INORGANIC FERTILIZERS FOR PONDFISH CULTURE [1]

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SEVEN TEXT FIGURES

This paper endeavors to review the fishpond fertilization practices in countries in the Indo-Pacific region, and to discuss some basic information on the use of inorganic fertilizers obtained from experiments done by the writer in Auburn, Alabama, U.S.A.

Fishpond Fertilization in the Indo-Pacific Region

The efforts directed toward increasing fish production in fishponds in the Indo-Pacific area have received considerable attention. The addition of fertilizing substances to ponds in order to attain increased production has been extensively practised. Unfortunately, most of the trials have been confined largely to the random application of organic materials that are cheap and easily available in the localities of application. Whatever abounds locally would be used singly and in rare instances with inorganic nutrients. It is often difficult to establish whether these organic matters are fertilizers for the ponds or direct feeds for the fish stock. The kind of fertilizer and the amount used as well as methods of application vary with indigenous experiences and availability of fertilizing products. Only recently have experiments on the use of inorganic fertilizers been undertaken.

Japan.—To derive maximum production from fishponds, intensive fish culture techniques including the use of fertilizers and artificial feeds are utilized in Japan. Frequent and heavy feeding of the fish stock is done and undoubtedly the feed used served as direct fish food and fertilizer as well. Some of the substances commonly used include silkworm pupae, cereal by-products (rice bran and meddlings and barley),

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male chicks from poultry farms, cheap marine fish (sardines) and slaughterhouse products (horse and pig livers, etc.) prepared for pond application.

Inorganic fertilization of fishponds was considered in Japan previously as a minor management practice. In the hope of triggering off the growth of the desirable flora, the phytoplankton, one to two applications of ammonium sulfate and superphosphate used to be routinely done. In some instances, pond fertilization with inorganic substances met with disfavor due to their added fertilizing effect on obnoxious weeds. This could have been due to minimal application of the mineral fertilizer. In recent years, studies have been conducted on the use of this type of fertilizer in heavier dosage and more frequent application than previously practised. Seven applications instead of one or two per year have been tried with good results. Maximum success has been shown with combined intensive feeding and inorganic fertilizer application.

Taiwan—Intensive methods of fish cultivation are practised in the fishponds of Taiwan. Heavy feeding with various organic materials indistinguishable from fertilization per se, has long been a standing practice. The more common substances used include: rice and wheat bran, night soil, tea seed, peanut and soybean cake, *Leucaena* seed meal and various animal manures. For a long time a pattern of fertilization characterized by four applications of these organic fertilizers during the crop season was followed. Then there grew a great demand for these fertilizing materials, giving rise to unprecedented costs.

From 1953 to 1956 a series of experiments was undertaken to determine the effectiveness of inorganic fertilizers which heretofore had not been generally utilized in fishponds. These studies included comparison of the efficiency and economy of using organic and inorganic materials applied singly or combined. The following results were established:

1. Inorganic fertilizers of 8–9–2 or 8–4–2 (N–P–K) at the rate of 300 to 500 kilograms per hectare per year can be used successfully in Taiwan ponds used for raising milkfish (*Chanos chanos*);
2. Inorganic fertilizers were found more effective in clear pond water with salinity above 1.5 per cent and sufficient sunlight reaching the pond bottom;

3. The average production of ponds treated with complete inorganic fertilizer was equal to that produced by treatment with rice bran in amounts double or with night soil 30 times the mineral fertilizer used;
4. Based on current prices in Taiwan at the time the studies were being conducted, the expenses incurred with the use of organic materials exceeded that of the chemical fertilizers; and
5. Compared with ponds receiving either chemical or organic fertilizers, those receiving combined chemical and organic fertilizers, yielded highest increase in production.

Southern China and Hongkong.—The use of organic materials both as feeds and fertilizing substances in ponds is also an age-long management technique in Southern China and Hongkong. The materials used include silkworm pupae, cut land grass, soybean meal, goatweed and other strong odored weeds (mint family), pig, sheep, buffalo and cattle manure, night soil, tea seed, poultry droppings, aquatic plants, rice bran and broken rice, and peanut cake. It is not unusual for one to see latrines, and pig and duck pens built over the ponds.

There seems to be no standard method of fertilizer application in this area but different local practices have been developed in the different fish producing communities. Different organic fertilizers such as cow dung, green manure, hog manure, and others are often rotated during the growing season. Likewise, fish and plant crops are rotated in the same field. With the continued use of organic fertilizers the pond bottom gradually becomes elevated necessitating periodic draining of the pond water and drying and scraping of the bottom soil.

It has not been noted whether or not inorganic fertilizers have been used in Southern China and Hongkong.

Malaya and Singapore.—All cheap and easily available organic materials are used in ponds to serve the dual purpose of feeding and fertilizing. There are no records noted showing whether or not inorganic fertilizers have been used. However, with the establishment of the Fish Culture Research Institute at Batu Berendam, Malacca, Malaya, experiments on mineral fertilization of ponds are being undertaken. Recent findings of that Institute on $N-P_2O_5-K_2O$ used separately and in various combinations show that 40 pounds of P_2O_5 per acre per year is the optimum fertilization for ponds in that region. This rate produced a poundage even higher than that produced by ponds fertilized with 6–3/4 tons of cow dung, an indication that inorganic fertilizers can be as cheap if not cheaper than organic manures for fishpond fertilization.

"Mixed farming" or the integration of animal husbandry, crop raising and fish culture in order to obtain the maximum utility for a given piece of farmland, is a well-developed practice in Malaya. The unique feature of this scheme is the attempt to circulate within the system the nutrients that have been made available to it from outside and conserving these nutrients in order to reduce to the minimum the requisition of external materials. Thus, the animal wastes fertilize the water to produce the maximum growth of microscopic plants as well as higher aquatic plants. These are in turn fed on by the fish. Part of the luxuriant growth of higher aquatic plants and excess stock of the rapidly multiplying species of fish are gathered and used to augment the feed used in the animal husbandry unit. In order to maintain their original depth, ponds are periodically drained, dried, and their bottoms scraped. The scrapings have been found good vegetable garden and orchard fertilizers.

India.—The method of fertilization characterized by heavy use of organic substances and manures as direct feeds and pond fertilizing materials practised in the Indo-Pacific region holds true with India. The materials commonly used include cow dung, stable refuse, poultry manure, oil cake and cut grass bundles.

With the growth of cities and unprecedented increase in population, the efficient disposal of refuse and sewage has become a big problem. India has demonstrated, particularly in the Bidyadhari Spill area in Calcutta, that fish culture in sewage-irrigated areas can provide a cheap means of sewage purification. From the stand-point of sanitation it has been observed that fish, fortunately, can not survive normally at points in the sewage line where the oxygen content is too low and where pathogens are to heavy to cause danger to public health. On the other hand, where the water has become clear and/or well diluted the enriched water favors a very rapid growth of the desirable species of fish to marketable size in as brief a period of 6 to 8 months.

Indonesia.—Like all the other countries of the Indo-Pacific region, Indonesia utilizes organic materials and manures for the artificial enrichment of her fishponds. Pig, duck and other animal manures are used. Vegetables found in quantities are used as green manuring materials. Experiments on the use of marygold plant, *Tithonia diversifolia,* for green manuring resulted in increased production of common carp (*Cyprinus carpio*) and tilapia (*Tilapia mossambica*) in ponds.

The use of inorganic fertilizers in this country is in the experimental stage. Its bright prospects seem to be indicated by the surprisingly high production derived from ponds in volcanic areas, the water of which is heavily laden with mineral nutrients.

Because of management practice in this area, brackish water ponds for milkfish are incidentally fertilized. Periodic replenishing of the pond water with new tidal water brings in nutrients with the water supply. The draining and drying of the pond bottom after each crop period is invariably followed by heavy growth of blue-green algae in the ponds. It has been postulated that nitrogen fixation may be taking place with the growth of this type of algae.

The use of sewage water from population centers for fish production purposes has proven to be successful in the cities of Jogjakarta and Bandung. Here fresh sewage are first treated by technical means in septic tanks and later allowed to flow and mix with irrigation water for ponds where fish is raised or to ricefields where, besides rice, fish is raised. High fish production for common carp, tilapia and milkfish has been derived from these sewaged-fed areas.

Philippines.—Pondfish culture in the Philippines is predominantly confined to brackish water ponds for milkfish; freshwater fishponds are still few and limited in extent. The peculiar management practice developed in this country's brackish water fishponds seems to provide for some degree of self-fertilization. This practice appears identical with those observed in Indonesian milkfish ponds. During the crop period, the regular replenishment of the pond water during the spring tides allows entrance of nutrients with the incoming water. After each cropping, the ponds are drained and exposed to sunlight. Usually a heavy growth of benthic algae predominantly of blue-green group develops immediately following this period. That fixation of nitrogen possibly takes place at the pond bottom at this time has been advanced by some workers in this field.

Artificial feeding to a limited extent is also practised in Philippine milkfish ponds. Feed used as direct fish food undoubtedly serves also as fertilizer. Rice bran is the principal item used especially in milkfish pond nurseries. Corn bran, bakery wastes and cereal by-products are also used. Animal manures especially poultry droppings are generally applied when available as fertilizers. These have been observed, fed on directly by the fish.

The use of inorganic fertilizers is under investigation with some indications of success. Experiments in the use of 8–18–4 (N–P–K) in milkfish pond nurseries resulted in better growth of the fish food, greater stocking capacity of ponds (from 30 to 50 fry per square meter) and faster rate of growth of the milkfish fingerlings. In milkfish rearing ponds complete fertilizer formulation 12–12–12 (N–P–K) was found to effect better growth on the algal food of the milkfish. In repeated experimental trials in one of the Philippine Bureau of Fisheries Fish Farm Stations for milkfish, repeated use of 16–20–0 (N–P–K) resulted in an average production of 1.3 tons of fish per hectare per year. This is almost four times greater than the present average production from unfertilized ponds in this country.

In spite of the demonstrated successes of these experiments general adoption of fertilization of ponds with inorganic substances has not come into being. The dearth of supply and the prohibitive prices demanded for inorganic fertilizers draw setbacks for their general use.

Results of an Experiment on Inorganic Fertilizers Done in Auburn, Alabama, U. S. A.

As a part of a continuing study on pond fertilization at the Farm Ponds Project, Agricultural Experiment Station of the Auburn University, Auburn, Alabama, the writer carried on a year-round experiment during the 1959 crop period. The study was designed to test the effect of no fertilization and non-nitrogenous fertilization in ponds that had received continued complete fertilizers during the preceding 15-year period. Two species of fish, common carp and goldfish (*Carassius auratus*), were used separately in three fertilizer treatments, namely, 0–0–0, 0–8–2, and 8–8–2 pounds of N–P_2O_5–K_2O per acre per application.

Results on chemistry of pond water.—The concentration of total nitrogen dissolved and in suspension in the water was related to the fertilization the ponds received; it was highest in the 8–8–2, followed next in the 0–8–2 and lowest in the 0–0–0 ponds (Table 1). These differences in levels in the three treatments were significant. The amount of total nitrogen in each of the unfertilized ponds remained at more or less the same level throughout the experimental period. The 0–8–2 ponds gradually increased in their total nitrogen content toward the

TABLE 1.—*Parts Per Million Total Nitrogen At Approximately Monthly Intervals In Ponds Receiving Different Fertilizer Treatments.*

Month	Carp ponds			Goldfish ponds			Period totals
	0–0–0	0–8–2	8–8–2	0–0–0	0–8–2	8–8–2	
1. April	0.97	0.68	1.07	0.94	0.79	1.61	13.40
	1.38	0.96	1.36	1.69	0.93	1.02	
2. May	1.44	1.43	1.12	0.87	1.43	1.56	14.30
	0.72	1.24	1.27	0.72	1.38	1.12	
3. June	0.74	1.08	2.18	0.49	0.61	0.93	12.07
	0.81	0.84	1.27	1.13	1.09	0.90	
4. July	0.91	0.94	1.08	1.11	0.78	1.24	12.21
	0.70	1.44	1.49	0.70	0.58	1.24	
5. August	1.11	1.33	1.39	1.18	1.51	1.22	13.90
	0.56	0.96	1.23	0.92	1.35	1.14	
6. September	0.77	1.01	1.54	1.07	1.23	1.58	14.08
	1.02	1.51	1.20	0.77	0.88	1.50	
7. October	0.86	0.98	1.47	0.91	0.80	2.16	14.84
	1.18	1.44	1.64	0.72	1.42	1.26	
Treatment totals	13.17	15.84	19.31	13.22	14.78	18.48	
Treatment totals (both fish)				26.39	30.62	37.79	

end, and that in the 8–8–2 the nitrogen content increased at an even higher rate than in the 0–8–2 (Fig. 1).

The inorganic nitrogen component (ammonia plus nitrate) in all the ponds started at a relatively high level and gradually decreased toward the end of the experiment. Ammonia, the more abundant fraction, declined rapidly during the period (Table 2 and Figures 2a and 2b). Nitrate was in minute quantities, but gradually increased during the experimental period (Table 3 and Figures 3a and 3b). Close relationship between the decline of inorganic nitrogen on the one hand and the increase of plankton on the other was observed.

Ammonia and nitrate in ponds receiving similar fertilizer treatments differed significantly in levels in the carp and goldfish ponds. Ammonia concentration was lower in the carp ponds than in the goldfish ponds; as carp stir the pond bottom

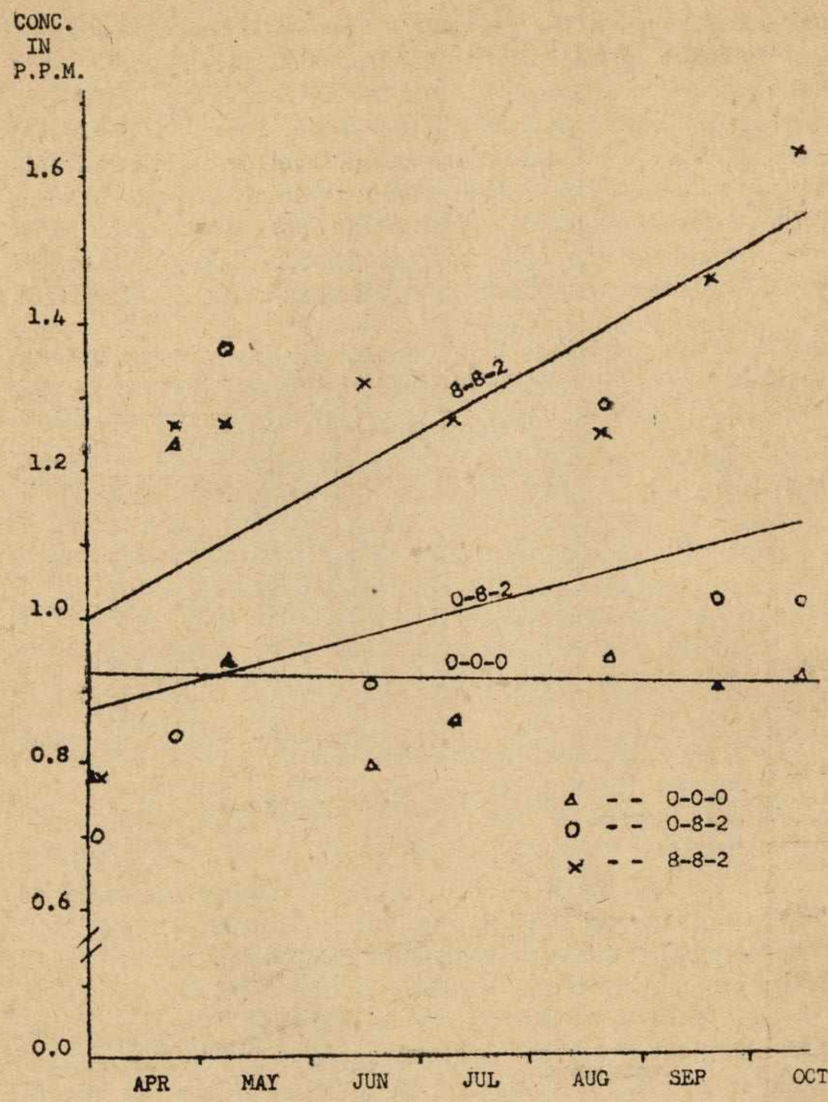

FIG. 1. REGRESSION LINES OF TOTAL NITROGEN CONTENTS OF POND WATERS RECEIVING DIFFERENT FERTILIZER TREATMENTS

and muddy the water, more rapid absorption of ammonia on clay colloids probably took place (Table 2 and Figures 2a and 2b). The nitrate concentrations were higher in the carp

TABLE 2.—*Parts Per Million Ammonia Nitrogen at Approximately Monthly Intervals In Ponds Receiving Different Fertilizer Treatments.*

Month	Carp ponds			Goldfish ponds			Period totals
	0-0-0	0-8-2	8-8-2	0-0-0	0-8-2	8-8-2	
1. April	0.37	0.29	0.13	0.35	0.29	0.30	4.20
	0.38	0.35	0.31	0.64	0.36	0.43	
2. May	0.38	0.37	0.34	0.53	0.30	0.41	4.30
	0.22	0.13	0.16	0.66	0.20	0.60	
3. June	0.20	0.29	0.34	0.23	0.26	0.41	4.28
	0.43	0.26	0.45	0.52	0.37	0.52	
4. July	0.18	0.26	0.29	0.18	0.14	0.24	2.93
	0.20	0.28	0.23	0.25	0.34	0.34	
5. August	0.13	0.13	0.20	0.21	0.13	0.21	2.49
	0.15	0.31	0.30	0.19	0.29	0.24	
6. September	0.04	0.06	0.13	0.14	0.08	0.08	1.19
	0.13	0.16	0.12	0.04	0.06	0.15	
7. October	0.08	0.04	0.32	0.12	0.04	0.24	1.81
	0.09	0.14	0.12	0.06	0.18	0.38	
Treatment totals	2.98	3.07	3.44	4.12	3.04	4.55	
Treatment totals (both fish)				7.10	6.11	7.99	

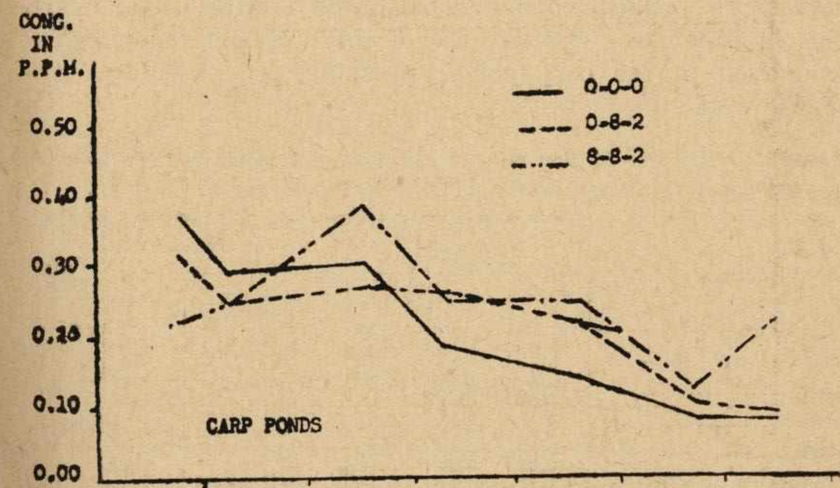

FIGURE 2a

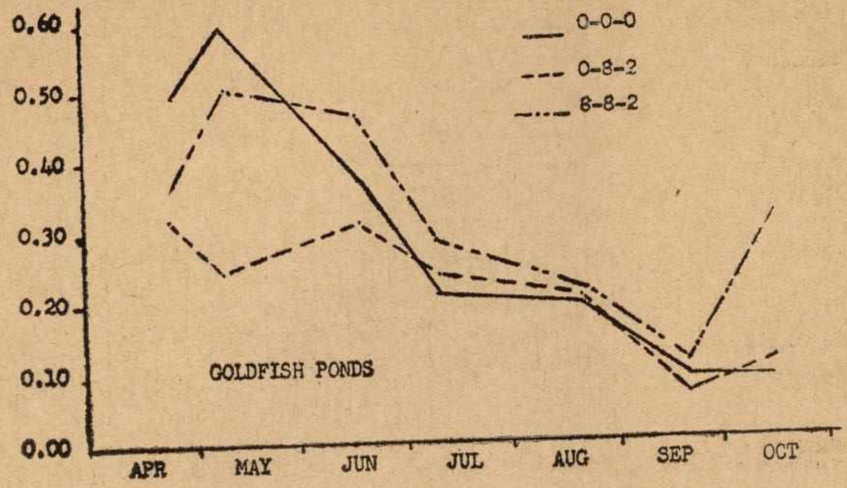

FIGURE 2b

AMMONIA CONCENTRATIONS IN CARP AND GOLDFISH PONDS RECEIVING DIFFERENT FERTILIZER TREATMENTS.

than in the goldfish ponds (Table 3 and Figures 3a and 3b). This indicated less effective use of this nutrient for plankton production in the carp ponds, probably as a result of the muddy water.

TABLE 3.—*Parts Per Million Nitrate Nitrogen At Approximately Monthly Intervals In Ponds Receiving Different Fertilizer Treatments.*

Month	Carp ponds			Goldfish ponds			Period totals
	0-0-0	0-8-2	8-8-2	0-0-0	0-8-2	8-8-2	
. April	0.07 0.04	0.06 0.05	0.07 0.06	0.03 0.05	0.06 0.05	0.05 0.04	0.63
2. Mav	0.06 0.06	0.13 0.07	0.07 0.06	0.03 0.05	0.09 0.11	0.12 0.08	0.93
3. June	0.07 0.06	0.14 0.10	0.15 0.10	0.05 0.06	0.07 0.10	0.10 0.08	1.08
4. July	0.14 0.08	0.13 0.10	0.14 0.10	0.08 0.04	0.08 0.06	0.08 0.09	1.12
5. August	0.11 0.09	0.12 0.10	0.17 0.06	0.13 0.07	0.11 0.13	0.07 0.11	1.27
6. September	0.09 0.12	0.11 0.20	0.23 0.10	0.07 0.09	0.10 0.12	0.11 0.11	1.45
7. October	0.10 0.10	0.12 0.18	0.24 0.09	0.06 0.06	0.06 0.12	0.20 0.08	1.41
Treatment totals	1.19	1.61	1.64	0.87	1.26	1.32	
Treatment totals (both fish)				2.06	2.87	2.96	

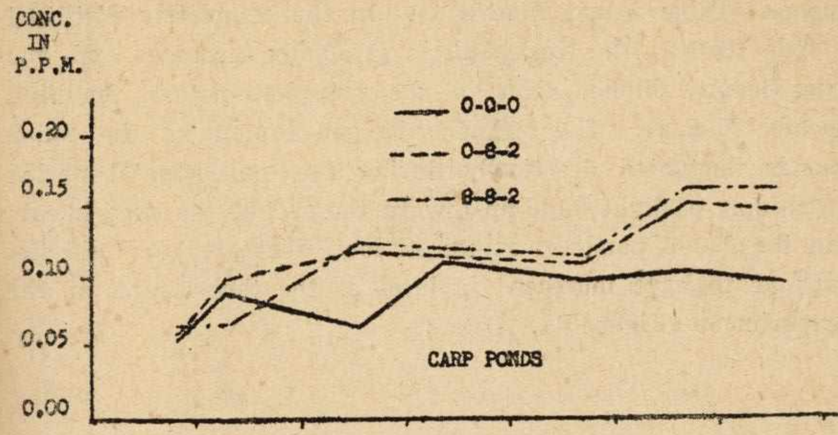

FIGURE 3a

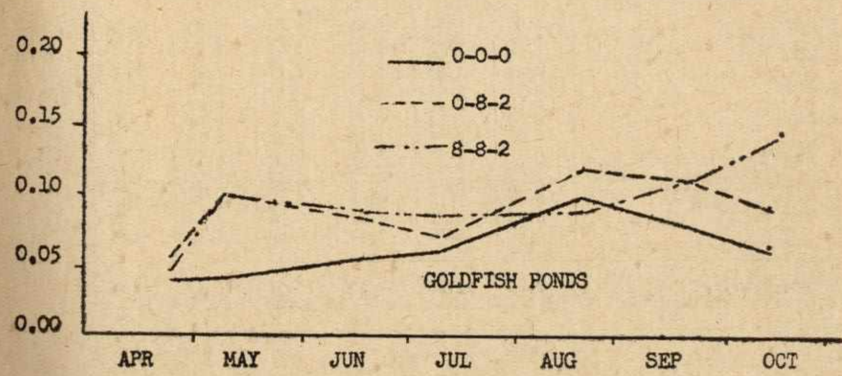

FIGURE 3b

NITRATE CONCENTRATIONS IN CARP AND GOLDFISH PONDS RECEIVING DIFFERENT FERTILIZER TREATMENTS.

The amounts of organic nitrogen in the fertilized 8–8–2 and 0–8–2 ponds were significantly higher than in the unfertilized 0–8–2 ponds (Table 4 and Figure 4). In the completely fertilized ponds (8–8–2) the concentration gradually increased and was significantly higher than in the phosphate-potash fertilized ponds (0–8–2). The organic nitrogen content of the 0–8–2 ponds fluctuated drastically during the experimental period with only a slight build-up toward the end of the experiment; in the 0–0–0 ponds it remained low, fluctuated and did not appear to have increased in level at the termination of the experiment (Figure 4).

TABLE 4.—*Parts Per Million Organic Nitrogen At Approximately Monthly Intervals in Ponds Receiving Different Fertilizer Treatments.*

Month	Carp ponds			Goldfish ponds			Period totals
	0–0–0	0–8–2	8–8–2	0–0–0	0–8–2	8–8–2	
1. April	0.53	0.33	0.87	0.56	0.44	1.26	8.57
	0.96	0.56	0.99	1.00	0.52	0.55	
2. May	1 00	0.93	0.71	0.31	1.04	1.03	9.07
	0.44	1.04	1.05	0.01	1.07	0.44	
3. June	0.47	0.65	1.69	0.21	0.28	0.42	6.71
	0.32	0.48	0.72	0.55	0.62	0.30	
4. July	0.59	0.54	0.64	0.85	0.56	0.91	8.13
	0.42	1.06	1.16	0.40	0.18	0.82	
5. August	0.87	1.08	1.02	0.94	1.27	0.94	10.24
	0.32	0.55	0.87	0.66	0.93	0.79	
6. September	0.64	0.84	1.18	0.86	1.05	1.39	11.44
	0.77	1.15	0.98	0.64	0.70	1.24	
7. October	0.68	0.82	0.91	0.73	0.70	1.72	11.62
	0.99	1.12	1.43	0.60	1.12	0.80	
Treatment totals	9.00	11.15	14.22	8.32	10.48	12.61	
Treatment totals (both fish)				17.32	21.63	26.83	

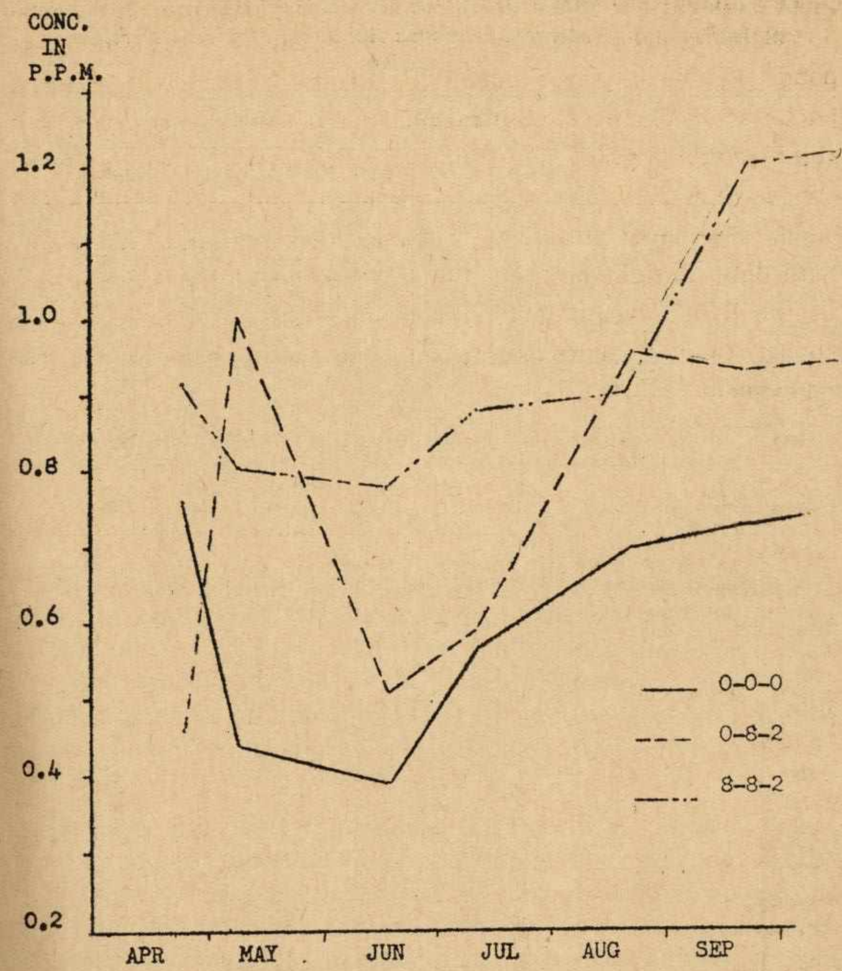

FIG. 4. ORGANIC NITROGEN CONCENTRATIONS IN PONDS RECEIVING DIFFERENT FERTILIZER TREATMENTS.

The concentration of dissolved inorganic phosphorus in the pond waters was related to the fertilizer treatment; it was significantly higher in the 0–8–2 and 8–8–2 than in the unfertilized ponds (Table 5 and Figures 5a and 5b). The

TABLE 5.—*Parts Per Million Dissolved Inorganic Phosphorus At Approximately Monthly Intervals In Ponds Receiving Different Fertilizer Treatments*

Month	Carp ponds			Goldfish ponds			Period totals
	0–0–0	0–8–2	8–8–2	0–0–0	0–8–2	8–8–2	
1. April	0.01 0.02	0.11 0.03	0.03 0.04	0.02 0.01	0.05 0.02	0.11 0.02	0.47
2. May	0.01 0.02	0.09 0.02	0.04 0.03	0.01 0.02	0.07 0.01	0.08 0.02	0.42
3. June	0.08 0.04	0.08 0.09	0.12 0.09	0.05 0.06	0.05 0.05	0.07 0.10	0.88
4. July	0.02 0.02	0.02 0.05	0.02 0.04	0.02 0.02	0.02 0.02	0.04 0.04	0.33
5. August	0.02 0.01	0.02 0.02	0.02 0.02	0.03 0.02	0.02 0.04	0.03 0.03	0.28
6. September	0.02 0.06	0.06 0.11	0.05 0.12	0.05 0.04	0.04 0.07	0.08 0.08	0.78
7. October	0.04 0.05	0.07 0.10	0.10 0.06	0.05 0.05	0.07 0.08	0.10 0.08	0.85
Treatment totals	0.42	0.87	0.78	0.45	0.61	0.88	
Treatment totals (both fish)				0.87	1.48	1.56	

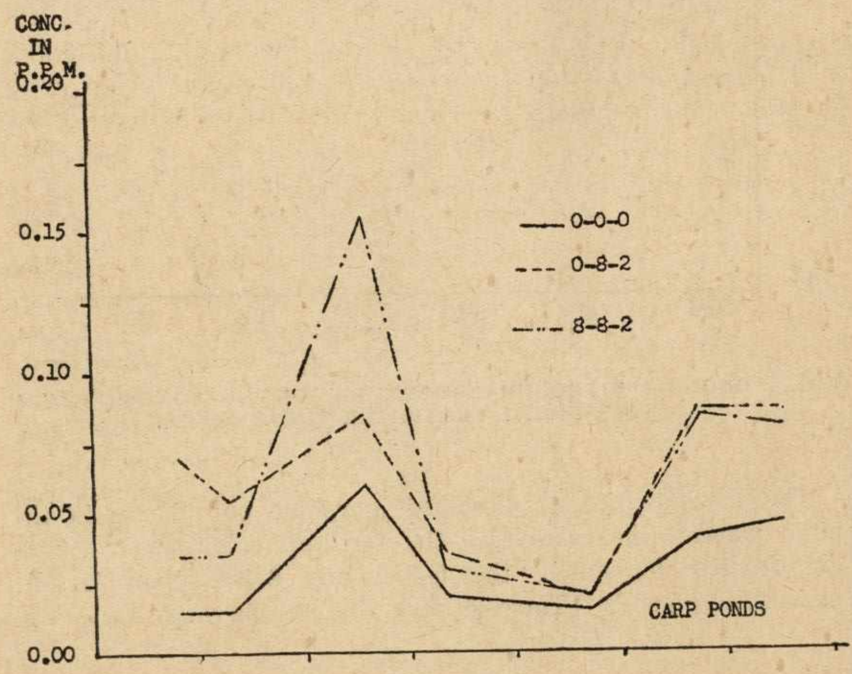

FIGURE 5a

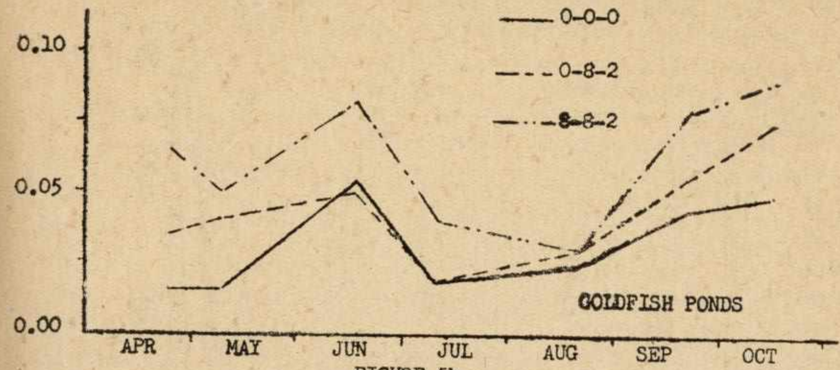

FIGURE 5b

PHOSPHORUS CONCENTRATIONS IN CARP AND GOLDFISH PONDS RECEIVING DIFFERENT FERTILIZER TREATMENTS

disappearance of inorganic phosphorus from the pond water after its application was extremely rapid; it was being lost at the rate of 12.7 per cent per day in the 0–8–2 and 14.3 per cent per day in the 8–8–2 ponds (Figure 6). The phosphorus content of the pond waters underwent unexplained cyclic changes during the experimental period (Figures 5a and 5b).

Plankton and bottom fauna.—Carp utilized bottom fauna (mainly aquatic insects) more completely than goldfish (Table 7). This was because carp feed heavily on bottom organisms while goldfish feed largely on plankton from the surface to the pond bottom. The amount of plankton and aquatic insects produced in the fertilized 8–8–2 and 0–8–2 ponds was significantly higher than in the unfertilized ponds (Tables 6 and 8 and Figure 7). A trend was indicated in the averages per sampling period that the 8–8–2 ponds had higher amounts of plankton and aquatic insects than the 0–8–2 ponds, but the difference was not statistically significant (Tables 6 and 8).

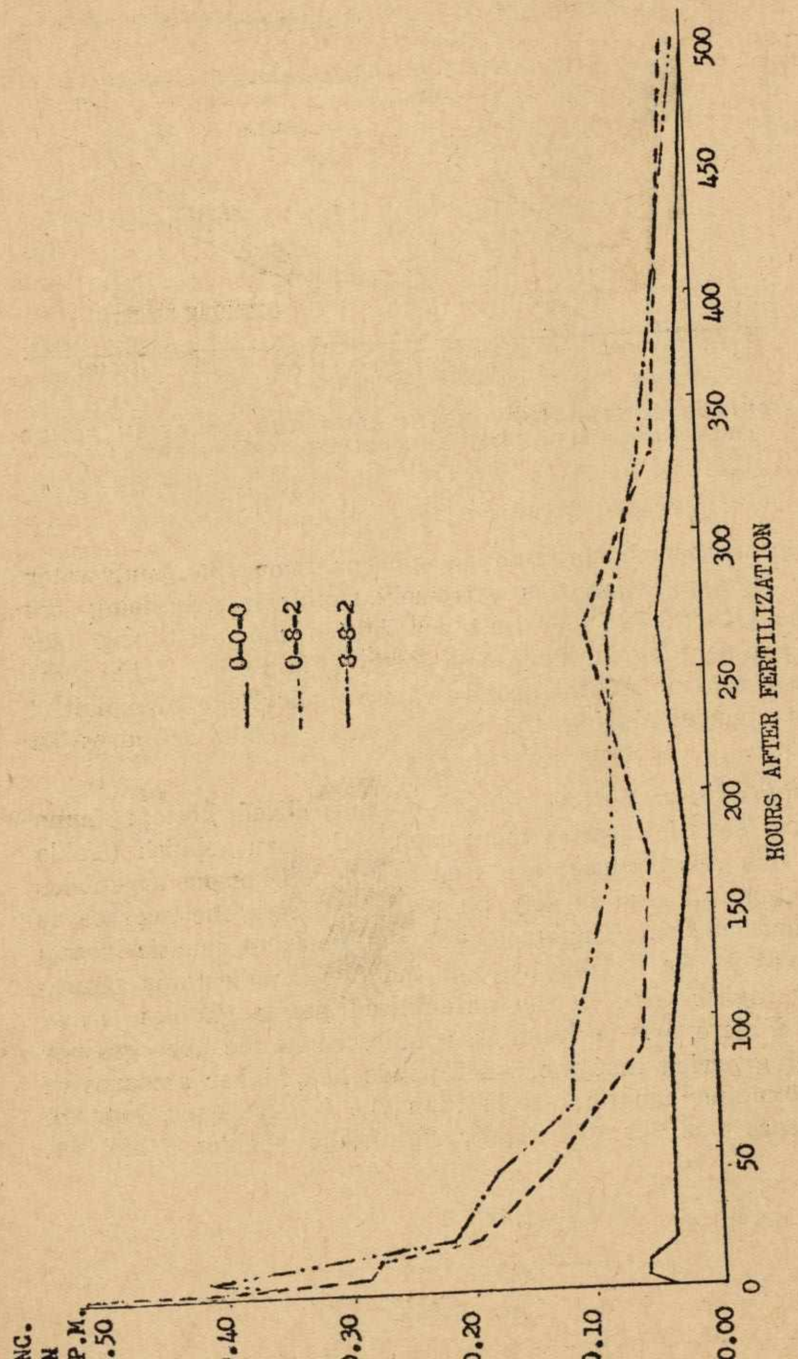

FIGURE 6

PHOSPHORUS IN POND WATERS AT SELECTED INTERVALS AFTER THE APPLICATION OF FERTILIZERS

TABLE 6.—*Milligrams per liter plankton at approximately monthly intervals in ponds receiving different fertilizer treatments.*

Month	Carp ponds			Goldfish ponds			Period totals
	0-0-0	0-8-2	8-8-2	0-0-0	0-8-2	8-8-2	
1. April	3.0	2.9	8.1	5.9	7.6	19.0	73.9
	2.6	3.9	8.8	4.1	3.5	4.5	
2. May	3.6	6.9	4.0	6.1	7.7	12.9	84.3
	2.5	9.2	8.1	4.3	10.0	9.0	
3. June	7.0	10.5	9.7	8.4	6.4	8.7	98.7
	6.7	10.7	9.1	5.0	5.6	10.9	
4. July	10.2	6.8	11.7	5.8	13.4	8.8	109.0
	7.5	15.0	11.2	5.4	6.0	7.2	
5. August	7.1	11.1	7.1	7.6	8.1	9.9	108.4
	6.4	7.8	10.3	11.4	11.1	10.5	
6. September	5.6	10.0	11.6	8.6	8.3	10.7	118.4
	10.3	20.4	8.6	7.2	7.8	9.3	
7. October	6.0	8.6	16.3	7.0	7.0	10.9	120.1
	11.2	20.8	9.2	6.1	8.8	8.2	
Treatment totals	89.7	144.6	133.8	92.7	111.3	140.5	
Treatment totals (both fish)				182.4	255.9	274.3	

TABLE 7.—*Ekman dredge sampling of bottom organisms (in milligrams dry weight per square foot of pond bottom)*[1]

Period	Carp ponds			Goldfish ponds			Period totals
	0-0-0	0-8-2	8-8-2	0-0-0	0-8-2	8-8-2	
1. June	2.24	6.11	3.97	4.16	12.95	0.00	40.13
	0.00	0.32	1.81	1.28	2.90	4.39	
2. September	0.88	0.84	1.28	2.63	2.20	3.15	34.56
	0.11	2.56	2.13	8.33	0.53	9.92	
3. October	0.96	2.91	0.21	1.16	3.73	1.65	49.44
	0.96	3.84	5.32	13.39	3.91	11.40	
Treatment totals	5.15	16.58	14.72	30.95	26.22	30.51	
Totals in carp and goldfish ponds		36.45			87.68		

[1] Values are given for each of two ponds for each treatment.

TABLE 8.—*Relative volumes of aquatic insects from ponds receiving different fertilizer treatments collected from masonite plate collectors (milliliters per square foot of surface)*[2]

Period	Carp ponds			Goldfish ponds			Period totals
	0-0-0	0-8-2	8-8-2	0-0-0	0-8-2	8-8-2	
1. June	0.5 0.0	4.0 0.5	10.2 8.5	0.1 0.2	5.8 9.5	11.5 2.1	52.9
2. July	5.5 0.0	6.5 6.0	8.0 2.5	8.0 0.9	2.9 1.5	7.5 8.0	57.3
3. August	2.5 0.2	4.0 2.2	14.0 3.7	10.5 0.4	3.2 4.8	3.9 5.0	54.4
4. September	2.5 2.0	4.4 3.4	3.6 2.9	2.4 0.8	4.5 8.0	7.6 7.2	49.3
5. October							
Treatment totals	13.2	31.0	53.4	23.3	40.2	52.8	
Totals in carp and goldfish ponds		97.6			116.3		

[2] Values are given for each of two ponds for each treatment.

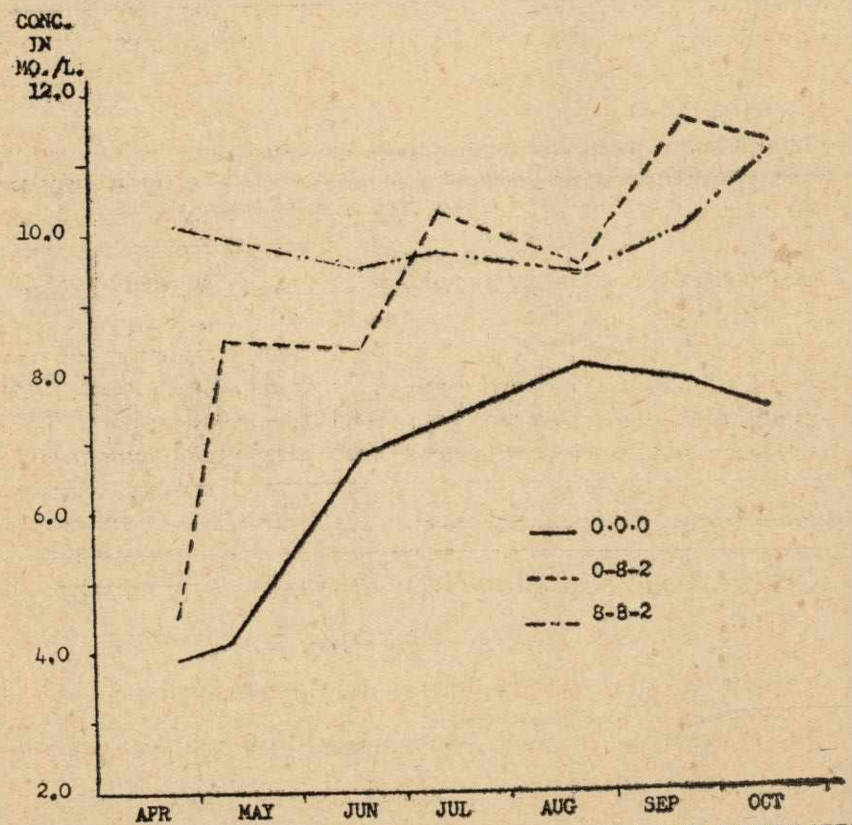

FIG. 7. PLANKTON IN PONDS RECEIVING DIFFERENT FERTILIZER

Fish production.—The production of fish both carp and goldfish was highest where complete fertilization was continued, followed next by phosphate-potash fertilization and lowest with no fertilization as indicated in the following table:

Fertilizer treatment	Average total production of Ponds in pounds per Acre	
	Carp	Goldfish
0-0-0	275.2	422.6
0-8-2	312.4	616.2
8-8-2	348.8	700.6

The increases in goldfish production resulting from 8–8–2 and 0–8–2 fertilization were significant; the increases in carp production were not significant although the averages in the 8–8–2 and 0–8–2 were consistently higher than in the unfertilized ponds. It may be speculated that longer period of the experiment might raise the difference to a level of significance.

General comments.—Some residual effect of the continued yearly application of complete fertilizers in the ponds during the fifteen years previous was noted. The unfertilized ponds in this experiment were calculated to be producing 3.7 times more carp and 1.7 more goldfish than in the original unfertilized state.

The fish, aquatic insects and plankton production of the ponds receiving different fertilizer treatments indicated that higher production resulted when fertilizers were applied. The chemical data tended to show that indigenous pond sources and/or fixation (in the case of nitrogen) can not fully be relied upon to supply the needs of continued and intensified biological production; for better results, the application of a suitable formulation of complete fertilizers is imperative.

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ILLUSTRATIONS

TEXT FIGURES