Nitrogen Fertilization in the Presence of Adequate Phosphorus

Workplan 7, Honduras Study 4D

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Introduction

Primary production and fish production in organically fertilized ponds were increased significantly when supplemented with sufficient inorganic nitrogen to raise total weekly nitrogen inputs to 28 kg/ha (Teichert-Coddington and Green, 1993; Teichert-Coddington et al., 1993). Nitrogen was apparently limiting productivity, but optimum nitrogen fertilization rates were not determined. The objective of this study was to quantify limiting levels of nitrogen in semi-intensive tilapia culture ponds supplied with adequate levels of phosphorus.

Materials and Methods

A completely randomized design was used to test 4 levels of inorganic nitrogen fertilization. Earthen ponds, 0.1 ha and 0.9 m mean depth, were fertilized with urea to supply 0, 7, 14, or 28 kg/ha-wk nitrogen. Each nitrogen level was replicated three times. All ponds were also fertilized with 8 kg/ha-wk of phosphorus as triplesuper phosphate. Total weekly fertilizer input was divided into two doses. Fertilizer was first dissolved in water before being applied to the pond.

Ponds were stocked with 11-g *Oreochromis niloticus* fingerlings at 2 fish/m^2, and guapote tigre at 500/ha to control reproduction. Fish were sampled monthly for growth.

Water sub-samples were collected from various locations in the pond with a column sampler and combined. The composite sample was analyzed according to standard methods (American Public Health Association (APHA) et al., 1992), unless otherwise indicated. Chlorophyll-*a* (Boyd and Tucker, 1992), filterable phosphorus, ammonia nitrogen, DO, and pH were determined weekly. Total phosphorus and total nitrogen by combined alkaline oxidation (Grasshoff et al., 1983), total alkalinity (titration to pH 4.5), total hardness, and primary productivity (free-water method) were determined monthly.

Ponds were stocked on 28 July 1994 and harvested after 146 d on 21 December 1994. Data were analyzed by ANOVA (Gagnon et al., 1989). Linearity of response to nitrogen fertilization was investigated by linear contrasts within the ANOVA model. Dunnett's T single tail test was used to compare means at different levels of nitrogen fertilization with the control. Differences were declared significant at alpha = 0.05.

Results

Nitrogen fertilization resulted in linear increases of total ammonia and total nitrogen (Figure 1, Table 1), as might be expected. Mean filterable phosphate was not significantly influenced by nitrogen fertilization (Figure 2), although the control mean concentration tended to be higher than the nitrogen fertilized treatments. The arithmetic difference between the control and nitrogen fertilized treatments became particularly large during the last month of growth (Figure 2). Total phosphorus did not significantly change with nitrogen fertilization (Figure 2). Total hardness and total alkalinity did not respond linearly to nitrogen fertilization (Figure 3). However, total hardness of each nitrogen treatment was significantly lower than the control. Only the

Table 1. Mean water quality variables for earthen ponds fertilized with 8 kg/ha-wk phosphorus as triple-super phosphate, and urea to supply 0, 7, 14, or 28 kg/ha-wk nitrogen.

Treatment	Total ammonia (mg/l)	Total nitrogen (mg/l)	Filterable phosphate (mg/l)	Total P (mg/l)	Total alkalinity (mg $CaCO_3$/l)	Total hardness (mg $CaCO_3$/l)	Chlorophyll *a* (µg/l)	Secchi disk visibility (cm)	Dissolved oxygen (mg/l)
0	0.051	2.29	1.911	1.97	79.7	57.4	100.3	26.1	4.7
7	0.099	3.14	1.170	1.99	65.5	43.4	195.2	19.6	4.1
14	0.180	4.02	1.144	1.84	66.3	37.9	291.5	18.4	4.3
28	0.303	5.97	0.921	1.95	69.2	41.1	393.1	16.5	4.0
Contrasts									
Linear	hs	hs				s	hs		
Quadratic								s	

s = significant ($P < 0.05$); hs = highly significant ($P < 0.01$)

lowest nitrogen treatment resulted in significantly lower total alkalinities than the control. Mean early morning dissolved oxygen concentrations were not significantly different among treatments.

Indicators of primary productivity responded positively to nitrogen fertilization. Chlorophyll *a* increased linearly with fertilization, and Secchi disk visibility decreased curvilinearly (Figure 4).

Fish growth did not respond significantly to nitrogen fertilization (Table 2, Figure 5). There was a tendency for both mean fish weight and production to increase at the 14 kg/ha treatment, but decrease thereafter. Fish growth was significantly curvilinear in all treatments (Figure 5).

Discussion

Primary productivity was clearly promoted by nitrogen fertilization in the presence of adequate phosphate. Phosphorus was high in all treatments with mean dissolved inorganic phosphate ranging between 0.92 and 1.91 mg/l for all treatments. The control treatment reached mean concentrations higher than 2.5 mg/l. Nitrogen fertilized treatments tended to have lower phosphate concentrations because of absorption by a higher biomass of phytoplankton. After the first month of production when phytoplankton had adequate time to become established, filterable phosphate significantly decreased with increased chlorophyll *a* ($P < 0.0001$; $R = 0.45$). A clear point was not established for which

Table 2. Mean tilapia production for earthen ponds fertilized with 8 kg/ha-wk phosphorus as triplesuper-phosphate, and urea to supply 0, 7, 14, or 28.

Treatment	Mean fish weight (g)	Total production (kg/ha)	Survival (%)
0	78.6	1412	86.7
7	70	1345	92.3
14	98.3	1664	82.5
28	64.4	1114	85.1

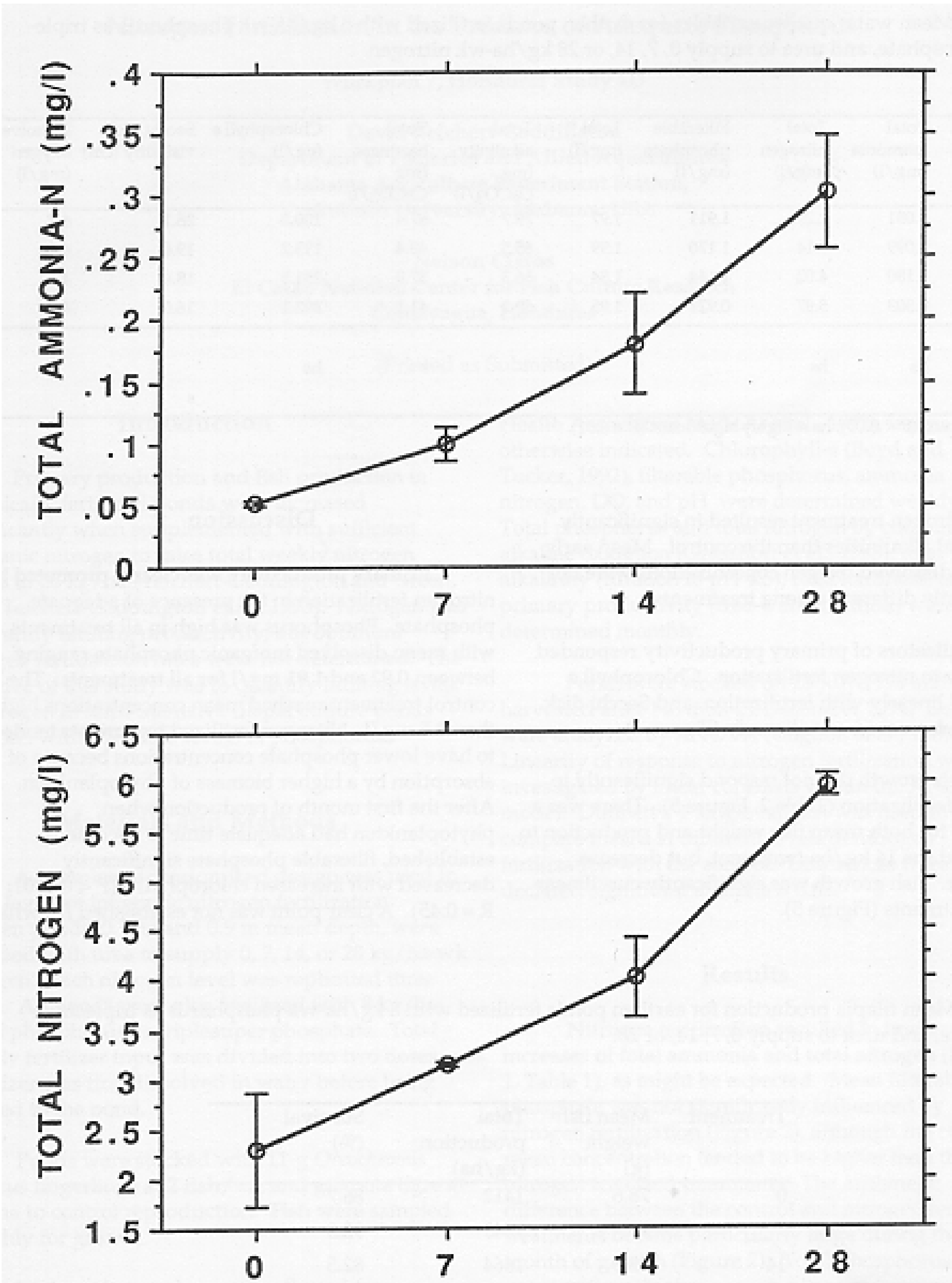


Figure 1. Mean total ammonia nitrogen and total nitrogen for each level of nitrogen fertilization in tilapia ponds supplied with 8 kg P/ha/wk. Bars around the mean indicate standard error.

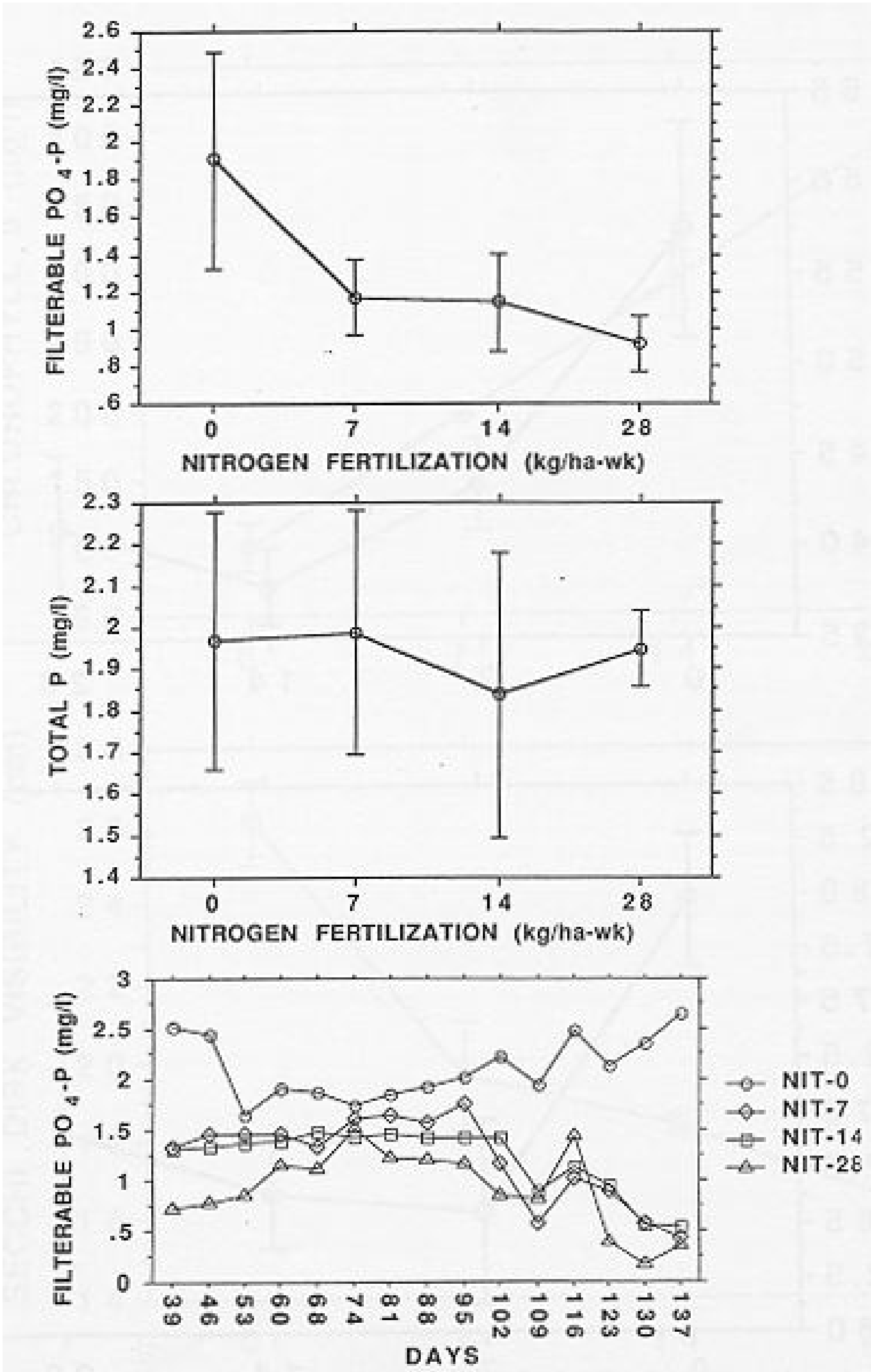


Figure 2. Mean filterable phosphate over time, and mean total phosphorus and filterable phosphate for each level of nitrogen fertilization in tilapia ponds supplied with 8 kg P/ha/wk. Bars around the mean indicate standard error.

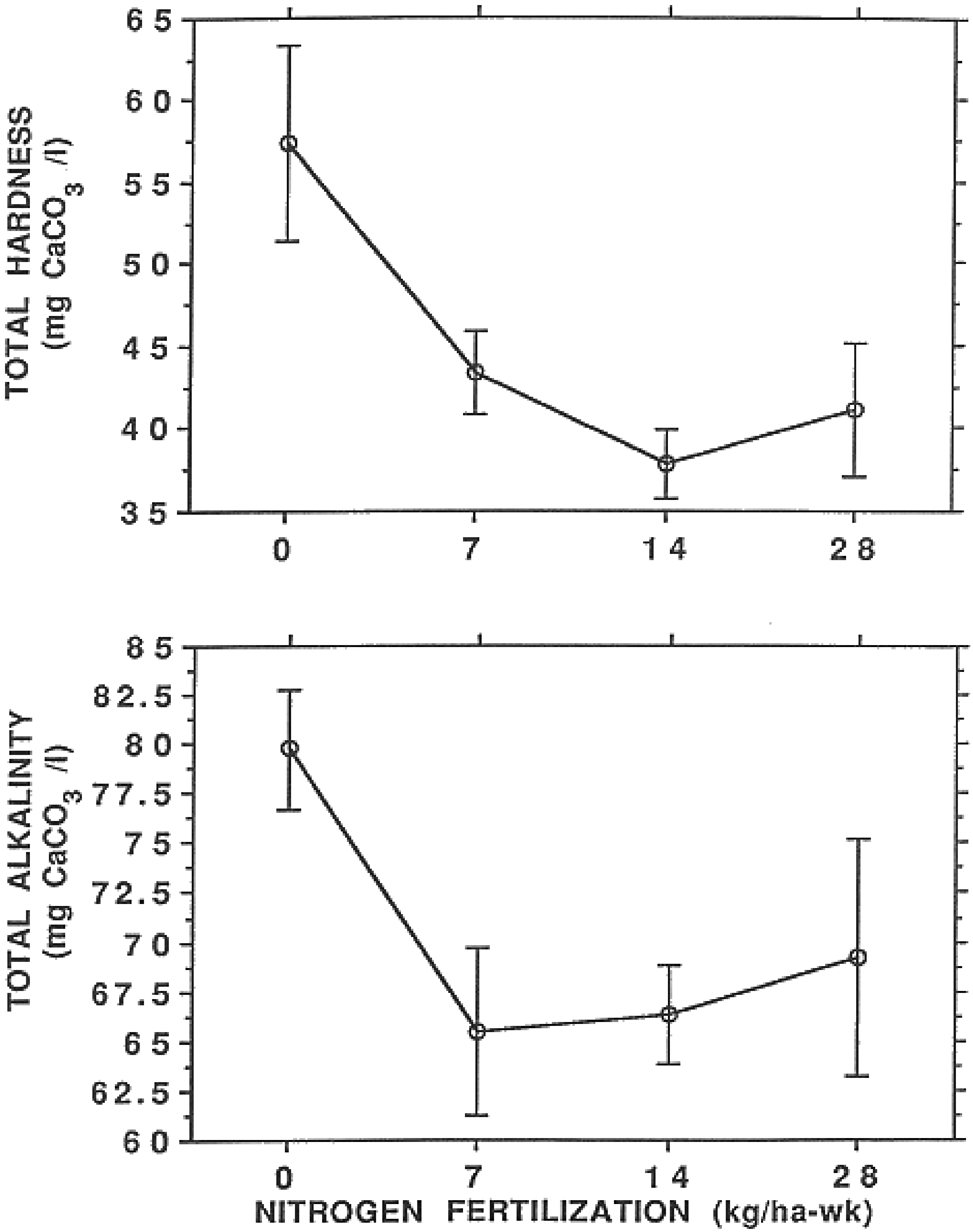
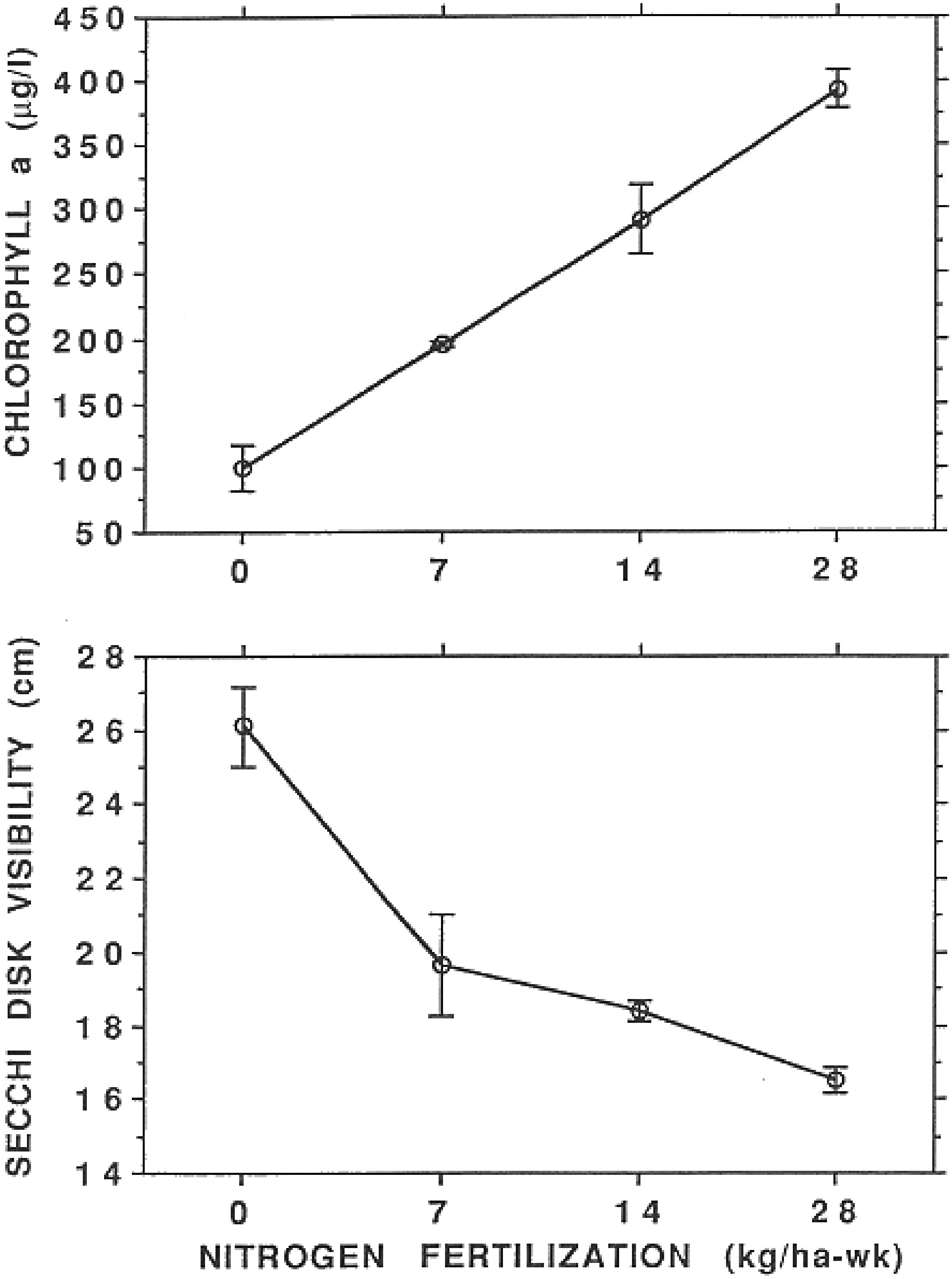
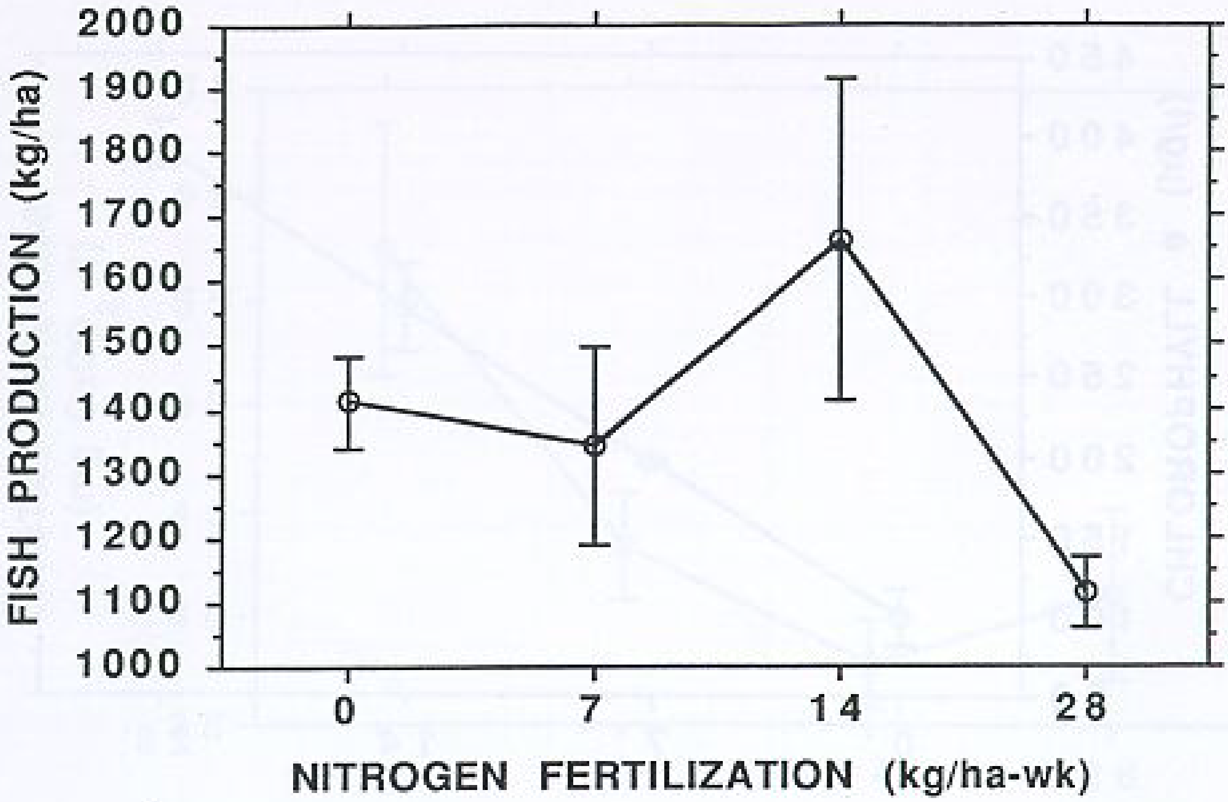


Figure 3. Mean total hardness and total alkalinity for each level of nitrogen fertilization in tilapia ponds supplied with 8 kg P/ha/wk. Bars around the mean indicate standard error.



ponds

Figure 4. Mean chlorophyll *a* and Secchi disk visibility for each level of nitrogen fertilization in tilapia ponds supplied with 8 kg P/ha/wk. Bars around the mean indicate standard error.



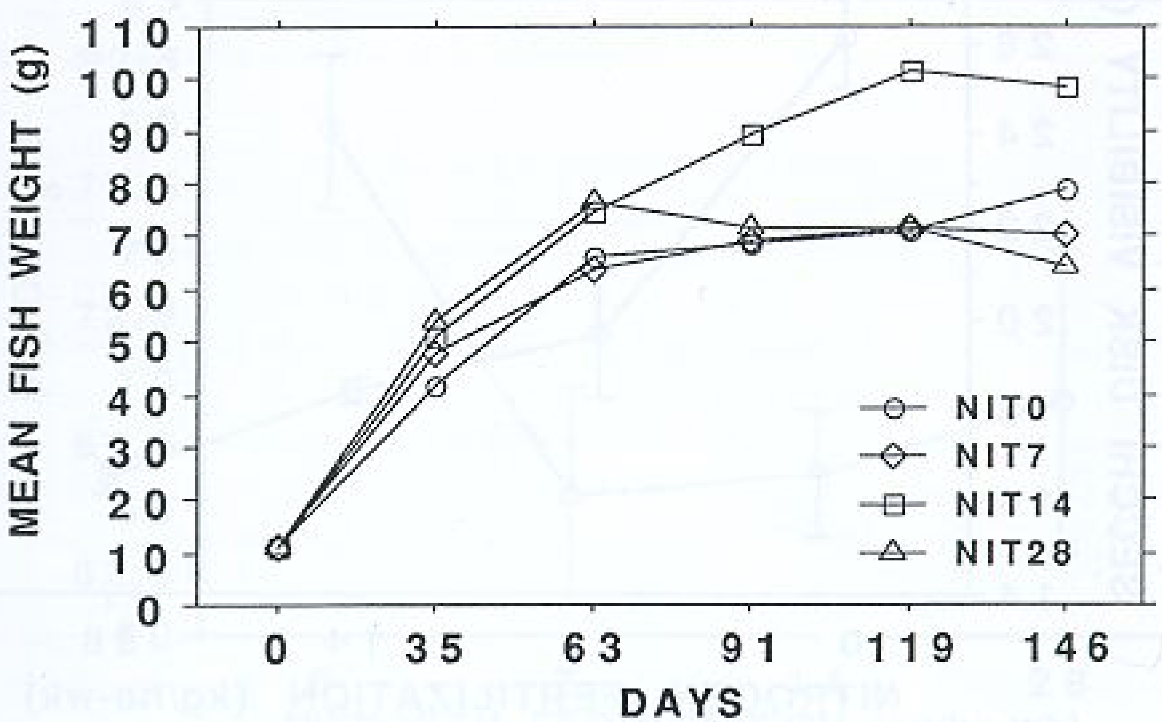


Figure 5. Mean tilapia growth over time, and mean total fish production for each level of nitrogen fertilization in tilapia ponds supplied with 8 kg P/ha/wk. Bars around the mean indicate standard error.

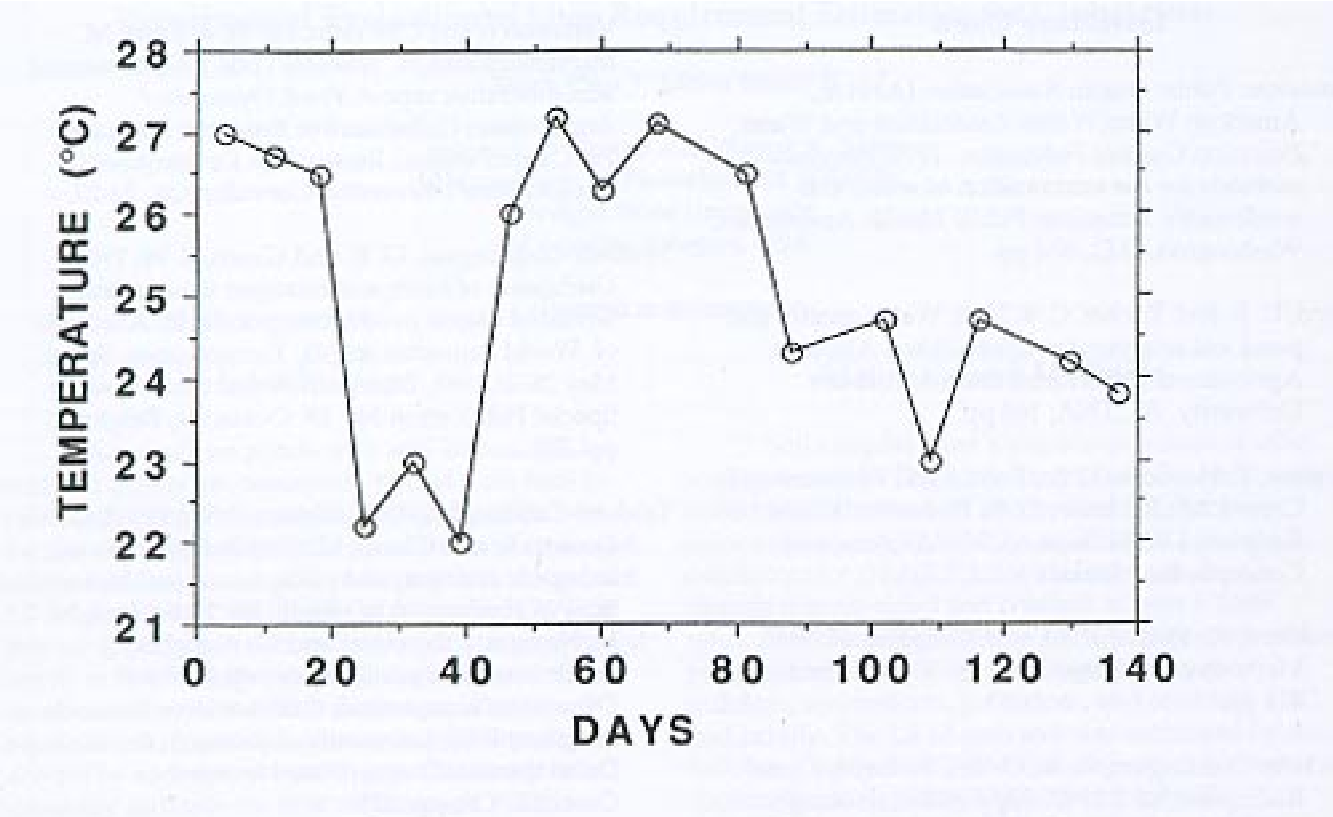


Figure 6. Mean early morning pond water temperature during the experiment.

nitrogen no longer limited primary productivity. However, occasionally high total ammonia levels (> 0.9 mg/l) in the highest nitrogen treatment indicated that ponds were approaching nitrogen saturation.

Despite an increase in primary productivity with nitrogen fertilization, a significant increase was not seen in tilapia production. It is suspected that cool water temperatures during the trial (Figure 6) inhibited fish growth. Growth leveled out after 90 d, about when water temperatures also dropped for a prolonged period. Fish were unable to take advantage of higher available nutrient supply. Indeed, fish production was low for all treatments. In 1992, a similar combination of inorganic P and N during the cool season yielded 1850 kg/ha (Teichert-Coddington et al., 1993), compared with 1664 kg/ha for the highest treatment yield during the current study. In 1991 (Teichert-Coddington et al., 1992), nitrogen supplementation of ponds fertilized with chicken litter significantly increased primary productivity, but did not affect tilapia yield of tilapia stocked at $1/m^2$, after 126 d of growth. It was concluded that fish were stocked at too low a rate and grown for too short a period to take advantage of the extra food supply. A subsequent experiment supported these conclusions. Ponds were stocked with tilapia at $2/m^2$, and fertilized with chicken litter and various levels of inorganic nitrogen (Teichert-Coddington and Green, 1993). Supplemental nitrogen inputs resulted in significant increases in primary production, and fish production was significantly increased at the C6:N1 input ratio resulting in record yields of 3500 kg/ha in 150 d.

Acknowledgments

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