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Limnological Studies of Intensively Stocked Grass Carp Rearing Ponds

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Abstract
The impact of three iso-caloric test diets, viz. 30, 35 and 40 percent crude protein (C.P.) on the physico-chemical characteristics of water and grass carp yields was studied for 270 days. In control treatment, fish yield was 84.47 percent dependent on water nitrates, phosphates and temperature while nitrates along with hardness, alkalinity, pH and temperature accounted for 85.90 percent variations in fish yield under 30 percent C.P. treatment. In 35 percent C.P. level fish yield showed positively significant regression on ammonia-N, electrical conductivity and water temperature. In 40 percent C.P. planktonic productivity showed positively significant while ammonia-N had negatively significant regression on fish yield. However, combined contribution of these two variables towards fish yield was 68.49 percent.

Key words: Grass carp, physico-chemical, regression

Introduction
The bulk of Asian aquaculture, which formed about 84 percent of the total aquaculture production of 15.30 million tone in 1990, is currently realized in intensive pond farming systems (New and Csavas, 1993). The major focus of fish nutrition research in the region has, therefore, been on making the supplementary feeding in semi-intensive systems cost-effective not only by developing diets that are perfect in their nutrient composition but also by improving our knowledge on the role of water quality and natural food in deciding dietary composition and/or feeding levels.
Knowledge on the optimum feeding requirements of cultured fish is necessary to achieve efficient production. This should consider the availability of nutrients to the fish in a given culture system and under varied environmental conditions. Several environmental factors e.g., oxygen, salinity and temperature influence the growth and food intake of fish (Brett, 1979). The productive utilization of dietary protein in fish largely depends on the nutritive efficiency and acceptability of the diet. Many substances in water and sediments of an aquaculture system are useful as nutrient. These include mineral salts, various carbon, nitrogen and phosphorus compounds (Fogg, 1975). Of these, nitrogen and phosphorus compound are usually found to have the greatest importance to primary production by aquatic organisms in fish culture systems (Hassan *et al.*, 1996). However, with such a practice, certain disadvantages are also associated, as the artificial feeds can deteriorate the water quality in intensively stocked fish ponds. This study was carried-out to compute regression models to explain the percentage contribution of various physico-chemical parameters towards fish yields under different levels of feed supplementation in earthen ponds.

Materials and Methods
Grass carp (*Cterropharyngodon idella*), averaging 15.08 g (SD 0.37; n = 83) weight and 1 10.20 mm (±1.30) and 126.40 mm (± 0.98) fork and total lengths, respectively, were stocked into earthen ponds (0.01 2 ha) separately with two replications for each of the treatments at a rate of 11875 fish per hectare (143 fish per pond, Pfeiffer and Lovell, 1990). The next day of stocking, feed supplementation of fish were started with iso-caloric (Total Energy = 2.796 to 2.887 kcal g^{-1}) diets (except control) at the rate of 10 g crumbled feed (Table 1) per 100 g of wet fish weight daily (at 10:00 a.m.) for the first two months (January and February) as follows:

Treatment	**Dietary level**
Control	without additives
T1	30% crude protein diet
T2	35% crude protein diet
T3	40% crude protein diet

Table 1: Ingredients and nutrient composition of grass carp (Ctenapharyngodon idella) feed

	Dietary protein levels (% C.P.)		
Ingredients	30	35	40
Rice polishing	44.0	31.0	20.0
Cotton seed meal	10.0	10.0	10.0
Sunflower meal	15.0	15.0	15.0
Corn gluten	6.0	12.0	14.0
Fish meal	20.0	20.0	20.0
Soybean meal	3.0	10.0	20.0
DCP/Bone	1.5	1.5	0.5
Vitamin-mineral premix	0.3	0.2	0.2
Sodium chloride (NaCl)	0.2	0.3	0.3
Digestible energy (kcal g^{-1})	2.88	2.86	2.79
Proximate Composition of Feed (Feed Crumbles)			
Moisture (%)	12.35	12.25	12.34
Crude protein (%)	30.07	35.11	39.98
Ether extract (%)	4.90	4.38	3.67
Ash (%)	7.11	6.75	7.05

Feeding rate was changed from 10 percent to 5 percent from March to September. Feed allowances were changed fortnightly, based on seined samples of 83 fish from each of the three feeding regimes under study.
Water samples were collected, fortnightly, from surface, column and bottom (using Kemmerer) at stations A, B and C from each of the ponds for the study period. Water

temperature, pH and dissolved oxygen were monitored daily (with meters: HANNA HI 8521 and 8043) at a depth of 0.50 m. Ammonia-N levels were measured weekly; nitrate and phosphate levels twice weekly. However, other physicochemical parameters, viz. Secchi's disc penetration, electrical conductivity, chlorides, total alkalinity, magnesium and total hardness were analyzed fortnightly (APHA, 1971; Boyd, 1981). The dry weights of planktonic biomass were also determined fortnightly through evaporation method. The data were subjected to statistical analysis by using Steel and Torrie (1980) through Micro-Computer. The comparison of mean values for various parameters was computed by using analysis of variance and Duncan's Multiple Range test through two-way classification (Factorial Experiment). in order to see the impact of physico-chemical variables on fish yield increments, regression models under 4 treatments, separately, were computed.

Results

Table 2 shows significant variations among treatments for various physico-chemical and biotic variables during the study period. Statistical analysis shows significant differences among treatments for pH, light penetration, phosphates, arnmonia-N, planktonic biomass and increase in fish yield. However, seasonal variations in all the variables were statistically significant except total alkalinity, chlorides arid ammonia-N. Table 3 shows final-step equations computed for the regression of fish yield increments on the selected physico-chernical characteristics of water. In control treatment, water temperature, phosphates and nitrates were the three water quality variables which were responsible for 84.47 percent variations in fish yield. All the partial regression coefficients, for the regression model, were significant. In T1 , water temperature, pH, total alkalinity, hardness and nitrates contributed 85.90 percent towards fish yield increments. All the regression coefficients were negative except for temperature. However, partial regression coefficients were significant for all the variables in the regression model except nitrate.

Table 2: Means for physico-chemical and biotic variables under different treatments. Treatment means with similar letters in a row are statiistically similar at $p<0.05$

Variable	Control	T1	T2	T3	ANOVA Mean square Treatment	Season
Water temperature (°C)	24.24a	24.33a	24.22a	24.35a	1.147NS	91.024**
pH	7.83b	7.78b	7.91b	8.05a	0.259**	0.174**
Electrical conductivity (mmhos cm^{-1})	1.85a	1.95a	1.91a	1.79a	0.088NS	0.257**
Light penetration (cm)	24.43a	24.27a	21.72b	20.28b	73.467**	793.532**
Dissolved oxygen (mg L^{-1})	8.35a	8.76a	8.55a	8.45a	0.572NS	19.201**
Total alkalinity (mg L^{-1})	350.18a	344.20a	332.14a	342.56a	1014.544NS	2564.257NS
Total hardness (mg L^{-1})	269.40a	264.51a	260.66a	262.69a	251.793NS	700.753**
Chlorides (mg L^{-1})	296.31a	300.77a	294.60a	296.14a	127.102NS	125.740NS
Phosphates (mg L^{-1})	9.13a	8.17a	5.28b	6.07b	57.752**	1E.964**
Nitrates (mg L^{-1})	4.03a	4.01a	3.97a	4.08a	0.038NS	1.268**
Ammonia-N (mg L^{-1})	0.05ab	0.06a	0.04ab	0.04b	0.002*	0.001NS
Pianktonnic biomass (g m^{-3})	11.79c	1 9.69b	27.78a	25.55a	948.411**	94.886**
Increase in fish yield (kg/pond)	6.73c	22.21b	27.83a	26.80a	1712.805**	938.514**

NS = Non-significant; ** = Significant at $p<0.01$; * = Significant at $p<0.05$

Table 3: Regression of increase in fish weight on the selected physico-chemical parameters of pond's water

		Regression Equation						R^2
			(P<0.05)	(p<0.01)	(p<0.05)			
Control	Inc. in fish wt. =	-15.95	+ 2.28 (Nit.)	+ 0.81 (P)	+ 0.25 (Temp.)			0.8447
	SE =		0.9077	0.1837	0.1178			
			(NS)	(p<0.05)	(p<0.01)	(p<0.01)	(p<0.01)	
T1	Inc. in fish wt. =	370.83	- 5.58 (Nit.)	- 0.30 (T. Hard.)	- 0.21 (T.Alk.)	- 30.87 (pH)	+ 2.79 (Temp.)	0.8590
	SE =		2.9978	0.1369	0.0648	10.5537	0.3661	
			(p<0.01)	(p<0.01)	(p<0.01)			
T2	Inc. in fish wt. =	-42.84	- 585.95 (Amm.)	+ 26.76 (E.C.)	+ 1.86 (Tem.)			0.8444
			102.9978	7.5803	0.3655			
			(p<0.01)	(p<0.05)				
T3	Inc. in fish wt. =	7.10	+7.10+1.62 (Plk.bio.)	- 277.89 (Amm.)				0.6849
	SE =		0.4620	110.4867				

R^2 = R squared (Coefficient of determination); Nit. = Nitrates; P - Phosphates; Tem. = Teri ierature; T.Hard. = Total hardness; T. Alk. = Total alkalinity; Amm. = Ammonia-N; E.C. = Electrical conductivity (mmhos cm^{-1}); Plk. bio. = Planktonic; T1 = 30% C.F. regime; T2 = 35% C.P. regime; T3 = 40% C.P. regime

In T2, ammonia-N showed negatively significant ($p<0.01$) regression on fish yield while the regression coefficient for electrical conductivity and water temperature were positively significant at $p<0.01$. This relationship explains 84.44 percent variations in fish yield. In T3, the regression of fish yield on ammonia-N was negatively significant again as observed in T2. However, fish yield under this treatment was 68.49 percent dependent on planktonic biomass and ammonia-N.

Discussion

Water temperature in all the treatments was suitable for grass carp rearing from April to September during which the mean fortnightly temperature ranged between 25.14 and 32.72°C (control); 25.44 and 32.35 (T1); 25.26 and 32.30 (T2); 25.25 and 32.66°C (T3). Pfeiffer and Lovell (1990) reported best temperature range of 26-30°C for grass carp rearing. Dissolved oxygen concentrations remained above 5.00 mg L^{-1} Un-ionized ammonia concentrations under all the treatments were higher than 0.0125 mg L^{-1}, which are the levels considered safe for freshwater fisheries (Piper *et al*., 1982). In T2 and T3, ammonia-nitrogen showed negative regression on fish yield increments. However, no bad effect of these ammonia levels have been reported under either of the treatments as fish survival rates were above 96 percent during the whole study period.

In all the treatments, except T3, water temperature along with other water quality variables exerted positive regression on fish yield increments (Table 3). Soderberg (1990) reported highly significant and positive correlation ($r = 0.99$) between water temperature and increase in fish weight, was due to increase in fish anabolic rate at high water temperatures. In T3, planktonic biomass along with ammonia-N were responsible for 68.49 percent variations in fish yield increments (Table 3). This indicates two ways of fish response towards artificial feed (i) direct utilization (ii) indirect utilization (Javed *et al*., 1993) through the fertilization effect of left-over feed, resulting in the planktonic production. Thus, feed added in ponds was completely utilized either through direct feeding of fish or indirectly when left-over feed, that decomposed at the pond bottom, released nutrients which contributed significantly towards planktonic productivity of ponds for fish grazing (Javed *et al*., 1993).

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