METHODS OF APPLYING LIQUID FERTILIZER TO FISH PONDS

CLAUDE E. BOYD, Department of Fisheries and Allied Aquacultures, Auburn University, AL 36849
WILLIAM D. HOLLERMAN, Department of Fisheries and Allied Aquacultures, Auburn University, AL 36849

Abstract: When applied to ponds at equivalent rates, liquid fertilizer was much more effective than granular triple superphosphate in increasing filtrable orthophate concentrations. Four methods of applying liquid fertilizers were tested: (1) liquid fertilizer was introduced into the intake side of a pump, mixed with water, and discharged into ponds, (2) a power sprayer was employed to spray the fertilizer over portions of pond surfaces, (3) a compression-type hand sprayer was used to spray fertilizer along shallow water edges of ponds, and (4) fertilizer was drained into the propeller wash of an outboard motor as the boat was driven back and forth over pond surfaces. All 4 methods proved effective. For 20 tests (5 for each method), filtrable orthophosphate concentrations averaged 0.02 mg/l before application and 0.29 mg/l 24-hr after treatment.

Proc. Ann. Conf. S. E. Assoc. Fish & Wildl. Agencies 35:525-530

Metzger and Boyd (1980), Boyd (1981*a*), and Davidson and Boyd (1981) demonstrated that liquid fertilizers are more efficient sources of phosphorus for fish ponds than solid, granular fertilizers. The use of liquid fertilizer reduces the amount of phosphorus that must be applied to produce a plankton bloom. Hence, it is cheaper to fertilize ponds with liquid fertilizers than with conventional fertilizers (Boyd 1981*a*, *b*).

Liquid fertilizer is denser than water, so some means of mixing the fertilizer with pond water is necessary to prevent density flow of the fertilizer to the pond bottom. In experiments, application of liquid fertilizers was achieved by mixing the concentrated fertilizer with water and splashing the mixture over pond surfaces. This procedure was time consuming, so the present research was conducted to evaluate several other methods of applying liquid fertilizers to ponds. In addition, filtrable orthophosphate concentrations in ponds fertilized with liquid fertilizer were compared to those of ponds treated with granular triple superphosphate.

This research was supported by funds from the National Fertilizer Development Center, Tennessee Valley Authority, Muscle Shoals, Alabama and Hatch Project Alabama Number 497.

METHODS

The liquid fertilizer was a clear ammonium polyphosphate (Poly N®) with a density of 1.44 kg/l (12 lb/gal) and N:P_2O_5:K_2O grade of 10-34-0. Granular triple superphosphate used in the study had a grade of 0-46-0.

Fourteen ponds located in the vicinity of Auburn, Alabama, ranged from 0.38 to 5.71 ha (0.94 - 14.11 acres) in area and from 1 to 2 m (3.28 - 6.56 ft) in average depth. Beginning in early June, 1980, fertilizer was applied to ponds at the rate of

9 kg of P_2O_5 per hectare per application (8 lb/acre per application) by 1 of the methods described below. Five of the ponds were only fertilized once, but the others were fertilized 2 or 3 times. When ponds were fertilized more than once, 1 month elapsed between applications. The method of application for a particular pond was always determined randomly.

A sampling grid of 10 stations was established over the entire surface of each pond and water samples were taken with a 90-cm (35-in) water column sampler (Boyd 1973) before and 24 hr after fertilizer application. Filtrable orthophosphate concentrations were determined by the ascorbic acid method (American Public Health Association et al. 1975).

Liquid fertilizer was applied by 4 methods: pump, power sprayer, hand sprayer, and from a moving boat. Each method of application was tested 5 times. A centrifugal irrigation pump with a capacity of 400 l/min (106 gpm) was modified to discharge liquid fertilizer. A tee was attached between the pump and suction hose on the intake side. A reducer was placed in the tee and a 1-cm (0.4-in) inside diameter ball valve was seated in the reducer. One end of a 1.3-cm (0.5-in) inside diameter polyvinylchloride hose was attached to the ball valve and the other end of the hose was inserted into an open container of liquid fertilizer. The suction hose was placed in the pond and the pump was operated to discharge water back into the pond at a site several meters from the intake. With the pump running, the ball valve was opened so that fertilizer was sucked into the incoming water, mixed, and discharged into the pond at a single site. Fertilizer flowed into the intake hose of the pump at 1.7 kg/min (3.75 lb/min).

The power sprayer was operated by a 3.75-kilowatt (5-hp) gasoline engine. The liquid fertilizer was mixed with twice its volume of water and discharged by the sprayer at 8.4 kg/cm^2 (120 psi). The mixture was sprayed from 1 site from the edge of ponds. Because the sprayer had a range of 10m (32.8 ft), fertilizer was applied over an area of about 160 m^2 (1,722 ft^2) in each pond.

A compression-type hand sprayer (10-l capacity) was used to apply undiluted fertilizer. The fertilizer was applied in a band approximately 7-m wide as the operator walked around the edges of ponds.

To make applications by boat, fertilizer was drained at 2 l/min into the propeller wash of an electric trolling motor (5 kg thrust). The boat was driven back and forth over pond surfaces as fertilizer was released.

Solid fertilizer (triple superphosphate) was applied either by broadcasting the granules in a 15-cm wide band around pond edges or by dissolving granules as well as possible in a container and releasing the slurry into the propeller wash of the outboard motor. Each method of application was tested 5 times.

RESULTS AND DISCUSSION

Boyd (1981*a*,*b*) recommended liquid fertilizer applications of 2 - 4 kg of P_2O_5 per hectare per application. A higher application rate (9 kg/ha per application) was employed in testing application techniques so that orthophosphate concentrations would be great enough for easy measurement.

All 4 methods of applying liquid fertilizer were effective in appreciably increasing average filtrable orthophosphate concentrations (Tables 1 - 4). The greatest increase in orthophosphate concentration was 0.54 mg/l in a trial using the outboard motor

(Table 4), while the smallest increase was 0.09 mg/l in a trial with the pump (Table 1). Filtrable orthophosphate concentrations were always 0.11 mg/l or higher 24 hr after application. Variation in filtrable orthophosphate concentrations between sampling stations in individual ponds did not differ greatly as indicated by ranges and coefficients of variation. Because the sampling grid covered the pond surface, this observation suggests that all techniques of application resulted in relatively uniform distribution of phosphate. However, applications by hand sprayer and outboard motor usually resulted in less variation than applications by the other 2 methods, presumably because the hand sprayer and outboard motor permitted greater surface coverage with fertilizer.

Table 1. Filtrable orthophosphate concentrations in ponds before and 24 hours after application of liquid fertilizer at 9 kg of P_2O_5 per hectare. Fertilizer flowed (1.67 kg/min) into intake side of pump, mixed with water, and discharged into pond at a single site. The pump had a capacity of 400 liters/min.

	Filtrable orthophosphate [a] (mg/l as P)							
	Before application				24 hours after application			
Area (ha)	Mean	SD	Range	CV (%)	Mean	SD	Range	CV (%)
0.61	0.01	0.006	0.004-0.02	60	0.36	0.046	0.23-0.44	13
1.19	0.01	0.008	0.004-0.03	80	0.16	0.015	0.13-0.18	9
1.19	0.02	0.01	0.004-0.04	50	0.26	0.014	0.25-0.29	5
1.21	0.004	0.0	0.004-0.004	0	0.31	0.046	0.26-0.38	15
1.33	0.02	0.009	0.004-0.03	45	0.11	0.031	0.06-0.14	28

[a] Data on each horizontal line are for 10 samples taken before and 24 hours after fertilizer application to a single pond.

Table 2. Filtrable orthophosphate concentrations in ponds before and 24 hours after application of liquid fertilizer at 9 kg of P_2O_5 per hectare. Fertilizer was applied at a single site by spraying over 160 m^2 of pond surface with a power sprayer.

	Filtrable orthophosphate[a] (mg/l as P)							
	Before application				*24 hours after application*			
Area (ha)	Mean	SD	Range	CV (%)	Mean	SD	Range	CV (%)
0.76	0.02	0.003	0.01 -0.02	15	0.26	0.032	0.20-0.30	12
0.81	0.01	0.006	0.002-0.02	60	0.44	0.15	0.25-0.67	34
1.59	0.02	0.01	0.004-0.03	50	0.24	0.060	0.16-0.31	25
1.59	0.01	0.004	0.01 -0.02	38	0.39	0.072	0.23-0.46	18
2.02	0.002	0.0	0.002-0.002	0	0.17	0.028	0.11-0.21	16

[a] Data on each horizontal line are for 10 samples taken before and 24 hours after fertilizer application to a single pond.

Table 3. Filtrable orthophosphate concentrations in ponds before and 24 hours after application of liquid fertilizer at 9 kg of P_2O_5 per hectare. Fertilizer was sprayed around edges (from shoreline to 7 m offshore) with a hand sprayer.

	Filtrable orthophosphate[a] (mg/l as P)							
	Before application				24 hours after application			
Area (ha)	Mean	SD	Range	CV (%)	Mean	SD	Range	CV (%)
0.38	0.02	0.006	0.01 -0.03	32	0.39	0.062	0.30-0.46	16
0.65	0.13	0.006	0.12 -0.14	5	0.54	0.034	0.49-0.60	6
1.21	0.004	0.0	0.004-0.004	0	0.24	0.022	0.20-0.27	9
1.33	0.02	0.005	0.01 -0.03	25	0.15	0.0043	0.14-0.16	3
1.59	0.03	0.006	0.02 -0.04	20	0.27	0.022	0.22-0.29	8

[a] Data on each horizontal line are for 10 samples taken before and 24 hours after fertilizer application to a single pond.

Table 4. Filtrable orthophosphate concentrations in ponds before and 24 hours after application of liquid fertilizer at 9 kg of P_2O_5 per hectare. Fertilizer was discharged into the propeller wash of an electric trolling motor as boat was driven over pond surface.

	Filtrable orthophosphate[a](mg/l as P)							
	Before application				24 hours after application			
Area (ha)	Mean	SD	Range	CV (%)	Mean	SD	Range	CV (%)
0.65	0.01	0.007	0.004-0.03	51	0.55	0.018	0.53-0.59	3
0.76	0.02	0.01	0.004-0.04	69	0.24	0.032	0.19-0.31	14
1.52	0.05	0.02	0.03 -0.08	40	0.31	0.032	0.26-0.36	10
2.02	0.03	0.01	0.02 -0.05	33	0.18	0.016	0.15-0.21	9
5.71	0.04	0.08	0.002-0.03	219	9 0.23	0.018	0.20-0.26	8

[a] Data on each horizontal line are for 10 samples taken before and 24 hours after fertilizer application to a single pond.

Mean filtrable orthophosphate concentrations varied widely for different trials of each method. These discrepancies resulted from differences in average depths of ponds, degree of vertical mixing of fertilizer with pond water, and phosphorus uptake by phytoplankton. Phosphorus uptake by phytoplankton was especially important because some ponds had much denser phytoplankton blooms than others on fertilizer application dates. Boyd and Musig (1981) demonstrated that 50% or more of the phosphorus applied to waters with dense phytoplankton blooms may be absorbed by the phytoplankton within 24 hr. Nevertheless, averages for all trials by each method were remarkably consistent for filtrable orthophosphate concentrations measured 24 hr after fertilizer application: pump 0.24 mg/l, power sprayer 0.30 mg/l, hand sprayer 0.30 mg/l, and outboard motor 0.30 mg/l.

Because of its high density, liquid fertilizer poured into water will simply sink without mixing appreciably (Metzger and Boyd 1980). Mixing of liquid fertilizer may be affected either by dispersing the fertilizer over the surface in small drops so that it will mix with water instead of sinking (sprayers) or by forcefully mixing the water and the fertilizer (pump and outboard motor). If the fertilizer is initially mixed well with a small portion of the water in the pond, natural circulation of the water will disperse the fertilizer throughout the pond volume. For example, application of liquid fertilizer by sprayer over a 160-m^2 area of a 2.02-ha pond resulted in adequate dispersion of the phosphorus within 24 hr (Table 2).

The method for applying liquid fertilizer will depend upon equipment available and individual discretion. Methods other than those described above can no doubt be developed. Liquid fertilizer used in this study was neutral, but some are highly acidic. Corrosion proof pumps and sprayers must be used to apply acidic solutions. Pumps and sprayers should be flushed with plenty of water even after dispensing neutral solutions.

Broadcast applications of 9 kg/ha of P_2O_5 in granular triple superphosphate (Table 5) did not increase filtrable orthophosphate concentrations as much as equivalent applications of P_2O_5 in liquid fertilizer (Tables 1-4). The average soluble orthophosphate concentration for all broadcast trials was only 0.05 mg/l. Granules of triple superphosphate do not dissolve appreciably while settling through the water column (Boyd 1981*c*). Most of the dissolution occurs as the granules lie on the bottom mud, greatly favoring adsorption of the dissolving phosphorus by the mud. Mixing of triple superphosphate with water and applying the mixture behind an outboard motor was more effective than broadcasting (Table 6). However, this method is not practical because it is difficult to even partially dissolve the required quantity of the triple superphosphate in a small volume of water. The underwater platform method (Lawrence 1954) is a more practical way of preventing triple superphosphate from settling on the mud. Clearly, the use of liquid fertilizers in fish ponds should be encouraged because they are much more effective than granular fertilizers in delivering phosphorus to the water. Unfortunately, liquid fertilizers are not widely available, and even where they are available, they are not packaged in small quantities needed by pond owners.

Table 5. Filtrable orthophosphate concentrations in ponds before and 24 hours after application of triple superphosphate at 9 kg of P_2O_5 per hectare. Fertilizer granules were broadcast around shallow water edges of ponds.

	Filtrable orthophosphate[a] (mg/l as P)							
	Before application				24 hours after application			
Area (ha)	Mean	SD	Range	CV (%)	Mean	SD	Range	CV (%)
0.38	0.01	0.007	0.004-0.02	70	0.05	0.005	0.04 -0.06	10
0.64	0.02	0.006	0.008-0.03	30	0.09	0.03	0.06 -0.12	33
1.21	0.01	0.008	0.002-0.02	80	0.05	0.04	0.02 -0.11	67
1.52	0.02	0.004	0.02 -0.03	20	0.09	0.03	0.05 -0.14	33
1.59	0.01	0.01	0.002-0.03	100	0.01	0.005	0.004-0.02	50

[a] Data on each horizontal line are for 10 samples taken before and 24 hours after fertilizer application to a single pond.

Table 6. Filtrable orthophosphate concentrations in ponds before and 24 hours after application of triple superphosphate at 9 kg of P_2O_5 per hectare. Fertilizer granules were partially dissolved in a container of water and the mixture was discharged into the propeller wash of an electric trolling motor as boat was driven over pond surface.

	Filtrable orthophosphate[a] (mg/l as P)							
	Before application				24 hours after application			
Area (ha)	Mean	SD	Range	CV (%)	Mean	SD	Range	CV (%)
0.38	0.02	0.01	0.01 -0.04	50	0.45	0.036	0.40 -0.49	8
0.67	0.002	0.001	0.001-0.004	50	0.28	0.027	0.23 -0.31	10
0.76	0.002	0.002	0.001-0.008	100	0.17	0.025	0.14 -0.21	15
1.19	0.02	0.009	0.01 -0.04	50	0.04	0.02	0.02 -0.09	50
2.02	0.005	0.004	0.001-0.01	80	0.10	0.026	0.016-0.11	30

[a] Data on each horizontal line are for 10 samples taken before and 24 hours after fertilizer application to a single pond.

LITERATURE CITED

American Public Health Association, American Water Works Association, and Water Pollution Control Federation. 1975. Standard methods for the examination of water and wastewater, 14th ed. Am. Public Health Assoc., New York. 1193pp.

Boyd, C. E. 1973. Summer algal communities and primary productivity in fish ponds. Hydrobiologia 41:357-390.

_____. 1981*a*. Comparisons of five fertilization programs for fish ponds. Trans. Am. Fish. Soc. 110:541-545.

_____. 1981*b*. Fertilization of warmwater fish ponds. J. Soil Water Conserv. 36:142-145.

_____. 1981c. Solubility of granular inorganic fertilizers for fish ponds. Trans. Am. Fish. Soc. 110:451-455.

_____, and Y. Musig. 1981. Orthophosphate uptake by phytoplankton and sediment. Aquaculture 20:135-138.

Davidson, R. G., and C. E. Boyd. 1981. Phytoplankton response to liquid fertilizers. Prog. Fish-Cult. 43:126-129.

Lawrence, J. M. 1954. A new method of applying inorganic fertilizer to farm fishponds. Prog. Fish-Cult. 16:176-178.

Metzger, R. J., and C. E. Boyd. 1980. Liquid ammonium polyphosphate as a fish pond fertilizer. Trans. Am. Fish. Soc. 109:563-570.