Water quality and yields in a polyculture of nonnative cyprinids in Mexico.

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RESUMEN

Se realizó un policultivo experimental de ciprinidos asiáticos y chinos. El objetivo principal de esta investigación fue el de comparar tres tipos de fertilizantes: biabono líquido de borrego, biabono líquido de cerdo y un fertilizante químico (urea más compuesto complejo). Se utilizaron nueve estanques divididos en bloques y aleatorizados; en cada estanque se introdujeron cinco especies de carpas: herbívora, plateada, cabezona, brema y barrigona, con una densidad de 1.5 peces/m^2. Cada dos semanas se registraron los parámetros de calidad del agua, se tomaron muestras de fitoplancton y se registró la productividad primaria y además,se midieron algunos índices de crecimiento para calcular el rendimiento en cada tratamiento. En todos los tratamientos los valores de temperatura, conductividad, sodio, potasio, dureza y alcalinidad total, fueron semejantes y los de oxígeno disuelto, amonio total, nitritos, ortofosfatos y fotosíntesis neta mostraron diferencias entre los biabonos líquidos y el fertilizante químico. La comunidad fitoplanctónica estuvo representada por 40 géneros, 16 de ellos fueron los más frecuentes, siendo las clorofitas el grupo dominante a lo largo del experimento. No se presentaron diferencias significativas en los rendimientos acuícolas.

Palabras clave: Calidad del agua, rendimientos acuícolas, policultivos, ciprínidos exóticos, fertilizantes orgánicos y químicos.

ABSTRACT

An experimental polyculture of Asiatic and Chinese cyprinids was carried out for the first time in Mexico in order to compare three kinds of fertilizers: fermented liquid sheep and pig manure and mineral fertilizer (urea plus complex compound). Nine ponds divided in blocks were used; each pond was stocked with five species of carp: grass, silver, bighead, wuchang fish and big belly carp, with a density of 1.5 fish/m^2. Water quality parameters were recorded every two weeks. Phytoplankton and primary productivity samples were taken and some growth indexes were calculated to obtain the yield in each treatment. In all the treatments the temperature, conductivity, sodium, potassium, chloride, total hardness and total alkalinity values were similar and DO, ammonium, nitrites, ortophosphates and net photosynthesis exhibited differences between fermented liquid manure and chemical fertilizer. Phytoplankton was represented by 40 genera, 16 of them were found more frequently. Chlorophyta were the dominant group throughout the experiment. No statistical differences were registered in the yields between treatments.

Key words: Water quality, yields, polyculture, nonnative cyprinids, organic and chemical fertilizers.

INTRODUCTION

Mexican fish culture has been associated with the management of nonnative species such as carp and tilapia. Carps culture has played an important role in rural areas as a source of animal protein for human consumption, and 78% of the epicontinental waters specially in the Central Mexican Plateau have adequate limnological conditions for the culture of this species.

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Yields obtained in extensive cultures are low and range from 50 to 450 kg/ha/year. Intensive monoculture and polyculture are not well developed, compared to other countries around the world where high yields are obtained through polyculture systems, using species with different food habits that take advantage of each one in the aquatic system niches (FAO, 1983).

Due to the advantages of polyculture systems and with the purpose of increasing yields in fish culture ponds, several species of nonnative carp were introduced in some countries including Mexico, where six species of Chinese and European carps has been cultured (Arredondo and Juarez, 1986).

Several studies about different topics related to water quality, chemical compounds, phytoplankton distribution and composition, nutrients and primary productivity have been carried out in fish ponds, some of them describe the space-time variables behavior and others try to obtain relationships between synergetic and antagonic parameters (Boyd, 1979 and 1982; Hepher, 1962; Hepher and Pruginin, 1981; Parker and Davies, 1981; Dickman and Efford, 1972; Noriega-Curtis, 1979), but there is scarce information that describes the relationship between the chemical compounds and the fish yields obtained under different fertilization conditions.

With regard to fish yields obtained in polyculture systems, China reported from 3,000 to 6,000 kg/ha/year, utilizing high densities between 1.8 to 2.0 organisms per square meter fertilizing with animal manure and compost. In India, the culture of native carps fertilizing with chemical compounds and animal manure, indicate yields that reach up to 3,500 kg/ha/year. In Israel, the use of polyculture has significantly increased yields, which range from 3,500 to 11,000 kg/ha (Chakrabarty *et al.*, 1976; Moav *et al.*, 1977; Schroeder, 1977; Wohlfarth, 1978; Lin, 1982).

In this paper we attempt to describe the water quality, nutrients and primary productivity in a polyculture of nonnative carps with respect to the fish yields, in ponds fertilized with two fermented liquid manures and chemical compounds under local conditions, for the first time in Mexico.

MATERIALS AND METHODS

Nine rustic ponds of the Integrated Fish Farming Center in Hidalgo State were used in this study. The surface areas of the ponds in hectares were as follow: P-1, 0.152; P-2, 0.300; P-3, 0.154; P-4, 0.214; P-5, 0.190; P-6, 0.178; P-7, 0.183; P-8, 0.182, and P-9, 0.139, with a mean depth of 1.5 m.

This study was carried out during one culture cycle, from october, 1982 to september, 1983, using five species of carp : grass carp, *Ctenopharyngodon idellus* ; wuchang fish, *Megalobrama amblycephala*; silver carp, *Hypophthalmichthys molitrix*; bighead carp, *Aristichthys nobilis* and big belly carp, *Cyprinus carpio rubrofruscus*. Random block design experiment was used including three treatments according to Prowse's (1968) criteria. Density was 1.5 fishe/m^2, and three kinds of fertilizers were added: two fermented liquid manure; sheep with a relation N/P of 211:1 and pig with 42:1, and one chemical, a mixture of one part of urea (46 N) and eight parts of complex compound (17N:17 P_2O_5 :17K_2O). Subsequently, five days a week until the end of the experiment, 1,000 l/ha of both liquid fertilizer and 30 kg/ha of chemical fertilizer were added in each pond. Herbivorous fish were fed *ad libitum* with alfalfa and vegetable waste.

Samples of water were collected with a horizontal Van Dorn bottle from a station on the output gate, stored in polyethylene bottles and transported to the laboratory. The following water quality analysis were conducted during 16 two-weeks periods until the harvest: surface water temperature and conductivity (with a conductivimeter YSI model 33); Secchi disk visibility; DO concentration (modified Winkler with sodium azida method); pH (glass electrode); total hardness, calcium and magnesium hardness, total alkalinity, chloride, sodium and potassium according to the procedures outlined by the American Public Health Association, 1971.

Nutrients were estimated with the following methods: total ammonia nitrogen with the phenate method (Wetzel and Likens, 1979); nitrite and nitrate nitrogen with the alpha methiletilendiamina and reduction column method, and soluble orthophosphates with the ammonium molibdate method (Margalef *et al.*, 1976).

Twelve samples of phytoplankton were collected in each pond during the experiment with a horizontal Van Dorn bottle and put into 125 ml polyethylene bottles; 10 to 20 drops of acetate lugol solution were then added, after stirring each sample for some minutes 1 ml was poured into a sedimentation bottle with distilled water according to Uthermohl's (1958) technique.

The monthly primary productivity was evaluated in one pond of each treatment according to Odum's, (1956) criteria and following the rate change of dissolved oxygen technique in 24 hour cycles (Hall and Moll, 1975). Yields were expressed as final biomass per surface area and time (kg/ha/year or kg/ha/day).

Statistical analysis were applied and including general statistics (mean, standard deviation, coefficient of variation) and one way analysis of ANOVA, utililizing SPSS package.

RESULTS

Water quality variables.

The values of water quality variables are expressed in Table 1.

Water temperature followed a similar model of the air temperature, establishing two well defined seasons; the first one was cold with a low value of 12 °C in the winter and a gradual increase until May when the maximum surface value recorded was 25 °C, no differences were observed in the three treatments (one way ANOVA; $p \geq 0.05$).

Conductivity presented small changes between treatments except in the ponds where fermented liquid sheep manure was added, pointing out some differences of 50 μmhos/cm at 25 °C. The pond water values showed a heavy ionic composition and a high alkaline reserve.

pH was constant throughout the experiment, reinforcing the high buffer capacity of the system with a high alkalinity level. Small changes of pH values were detected (1.5 units between maximum and minimum) as a characteristic of water with a high alkalinity. Mean values ranged from 8.6 to 8.9.

Sodium and potassium ions have a high limnological importance; most waters present low concentrations, with sodium values higher than those of potassium. However, in this case, concentration of both elements was higher than in other kinds of waters, with a sodium/potassium ratio between 25 and 28 and with average values of sodium and potassium of 1.59 g/l and 59 mg/l respectively.

Sodium behavior along the experiment was similar in the ponds, showing a conspicuous tendency to increase in the warm season. The ponds fertilized with fermented liquid sheep manure presented the lowest mean value (1.50 g/l).

Potassium values were lower than sodium values, with average of 56.5 and 59.0 mg/l. Potassium exhibited a different behavior than sodium, gradually increasing during growing season.

Chlorides concentration presented fluctuations throughout the experiment and the average values varied between 212.6 and 240.8 mg/l. The mean values of total hardness fluctuated between 397.3 and 408.3 mg/l.

Table 1. Mean values (size sample, standard deviation and coefficient of variance) of the variables registered along the experiment.

Variables	1 Liquid sheep manure	2 Liquid pig manure	3 Urea + complex formula
Temperature °C	18.3 (48,3.47,19)	18.5 (48,3.17,17)	18.2 (48,3.24,18)
Conductivity μmhos/cm (25 °C)	1272 (48,130.8,10)	1294 (48,84.4,7)	1298 (48,75.9,6)
pH	8.65 (48,0.37,4)	8.71(48,0.36,4)	8.88 (48,0.27,3)
Sodium mg/l	1500(39,326.5,22)	1500 (39,314.8,20)	1600 (39,320,20)
Potassium mg/l	59.0 (39,11.5,19)	56.5 (39,15,27)	56.9(39,13.8,24)
Chloride mg/l	212.6 (42,67.6,32)	240.8 (42,80.6,34)	230.5 (42,230.5,30)
Total hardness mg/l	408.3 (47,74.1,18)	397.3 (48,78.7,20)	407.3 (48,60.7,15)
Total alkalinity mg/l	292.4 (43,89.9,31)	274.6 (45,93.6,34)	263.5 (45,92.41,31)
Secchi disk visibility (m)	0.63 (48,0.339,54)	0.82 (48,0.33,73)	0.97 (48,0.56,58)
Dissolved oxygen mg/l	8.8 (46,3.9,44)	9.9 (47,4.5,45)	10.4 (48,3.9,38)
Ammonium mg/l	0.13 (48,0.25,190)	0.082 (48,0.15,180)	0.24 (48,0.39,168)
Nitrates mg/l	0.66 (42,0.49,75)	0.72 (42,0.53,73)	0.54 (42, 0.38,71)
Nitrites μg/l	88.3 (45,88.2,100)	131 (45,152.5,117)	424.6 (45, 307,72)
Orthophosphates mg/l	0.38 (47,0.52,136)	0.21 (48,0.36,174)	0.54 (48,0.58,107)
Net photosynthesis gC/m²/day	3.01 (8,1.76,60)	2.98 (7,0.9,30)	3.89 (8,2.36,61)

Average values of total alkalinity fluctuated between 263.5 and 292.4 mg/l, with a similar behavior in the three treatments, decreasing in the cold months and increasing in the warm season.

The lowest mean values of visibility were registered at 63 cm, in the ponds fertilized with liquid sheep manure and the highest value at 97 cm in the chemical treatment ponds. The results demonstrated a similar behavior between liquid sheep manure and chemical treatment and differences in those ponds fertilized with liquid pig manure. A decreasing tendency was observed from February to June, when minimum values were registered at 15 cm, indicating a direct relationship with water temperature and primary productivity.

DO values registered during growing season showed the lowest values in liquid manure treatments with a major variation, and the highest values were recorded in chemical treatment ponds. These values were never lower than 1.10 mg/l and the highest value reached 25 mg/l.

Ammonia mean values varied between 0.08 and 0.24 mg/l. These values are far below those of toxic levels. High values are present in the chemical treatment with a maximum of 2.02 mg/l, and the lowest values are present in the liquid pig manure with 0.70 mg/l. High concentration points were recorded, in ponds treated with sheep manure, reached concentration of 1.31 mg/l in January and 1.0 in April, whereas ponds treated with liquid pig manure reached 0.70 mg/l in January and the urea plus complex compound showed three high concentration points, in December, April and June, with 1.02, 0.75 and 2.02 mg/l respectively.

Nitrates represented 45, 76 and 77% of the total nitrogen chemical species with a general tendency to reduction and a small increase in July. In the liquid manure treatments, seasonal behavior was similar and in the chemical treatment it was different, presenting two drops in December and June. Average values varied from 0.54 to 0.72 mg/l, with a maximum of 2.57 mg/l.

Nitrites percentages were the lowest of the nitrogen chemical species, in the liquid pig manure treatment it was 10%, in the liquid sheep manure 14% and in the chemical treatment 35%. Average values varied from 0.08 a 0.42 mg/l, with a wide variation throughout the experiment. General behavior was similar between treatments. Chemical treatments registered the highest value at 1.09 mg/l.

Mean soluble orthophosphates varied from 0.21 to 0.54 mg/l, with a wide fluctuation during growing season. The highest values were recorded in the chemical treatment with a maximum value of 3.4 mg/l in cold season.

Phytoplankton.

The phytoplankton genera comprising the communities in the ponds suffered changes throughout the growing season. Sixteen genera were the most common and some of them were present in only one treatment; for example, *Scenedesmus quadricauda* and *Trachellomonas* sp. were present in pig liquid manure; *Pediastreum boryanum* in urea and complex compound and *Nitzschia palea* in sheep liquid manure (Table 2). In all treatments, Chlorophyta were dominant with a total percentage of 41 to 59%, followed by Bacillariophyta in sheep liquid manure and chemical fertilizer (22 and 25% respectively) and Cyanophyta (23%) in pig liquid manure. Cyanophyta were dominant in June and July and other groups, such as Chrysophyta and Pyrrophyta, increased towards the end of the experiment.

Table 2. Total abundance (org/ml) of genera and species with a major frequency in the treatments along the experiment.

Group and species	Urea+complex compound	Fermented liquid sheep	Fermented liquid pig
CHLOROPHYTA.			
Monorraphidium sp.	81,950	84,300	56,600
Schroederia setigera	76,420	43,790	17,390
Oocystis sp.	63,450	463,400	64,800
Scenedesmus bijuga	36,450	45,350	37,150
Scenedesmus acuminatus	19,650	13,600	24,000
*Scenedesmus quadricauda**	———	———	11,200
*Pediastrum boryanum**	6,250	———	———
Elakatothrix sp.*	———	10,250	———
Sphaerocystis sp.*	———	———	14,850
BACILLARIOPHYTA.			
Nitzschia sp.	94,750	107,516	153,850
*Nitzschia palea**	———	54,500	———
Cyclotella menenghiniana	60,250	73,100	135,850
Denticula tenuis	18,300	23,900	———
EUGLENOPHYTA.			
Euglena sp.	154,650	59,050	59,800
Trachellomonas sp.*	———	———	115,250
CYANOPHYTA.			
Oscillatoria sp.	132,440	178,950	255,200

* Only present in one treatment.

The dominant genera in each treatment were as follows: nine genera in sheep liquid manure (*Oscillatoria, Elakathotrix, Monorraphidium, Oocystis, Scenedesmus, Schroederia setigera, Cyclotella menenginiana, Denticula tenuis* and *Nitzschia*); six genera in pig liquid manure (*Monorraphidium, Oocystis, Schroederia, Sphaerocystis, Cyclotella* and *Nitzschia*) and five genera in chemical fertilizer (*Monorraphidium, Oocystis, Scenedesmus, Cyclotella* and *Nitzschia*).

Primary productivity and yields

Net photosynthesis was similar in the liquid manure treatments, with two maximum points: in February and June in the liquid sheep manure and February and May in the liquid pig manure. The behavior model in the chemical treatment was different, with a decreased values in April and an increase in June until a maximum value was reached. Mean values fluctuated between 2.89 and 3.89 gC/m^2/day, with a maximum value of 8 gC/m^2/day in the chemical treatment.

On Day 281 and Day 309 of fish culture time, the total yield was 4,632 kg in two hectares, with no significant differences between treatments (one way ANOVA test $p \geq 0.05$). According to the results, the major yields were obtained in the chemical treatment with a mean value of three metric tons/ha, followed by 2.2 tons/ha in liquid pig manure and 2.0 kg/ha in liquid sheep manure and the survival rate was more than 70% (Table 3).

Table 3. Final yields obtained in this experiment.

Treatment	Surface (m^2)	Initial biomass (kg)	Final biomass (kg)	Yield kg/ha	Daily yield kg/ha	Survival rate (%)
Fermented liquid sheep manure	7,885	19.2	1,524	1,933	6.52	74.70
Fermented liquid pig manure	6,207	20.6	1,375	2,215	7.83	81.34
Urea + complex compound	5,819	21.6	1,732	2,977	10.02	81.54
Total	19,911	61.4	4,632			

DISCUSSION

Water temperature had a direct effect on the growth rate during the growing season, reinforcing the importance of this variable on fish yields. The experiment was carried out during two defined periods, one of them with low temperatures from November to February, and the other with high temperatures, from April to August with an average temperature of 18 °C. A growing season between 5 or 7 months a year can be established in this area.

The high values of water pond conductivity showed high ionic loads and alkaline reserve. Differences between ponds fertilized with fermented liquid sheep manure and the other treatments can be attributed to a lower quantity of dissolved solids in the lixiviation process and a poor microbial activity (Fry, 1974).

pH values maintained an alkaline tendency and were affected by its own dynamics in the ponds, where photosynthesis played an important role. According to the mean value > 8.6, these waters can produce high fish yields (Boyd, 1979; Boyd and Lichtkoppler, 1979).

The mean values of potassium and sodium were considered high in comparison to other waters and they covered the minimum requirement to reach good pond fertilization (1.5 mg/l according to Boyd, 1982). Some works papers report high values of both ions in ponds constructed on fertilized soils and arid regions, where the concentrations increase due to evaporation or by the contribution of the water springs. A high concentration of these ions have a direct relationship with some physiological processes, reducing ammonia and nitrites toxicity, avoiding pH fluctuations and osmorregulatory problems in fish (Parker and Davis, 1981).

Chloride concentrations were high due to the spring water which was the main source of this ion. Frequently, salinity in this area reaches values from 500 to 2,500 mg/l with an excess of sodium and chloride ions, increasing alkaline reserve remarkably and maintaining a high buffer capacity.

Total hardness surpasses total alkalinity and for this reason divalent ions are probably associated with other elements such as sulfates, chlorides, silicates, nitrates or borates more than carbonates and bicarbonates (Boyd, 1979; Boyd and Lichtkoppler, 1979). The pond water can be classified as very hard.

Alkaline waters are considered to have a high productivity and prevent carbon dioxide liberation. A value of 200 mg/l is considered good for fish culture. Under these conditions, bicarbonates are used as a main source in the photosynthesis process.

The differences of Secchi disk visibility observed between pond blocks can be attributed to the specific composition and total abundance of phytoplankton, without considering other causes such as clay suspension and the presence of humic acids that contributed to water turbidity (Boyd, 1979; Boyd, 1982).

A DO concentration from 3 to 5 mg/l can maintain a good fish growth and survival; and over 5 mg/l, optimal conditions are present (Boyd, 1979; Stickney, 1979; Parker and Davies, 1981). Personal observations showed that some cyprinid species have less resistance to low values of DO, such as wuchang fish (*Megalobrama amblycephala*), and silver carp (*Hypophthalmichthys molitrix*) and the species with a major capacity were big belly carp (*Cyprinus carpio rubrofruscus*) and grass carp (*Ctenopharyngodon idellus*). Hepher and Pruginin (1981) indicated an improvement of DO balance when silver carp and tilapia were cultivated together. The former feed on the excess of micro algae, causing an unbalance on primary productivity, and the latter consumes inorganic detritus.

Regardless of the high values of ammonia registered, lethal average concentrations depend on temperature and pH. In this study, the highest value was 2.02 mg/l, with a pH of 8.4 and 20°C of water temperature; the percentage participation of toxic ammonia (NH_3) is about 9.0% equivalent to 0.18 mg/l, which is considered in sub lethal level (reported lethal toxic values are between 0.6 and 2.0 mg/l and sub lethal between 0.1and 0.3 mg/l, according with Boyd and Lichtkoppler, 1979) . On the other hand some inorganic ions are effective in decreasing ammonia and nitrite toxicity. When total hardness increases, negative effects of toxic ammonia decrease and the chloride ions have a protecting effect against high nitrite concentration due to their ability to reduce osmotic and osmorregulatory troubles (Parker and Davies, 1981).

The main sources of nitrites were water and fertilizers; however, some experiments have demonstrated that the feces of herbivorous species increase nitrate concentration in the water pond remarkably. Venkatesh and Shetty, 1978 indicate that nitrate values increase when grass carp is fed with macrophytes. Water quality and the influence of herbivorous species were evaluated by Ahling and Jernolov, (1971) and Sutton and Blackburn, (1972), reporting an increase in the nitrogen concentration in bodies of water where herbivorous fishes were fed with aquatic macrophytes.

Since as target species in this experiment were grass carp and wuchang fish (herbivorous fish), feces and food played an important role as a source of nitrates and ammonium. Nitrates are toxic in high concentrations. Colt and Armstrong (1981), suggested that the lethal level of nitrates can fluctuate between 1,000 and 2,000 mg/l, and these values were never detected during this study. On the other hand nitrites values never reached sub lethal levels, further more the high contents of calcium and chlorides increased the tolerance more than 20 to 60 times, because these elements compete with the nitrite transportation through the fish gills.

According to the limnological characteristics of the ponds water, phosphorous can be precipitated in the form of calcium phosphate and can be adsorbed by sediments (Boyd, 1979). Phosphate concentration decreases rapidly in hard alkaline waters, as in this case (Boyd, 1982). For this reason, high levels of phosphorous must be added frequently to maintain a good productivity in the ponds.

The results of phytoplankton community analysis were similar to others obtained in other countries. In some ponds in the south of USA, Chlorophyta and Cyanophyta were most abundant. In Auburn University ponds Chlorophyta and Cyanophyta were the dominant groups during summer, and eutrophic bodies of water generally develop blooms of Cyanophyta, and inorganic fertilizers can produce high concentrations of green micro algae genera such as *Scenedesmus* sp., *Ankistrodesmus* sp., *Chlorella* sp., *Staurastrum* sp., *Pandorina* sp. *and Cosmarium* sp. in ponds (Boyd, 1979).

Some species of Chlorophyta and Euglenophyta are typical of waters rich in calcium and nitrogen. *Oocystis sp., Cyclotella* sp., *Scenedesmus* sp. *and Peridinium* sp. are indicators of water with a high concentration of ions, whereas species such as *Pediatrum* sp., *Trachellomonas* sp., *Ankistrodesmus* sp., *Melosira* sp., *Staurastrum* sp. *and Cyclotella* sp. are present in eutrophic waters (Margalef, 1983).

The mean number of phytoplankton species in ponds without fertilization in New York, USA was of 11.5; 14.5 with a moderate fertilization and 6.8 with a high load. Diatoms were rare, and Chlorophyta was the most dominant group in all the ponds (Hall *et al.*, 1970). Fertilization resulted in a phytoplankton increase without a control of generic composition. In this study, some species were present in only one treatment. *Scenedesmus quadricauda, Sphaerocystis* sp. *and Trachellomonas* sp. were present in ponds fertilized with fermented liquid pig manure; *Pediastrum boryanum* in urea plus complex compound treatment, and *Elakatothrix* sp. and *Nitszchia palea* in fermented liquid sheep manure treatment. The highest number of dominant species throughout the experiment was found in the ponds fertilized with fermented liquid sheep manure. These results agree with those of authors like McIntire and Bond, (1962); Dickman and Efford, (1972), and Boyd, (1973).

The results of net photosynthesis revealed a differential behavior between organic manure and chemical fertilizers, with an average value of 2.9 to 4.0 gC/m^2/day that are similar to others results reported in fish ponds by Noriega-Curtis, 1979.

The differences can be attributed to the high quantities of nitrogen, phosphorous and potassium added by the action of fertilizers. The maximum value of net photosynthesis was registered in the chemical treatment, in contrast with other studies where the highest values were obtained with animal manure treatments (Hepher, 1962; Boyd, 1973). The chemical fertilizer showed to be more effective to increase the primary productivity and to obtain higher fish yields. On this matter some studies have not demonstrated significant differences in fish yields between organic and chemical fertilizer (Bombeo-Tuburan *et al.*, 1989). In all the treatments some water quality factors such as temperature, conductivity, concentration of sodium, potassium, chloride, total hardness and total alkalinity were similar. However, other factors such as DO, ammonium, nitrites, orthophosphates and net photosynthesis were different specially in those ponds where chemical fertilizer was added. The results of yields and the survival rate obtained in these treatments were similar to those reported by other works such as Sinka and Vijaya, (1975); Chakrabarty *et al.*, (1976); Moav *et al.*, (1977); Schroeder, (1977); Wohlfarth, (1978); Prinsloo and Schoonbee, (1984 a, b and c) in other parts of the world, however represent for our country an alternative to increase yields in ponds and other bodies of water specially those located in the rural areas.

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