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Effect of Phosphorus Supplemented Diet on Water Quality of Catfish Pond

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Phosphorus is an essential element for growth and metabolism in fish. However high levels of phosphorus in the feed can lead to poor water quality of pond, and can also be a potential source of pollution, when pond water is released to the environment. In this study phosphorus supplemented diets containing 0.0, 0.9 or 1.9% of (dicalcium) phosphate were offered to channel catfish and changes in water quality of ponds and phosphorus levels in fish were measured. Higher level of (1.9%) supplementation of phosphorus in diet resulted in higher concentration of T-P and SRP in pond waters. Also it produced negative effects on fish production by lowering feed coefficient and rate of increment in body weight. Surplus phosphorus can affect fish growth and water quality of pond.

Key words: Water quality, Channel catfish, Phosphorus diet

Introduction

Phosphorus is generally recognized as a key nutrient in still-water fish pond as well as natural ecosystem. This nutrient can also be a source of pollution, when overloaded to wild stream, reservoir, even a fish pond (Boyd 1990; Ketola and Harland 1993; Boyd and Tucker 1995). Especially high phosphorus content in commercial feeds may release large quantities of phosphorus into the water and wake up to water pollution. Lovell (1978) and Wilson et al. (1982) determined the minimum dietary phosphorus requirement of the catfish to be 0.42~0.45%. Boyd (1985) demonstrated that only 20~40% of the phosphorus in catfish feed fed is retained by the fish. Therefore, there is a need to keep the phosphorus level optionally and not to affect water quality of the pond (Dougall et al. 1996). Poor water quality can adversely affect fish growth, fish health and total production.

Cole and Boyd (1986) noted that as feeding rate increased, the water quality deteriorated. Metabolic waste of fish and uneaten feed often degrade the water quality by elevating level of nitrogen, phosphorus and dissolved organic matter in the water. Recent work (Schwartz and Boyd 1994a) showed that 28% nitrogen, 29% phosphorus, and 17% organic matter supplemented feed alone were removed by the catfish. In contrast, the other remaining part of the feed was adsorbed in sediment and/or removed by microbial activity. These surplus nutrients also stimulate phytoplankton bloom. Sometimes the dissolved oxygen concentration is lowered in pond with overgrowing phytoplankton. Tucker and Boyd (1985) reported that as feeding rate increased, the frequency of aeration required to maintain adequate dissolved oxygen concentration also increased. Several studies have also noted that phytoplankton biomass in a catfish pond is related to changes in water quality (Hargreaves and Tucker 1996 : Gross et al. 1998). This study investigates the effect of 3 different levels of phosphorus supplementation

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to the feeds on the water quality of a channel catfish pond.

Material and Methods

The experiment was carried out in 20 ponds of Fisheries Research Station in Auburn University from 11 June to 23 September 1998. The ponds were rectangular in shape with concrete walls and soil bottom, and each pond had an area of 400 m^2 with an average depth of 1 m. Water was supplied to ponds by gravitation from a large reservoir nearby station.

For the experiment, 650 channel catfish fingerlings (about 10.3 g) were stocked in each pond. The floating pelleted feed was prepared to contain 3 different levels of phosphorus (Table 1) and was offered every morning.

The ponds were monitored between 0700 and 0800 once every week. Water temperature and dissolved oxygen (DO) were measured with DO meter (YSI-54). For other parameters of water quality, samples were taken from 60 cm depth. The following analyses were made, portable pH meter (Corning-7) for measuring pH, acid titration for total alkalinity, membrane (GF/C) filtration for total suspended solid (TSS), potassium persulfate for total-P and total-N, ascorbic acid for soluble reactive phosphorus (SRP), phenate for total ammonia nitrogen (TAN) and 90% acetone extract for chlorophyll a. All the analytic methods were followed, adopting the standard procedures of Boyd and Tucker (1992).

At the termination of experiment, fishes were harvested, counted and weighed. Total phosphorus level in fish was determined by the molybdovandate method (Jackson 1964).

Table 1. Ingredients of experimental diets with 3 phosphorus levels

Ingredient	Diet 1	Diet 2	Diet 3
Soybean meal (48%)	46	46	46
Cottonseed meal (41%)	14	14	14
Ground corn	31.8	31.1	29.8
Wheat middlings	6	6	6
Lysine HCl	0.5	0.5	0.5
Trace mineral mix	0.1	0.1	0.1
Vitamin mix	0.1	0.1	0.1
Stabilized vitamin C	0.05	0.05	0.05
Menhaden fish oil	1.5	1.5	1.5
Dicalcium phosphate	0	0.9	1.9

Results and Discussion

Fig. 1 shows the changes in the water quality profile. Mean water temperature of experimental ponds was the highest on 9 July and lowest on 5 September. There was no big difference in water temperature between the ponds, but the temperature was a little lower in pond receiving Diet 2 (Fig. 1).

During the experiment, the ponds were characterized by the presence of a large population of phytoplankton with a dominance of chlorophyta. Dissolved oxygen (DO) and pH levels were altered by phytoplankton respiration and photosynthesis. Generally the levels of phytoplakton, DO and pH were higher during phytoplankton growth. DO concentration was low on 23 July and high on 22 August. A decreasing tendency for DO was observed, when phytoplankton was not in full bloom. Aerators were used for supply additional oxygen to maintain a desirable level (above 4 mg/L). pH fluctuated but gradually increased and did not show changes due to supply of diets with different levels of phosphate. Total alkalinity was between 45~78 mg/L in all ponds and gradually increased, especially at the end of September. It (above 20 mg/L) promoted rapid production and served as buffer, avoiding dramatic pH fluctuation (Boyd 1990).

Total suspended solid reflected indirectly the productivity in pond, when the TSS was low during summer but high at the end of September. High temperature and too strong irradiation could have adversely affected. Ponds receiving Diet 3 were usually characterized by poor growth of phytoplankton.

On the other hand, surplus phosphorus from diet can eutrophicate pond and natural waters. Therefore its level must be regulated appropriately (Schwartz and Boyd 1994a). In earthen catfish ponds, total phosphorus level was at the peak during summer and fall (Schwartz and Boyd 1994b). In general, higher concentration of phosphorus in diet affected the quality of pond water. Higher concentrations of phosphorus was more easily detected in ponds receiving Diet 3 than in others. Soluble reactive

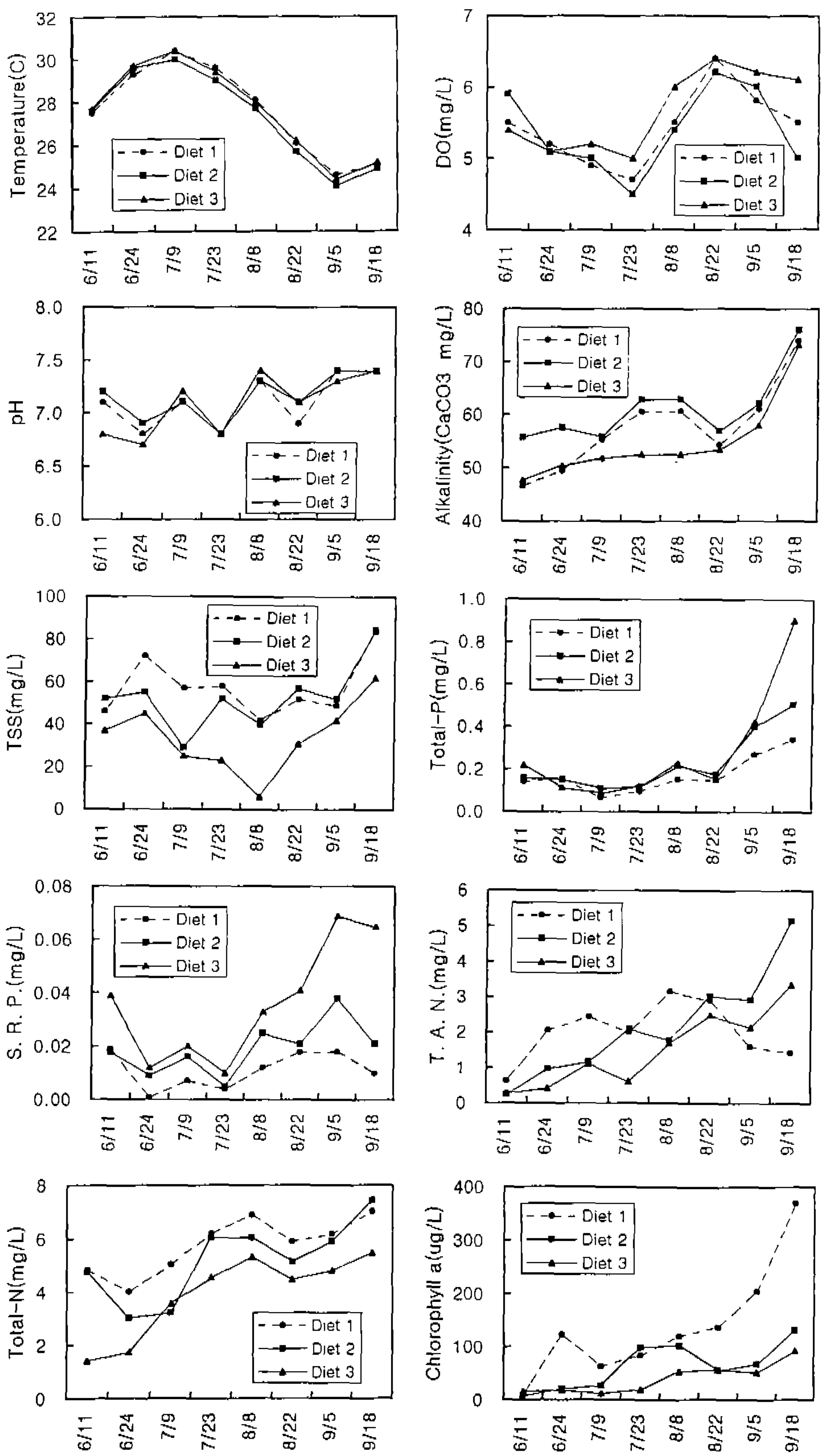

Fig. 1. Changes in water quality of channel catfish ponds receiving diets containing different levels of phosphorus.

Table 2. Effect of different levels of phosphorus containing diets on harvest and phosphorus level in fish. Percent values for P in fish are shown in brackets

Diet	Initial		Harvest		Increment weight (%)	Feed coefficient	Mortality (%)	P in body (mg/g dry weight)
	No	W (kg)	No	W (kg)				
1	650	6.70	477	167.86	3,320.4	2.13	26.62	6.68 (0.67%)
2	650	6.67	561	208.42	3,531.4	1.66	13.77	8.37 (0.84%)
3	650	6.76	504	156.15	2,916.7	2.25	22.46	6.98 (0.70%)

phosphorus concentrations oscillated between 0.001~0.069 mg/L. The SRP concentration increased from August to early of September in all the ponds. In ponds receiving different Diets, its concentration was in the following order : Diet 3, Diet 2 and Diet 1. The present findings that phosphorus concentration in pond water directly affected by phosphorus concentration in diet also confirm the earlier observation of Gross et al. (1996).

Total ammonia nitrogen increased with time and reached the highest value in September except in ponds receiving Diet 1. In September TAN concentration was 5.2, 3.3 and 1.4 mg/L for ponds receiving Diets 2, 3 and 1, respectively. Unionized ammonia is toxic to fish even at low concentration and has been identified as potential toxicant in intensive fish culture (Boyd 1979 ; Tucker 1984). Several sources including feeding may cause changes in TAN in aquacultural ponds. Total nitrogen increased with time as shown in TAN. Fishes excreted ammonia as the main end product of nitrogen metabolism. Generally, ponds receiving Diet 1 showed higher level of total nitrogen.

The possibility of using the chlorophyll content of whole natural communities as a measure of productivity has been shown (Odum 1971). However it might be said that chlorophyll would be a index of standing crop of phytoplankton rather than of productivity. In this study chlorophyll a concentration increased during the experimental period and showed a higher level in ponds receiving Diet 1 than the other ponds, receiving Diets 2 and 3.

The stocking density in pond was 650 animals weighing 6.7 kg. The harvest contain 477~561 animals with 13.77% mortality for ponds receiving Diet 2, and 26.62% for ponds receiving Diet 1. The increment of weight was higher for fish fed on Diet 2 than the others. The feed coefficient ranged between 1.66 and 2.25. This is typical for channel catfish production (Lovell 1989). For fish fed on Diet 2, the feed coefficient was lower than for the others, indicating that it is the optimal growth for catfish.

Phosphorus in body of channel catfish harvested ranged between 0.67 and 0.84%. It was higher in fish fed on Diet 2 and lower in fish fed on Diet 1. This indicates that the higher the concentration of phosphorus slower is the slower in the growth of fish and poorer is the pond water quality.

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