences, Lahore, Pakistan
[***]Fish Seed Hatchery, Chashma, Mianwali, Department of Fisheries, Pakistan
[****]Department of Chemistry and Biochemistry, University of Agriculture, Faisalabad, Pakistan
Corresponding author e-mail: chmajidhussain@hotmail.com

ABSTRACT

A field trial was conducted to see the effect of low level of mineral phosphorous and medium level of nitrogen on the planktonic productivity and increase in fish production. Earthen ponds, each having dimension of 30×16×2m; area, 0.048 ha, were stocked with fish viz. *Hypophthalmichthys molitrix*, *Labeo rohita* and *Cyprinus carpio* at ratio 65: 20: 15, respectively. The treatment pond was fertilized with phosphorus and nitrogen @ 0.06% and 0.12% of wet fish body weight day^{-1} while reference / control pond was not fertilized with phosphorus and nitrogen. Water samples were collected fortnightly for qualitative and quantitative estimation of plankton and showed four genera of Chlorophyceae, one genera of Chrysophyceae and three genera of Bacillariophyceae. Among zooplanktons, the Ciliates, Keratella, Cyclops and Daphnia were found maximum in the treated pond while very poor in the reference pond. The difference between treated and control pond for the production of planktonic biomass was statistically significant at $p<0.05$. The significant impact of treatment on planktonic productivity enhanced the fish production significantly higher in treated pond.

Key words: Phosphorus, nitrogen, planktonic biomass, fish.

INTRODUCTION

Fish is one of the best and abundantly found aquatic organisms in the world with superior nutritional value. Pakistan has been endowed with vast expanse of both marine and inland fisheries resources which possess great development potential and can support a rich variety of fish of nutritional significance and economic value. The biomass productivity of water bodies can be enhanced by using inorganic fertilizers. It is widely recommended that biological productivity in aquaculture ponds is limited by nutrients. Appropriate application of fertilizers has become a management protocol in aquaculture. It compensates deficiency of specific nutrients and enhances the biological productivity by autotrophic and heterotrophic process (Debeljak *et al*., 1990; Das and Jana, 1996).

Optimal fertilization rate produces maximal phytoplankton and zooplankton without any detrimental effect on the quality of water as well as on fish growth. In pond management it is important aspect because excess fertilizers are not only expensive but are also liable to eutrophication of water bodies (Bhakta, 2003). The optimum range of water quality parameters such as temperature, dissolved oxygen, pH, total alkalinity and total hardness is also important to obtain good growth in fishes under intensive culture conditions (Abid and Ahmed 2009). The purpose of the present study was to examine the responses of low level of mineral phosphorus and medium level of nitrogen on the biotic life and growth performance of carps (*Hypophthalmichthys molitrix*, *Labeo rohita* and *Cyprinus carpio*) in earthen ponds using a fixed stocking density.

MATERIALS AND METHODS

The experiment was undertaken in earthen ponds (30×16×2m; area, 0.048 ha) each, stocked with 163 *Hypophthalmichthys molitrix*, 50 *Labeo rohita* and 38 *Cyprinus carpio* (65: 20: 15). Stoking density was 1 fish / 2.83m^3. Reference ponds were not fertilized, while the treatment ponds were fertilized with 0.06 percent phosphorus plus 0.12 percent nitrogen of wet fish weight day^{-1}.

Water samples were collected from the surface as well as from the bottom for the qualitative and quantitative study of plankton and were examined under microscope (APHA 1992), following the sand filtration procedure for the enumeration of phytoplankton (Boyd, 1981). For the estimation of zooplankton, insect larvae and other animals 10 liter of water was taken fortnightly from surface, column and bottom of each pond, pooled and filtered through the planktonic net (mesh size 56 µ). The organisms were observed under microscope and identified up to generic level by following Wards and Whipple (1959) and Marshal (1980).

At least 10 specimens of each fish species were collected randomly from both treatments and control group fortnightly to determine growth of fish. Each treatment and control was triplicated. The experiment was carried out for 12 months.

RESULTS

Four genera of Chlorophyceae, one genera of Chrysophyceae and three genera of Bacillariophyceae were recorded during the experimental period on different fortnights from the ponds. Among Chlorophyceae, Volvox were represented by 80 and 10 individuals 5 ml^{-1} in the treated and reference ponds, respectively. The Chryophyceae were maximally represented by Synura 40, Bacillariophyceae by Synedra 48 and Myxophyceae by Anabaena 60 individuals $5ml^{-1}$ in the treated pond, and were absent in reference pond. Among zooplanktons, the Ciliates were the maximum 32, keratella 40, Cyclops 52 and Daphnia 32 in the treated pond while concentration of these organisms did not exceed 5 to 6 individuals 5 ml^{-1} in reference pond during the study period. The dry weight of planktonic biomass in the experimental period ranged from 49.00 to 327.00 and 8.00 to 58.00 g m^{-3} in treated and control ponds, respectively.

Table1 shows the regression coefficients between increase in fish production and planktonic biomass under the influence of the two treatments. The higher value of “r” for T_1 (0.705) predicted high reliability of the equation, while lower value of 0.155 under T_0 could be due to poor response of reference pond towards the planktonic biomass.

In treated pond, both the inorganic fertilizers i.e. phosphorus as well as nitrogen were incorporated together, to explore the possibility of additional increase in planktonic productivity and fish biomass. Treated pond showed 19349.73±15316.99 g average increase in fish biomass as compare to control pond where the value was 1237.58±586.04 g. The difference between treated and control pond was statistically significant at $p<0.05$. The relationship between 167.50±76.30 g m^{-3} average increase in planktonic biomass / fortnight and 26.87±20.82 g m-3 average increase in fish production / fortnight was also statistically significant in treated and control pond (Table 2).

Table 3 shows that total fish production per year of *Hypophthalmichthys molitrix*, *Labeo rohita* and *Cyprinus carpio* as 358.57 and 25.05 kg, 61.56 and 7.44 kg, 49.21 and 6.60 kg for T_1 and T_0, respectively. As regards the total fish production $pond^{-1}$ $year^{-1}$ for all the fish species together, the values were computed as 469.34 and 39.10 kg while the net fish production was computed as 462.52 and 29.70 kg in T_1 and T_0, respectively.

In T_1 planktonic biomass showed statistically significant ($p<0.01$) correlation with air temperature, water temperature, pH, total hardness, magnesium, nitrates, total solids and total dissolved solids while it was statistically significant ($p<0.05$) for light penetration and dissolved oxygen. However, in T_0 planktonic biomass correlated statistically significant at $p<0.01$ with total hardness, magnesium, total solids and total dissolved solids and correlated with air temperature, water temperature and dissolved oxygen at $p<0.05$. The relationship among all the remaining parameters in T_1 and T_0 was statistically non-significant (Table 4). Physico-chemical characteristics of tube-well water and nitrogen, phosphorus and potassium contents of ponds bottom, calculated at the start of experiment are also represented in Table 5.

DISCUSSION

High yield of fish can be obtained by plankton abundance in culture system with addition of appropriate fertilizer. Fertilization can be increased to a certain limit and excess may deteriorate water quality and has adverse effect on fish growth (Dhawan and Kaur, 2002). Therefore keeping in view the above aspects, low level of mineral phosphorus and medium level of nitrogen were used in this experiment. The increase in planktonic biomass and fish production in T_1 was significant due to the addition of different levels of phosphorus and nitrogen fertilizers. However, response was poor in T_o without any addition of fertilizer. These results are in line with Uddin *et al*., (1987), Jana *et al*., (2001), who achieved better production of planktonic organisms as well as fish with the addition of nitrogen and phosphorous fertilizers at various levels. Garg and

Table: 1. Regression equations of average increase in fish production on an average dry weight of planktonic biomass under the treatments

Treatments	Averages		Regression coefficient			R^2	r
	Planktonic Biomass gm^{-3}	Inc. in fish production g m^{-3}	a	b	SE		
T_0	30.08^b	1.72^b	1.367	0.0117	0.822	0.024^{NS}	0.155
T_1	167.50^a	26.87^a	5.347	0.1924	15.43	0.497^{**}	0.705

NS = Nonsignificant ($\rho > 0.05$); ** = Highly significant ($\rho < 0.01$). T_o= Control pond; T_1= Treatment pond.

Table: 2. Fertilization rate and phosphorus + nitrogn incorporation efficiencies of fish in the pond treated (0.06% phosphorus + 0.12% nitrogen) and control ponds.

	Treated pond	Control pond
Average water temperature (°C)	22.57±7.84	22.53±7.85
Average total fish biomass (g)	165437.70±137376.70	24574.41±9053.29
Average T.S.P.(g)/ fortnight	3251.656	-
Average phosphorus (g)/ fortnight	1496.507	-
Average Urea(g) / fortnight	6475.155	-
Average nitrogen (g)/ fortnight	2979.141	-
Average increase in fish biomass (g)	19349.73±15316.99	1237.58±586.04
Average increase in planktonic biomass (g m^{-3}) / fortnight	167.50±76.30^a	30.08±10.80^b
Average increase in fish production (g m-3) / fortnight	26.87±20.82^a	1.72±0.80^b

Table: 3. Total fish production of treated (T_1) and control (T_0) ponds.

	Hypophthalmichthys molitrix		*Labeo rohita*		*Cyprinus carpio*		All fish species	
	T_1	T_0	T_1	T_0	T_1	T_0	T_1	T_0
Stocking density	163	163	50	50	38	38	251	251
Initial average weight (g)	39.10	39.00	37.60	37.55	30.20	30.64	106.90	107.19
Final average weight (g)	2227.13	154.20	1231.16	146.52	1295.11	173.66	4753.40	474.38
Fish production $pond^{-1}$ $year^{-1}$ (kg)	358.57	25.06	61.56	7.44	49.21	6.60	469.34	39.10
Net fish production $pond^{-1}$ $year^{-1}$ (kg)	354.77	18.82	59.68	5.45	48.07	5.43	462.52	29.70

Bhatnagar (2000) used three different fertilization frequencies in ponds and observed highest value of fish biomass, specific growth rate, net primary productivity, planktonic population and nutrients. Anetekhail *et al*., (2005) investigated the growth response of North African catfish (*Clarias gariepinus*) fry to inorganic fertilizers and found their significant influence on quality and quantity of plankton, which in turn determined the growth and well-being of catfish fry. Their findings are also coincide with the results of present study.

The higher growth rate of *Hypophthalmichthys molitrix, Labeo rohita* and *Cyprinus carpio* in T_1, treated with 0.06 percent phosphorus and 0.12 percent nitrogen, of wet fish body weight per day demonstrated the potential of the application of phosphorus and nitrogen at this level, as had been reported by Lin and Chen (1967), who observed a turn from loss to profit by the use of superphosphate fertilizers. They revealed that most efficient and economical dose of P_2O_5 was 40 kg ha^{-1}. Due to addition of mineral phosphors and nitrogen higher biomass was produced in T_1, as a result of which the increase in fish production also remained maximum in treatment pond. The findings of the experiment were in line with Yusoff and McNabb (1997), who worked on the growth of four fish species in earthen ponds for 352 days in three treatments. Net fish production was 437 kg ha^{-1}, 1034 kg ha^{-1} and 1713 kg ha^{-1} in reference, TSP and TSP-urea treatments, respectively. Nawaz *et al*., (1997) also obtained the net fish production of 3680 and 516 Kg/ha/year in N:P:K (20:20:30) fertilized and control ponds, respectively. It is evident from experiment that fertilizers are important requirement for the induced growth of phytoplankton and zooplankton, which both in turn culminates the fish growth. The similar results are also revealed by the study of (Kolo *et al*., 2001; Aminu and Ahmed, 2001; Jha *et al*., 2006) who finds increased growth of fish due to addition of nitrogen and phosphorus fertilizers. In conclusion, the use of low level of mineral

Table: 4. Correlation coefficients between dry weight of planktonic biomass and various physico-chemical characteristics of pond water under treatments.

Variable	Dry weight of planktonic biomass	
	T_1	T_0
Air temperature (°C)	0.844**	0.447*
Water temperature (°C)	0.891**	0.448*
Secchi's disc visibility (cm)	-0.443*	-0.237
Dissolved oxygen (mg L^{-1})	0.520*	-0.477*
pH	0.660**	-0.108
Total alkalinity (mg L^{-1})	0.075	-0.262
Total hardness (mg L^{-1})	0.623**	0.606**
Calcium (mg L^{-1})	0.307	0.245
Magnesium (mg L^{-1})	0.410**	0.530**
Nitrates (mg L^{-1})	0.461**	0.290
Sodium (mg L^{-1})	0.242	0.267
Potassium (mg L^{-1})	0.398	0.363
Chlorides (mg L^{-1})	0.350	0.296
Total solids (mg L^{-1})	0.788**	0.650**
Total dissolved solids (mg L^{-1})	0.675**	0.536**

*= Significant (P<0.05); ** = Highly significant (P<0.01)

phosphorus and medium level of nitrogen augmented the population of plankton. Phytoplanktons are major food organisms for intermediate consumers. Both types of fertilizers can be added in ponds especially those in which herbivorous fishes are reared, and to achieve maximum production of plankton in the ponds for increased fish biomass and hence high profitability.

Table: 5. Physico-chemical characteristics of tube-well water and N.P.K. contents of ponds bottom.

Characteristics OF Tube-well water	
Variable	**Average Annual Concentrations**
pH	7.72 ± 0.60
Carbonates (mg L^{-1})	45.60 ± 3.82
Bicarbonates (mg L^{-1})	344.10 ± 10.34
Total alkalinity (mg L^{-1})	403.86 ± 14.16
Clacium (mg L^{-1})	15.30 ± 2.26
Magnesium (mg L^{-1})	30.28 ± 6.48
Total Hardness (mg L^{-1})	226.55 ± 16.10
Chlorides (mg L^{-1})	240.38 ± 17.61
Sodium (mg L^{-1})	250.84 ± 22.74
Potassium (mg L^{-1})	14.65 ± 2.54
Ortho-phosphates (mg L^{-1})	0.002 ± 0.0014
Nitrates (mg L^{-1})	1.05 ± 0.21
Ammonia (mg L^{-1})	Nil
Total Nitrogen (mg L^{-1})	2.34 ± 0.98
N.P.K. CONTENTS OF POND BOTTOM AT THE START OF THE EXPERIMENT	
Available nitrogen (%)	0.015 ± 0.009
Available phosphorus(mg L^{-1})	1.98 ± 0.512
Available potassium (mg L^{-1})	46.14 ± 6.723
pH	7.98 ± 0.05

REFERENCES

A. P. H. A. (1992). Standards Methods for the Examination of Water and Waste Water. 18th ED. American Public Health Association. Washington, DC. 1268 p.

Abid, M. and M.S. Ahmed. (2009). Growth response of *Labeo rohita* fingerlings fed with different regimes under intensive rearing. J. Anim. Plant Sci., 19: 45-49.

Aminu, R. and K. S. Ahmed (2001). Plankton periodicity and some physico-chemical parameters of the intake water channel of Lake Chad. J. Aquatic. Sci. 19: 104-110.

Anetekhail, M. A., F. G. Owodeinde, A. A. Denloye, S. L. Akintola, O. J. Aderinola, and J. I. Agboola (2005). Growth response of North African catfish fry to organic and inorganic fertilizers. Acta Ichthyologica Piscatoria. 35: 39-44.

Bhakta, J. N. (2003). Fertilizer–microbial interactions in wastewater system: influence of fertilizer dose and stocking density of fish. Ph.D Thesis. University of Kalyani, India. 188 p.

Boyd, C. E. (1981). Water Quality in Warm Water Fish Ponds. Auburn University Agricultural Experiment Station Alabama. 395 p.

Das, S. K. and B. B. Jana (1996). Pond fertilization through inorganic sources: An overview. Ind. J. Fish. 43: 137-155.

Debeljak, L., M. Turk, K. Fasaic, and J. Popovic (1990). Mineral fertilizers and fish production in carp ponds. In: R. Berka and V. Hilge (Eds.), Proceedings of the FAO-EIFAC Symposium on Production Enhancement in Still Water Pond Culture, Research Institute of Fish Culture and Hydrobiology. Vodnany Czechoslovakia. 14: 187-193.

Dhawan, A. and S. Kaur (2002). Pig dung as pond manure: Effect on water quality, pond productivity and growth of carps in polyculture system. Naga, The World Fish Centre Quarterly. 25: 11-14.

Durans, J. R. and C. Leveque (1980). Flore et Farune Aquatiques de 1, Afrique-an-off Erch. Sci. Tech. Qutre-Mer. 1: 5-46.

Garg. S. K. and A. Bhatnagar (2000). Effect of fertilization frequency on pond productivity and fish biomass in still water ponds stocked with *Cirrhina mrigala*. Aqua. Res. 31: 409-414.

Jana, B. B., P. Chakraborty, J. K. Biswas, and S. Ganguly (2001). Biogeochemical cycling bacteria as indices of pond fertilization: Importance of CNP ratios of input fertilizers. J. Appl. Microbiol. 90: 733-740.

Jha, P., S. Barat, and C. R. Nayak (2006). A comparison of growth, survival rate and number of marketable koi carp produced under different management regimes in earthen ponds and concrete tanks. Aquaculture International. 6: 615-626.

Kolo, R. J., I. A. Mani, and H. A. Musa (2001). Effects of different types of fertilizers on plankton productivity in earthen ponds. J. Aquatic Sci. 16: 127-131.

Lin, S. Y. and T. P. Chen. (1967). Increase of production in fresh water fish ponds by the use of inorganic fertilizers. FAO (Food Agri Org UN). Fish Rep. 44: 210-225.

Marshal, A. J. (1980). Text Book of Zoology. Vol. 1. Invertebrates. (7th Ed.). The Macmillan Press Ltd London.

Nawaz, M., M. Afzal and A. Sheri. (1997). Effect of inorganic fertilizers N:P:K (20:20:30) on the growth performance of the carps in polyculture system. J. Anim. Plant Sci., 7:17-19.

Uddin, M. S., A. Malek, D. Deppert, P. Perschbaer, and M.S. Shah (1987). Effect of inorganic fertilizer. 1. On growth of the carp fingerlings in composite culture. Bangladesh J. Fish. 10: 57-61.

Wards, H. B. and G. C. Whipple (1959). Freshwater Biology. John Willey and Sons Inc London.

Yusoff, F. M. and C. D. McNabb (1997). The effects of phosphorus and nitrogen on phytoplankton dominance in tropical fish ponds. Aqua. Res. 28: 591-597.