Phosphorus Management for Fish Ponds Located in Red and Lateritic Soil Zones

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Fish ponds in red and lateritic soil zones exhibit low availability of phosphorus (P), resulting in restricted accumulation of various fish food organisms and, thereby, lesser fish production. This study indicated that fish yields in such ponds can be improved substantially through adoption of adequate P management practices. In view of high P-fixing capacity of such pond soils, a higher dose of P...split as smaller, more frequent applications along with adequate potassium (K), manure, and lime...was found effective.

The importance of bottom soils in influencing productivity of fish ponds is well documented. Not only does this phase help in gradual release of different nutrient elements to plant or bio-available forms for the benefit of the fish food organisms, but it also controls many of the significant bio-chemical reactions occurring in aquatic eco-systems (Mandal and Chattopadhyay, 1992; Boyd, 1995).

Yields of fish in ponds under red and lateritic soil zones are generally low due to adverse soil properties which appear to somewhat restrict the production of primary fish food organisms. A survey revealed that among different soil properties, primary productivity of fish ponds of red and lateritic soil zones is governed significantly by pH and availability of P and K (Neogy et al., 1994). Since P availability is usually very low in these soils, owing to substantial fixation as insoluble iron (Fe) and aluminum (Al) compounds, a series of studies was conducted to develop an efficient P management programme for fish ponds located in these soil zones.

Supply of adequate P nutrition to primary food organisms in fish ponds can be greatly improved with proper management.

Material and Methods

The investigation was carried out in three different phases. During the initial phase of the study, P fixing capacity of 10 fish pond soils collected from typical red and lateritic soil zones of West Bengal, India, was determined (Waugh and Fitts, 1966). During the second phase of the study, yard experiments were used to study the effects of splitting P fertilizer application, the combined use of lime and organic matter, and

also use of K along with P on use efficiency of P fertilizers with relation to production of primary fish food organisms. In the last phase of the study, an on-farm trial was carried out to assess efficiency of the developed P management technology compared to the conventional fertilization practice with regard to yield of fish in ponds of red and lateritic soil zones. Three typical fish ponds of similar nature were selected in West Bengal. One pond was treated conventionally with 100-50 kg N-P_2O_5/ha/year split in monthly doses. The second pond was treated with 100-100-30 kg N-P_2O_5-K_2O/ha/year distributed in equal monthly doses. In this pond, lime was applied at 100% of the recommended dose. In the third pond, treatments were similar to the second pond. However, P application was split in 2-week intervals along with cow dung slurry, with lime added at 50% of the recommended dose.

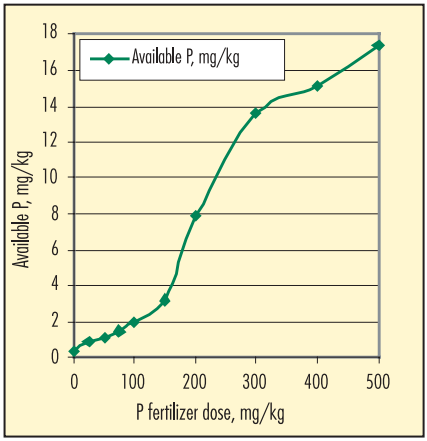

Figure 1. Phosphorus fixing capacity of fish pond soils under red and lateritic soil zones, West Bengal.

Results and Discussion

The study on P-fixing capacity of these soils showed that the conventionally recommended dose (about 50 kg P_2O_5/ha) did not have any practical impact on raising the available P status of these pond soils above the critical level of 13 parts per million (ppm). Much higher doses are required for this purpose (**Figure 1**). Since it is not practicable to increase the rate of P fertilization to very high levels in these resource poor soil zones, it would be a better proposition to increase the dose to some extent and, at the same time, improve the efficiency of any added P.

In view of high P-fixing capacity of the pond soils of red and lateritic soil zones, it was considered worthwhile to restrict the added P fertilizer from coming into contact with the bottom soil to increase P availability to primary fish food organisms in water. For this purpose, splitting the dose of P fertilizer was considered to be an effective measure. As a general norm, fertilizers are applied in fish ponds at equal monthly installments. In the present study, splitting the dose of P fertilizer to weekly or fortnightly (bi-weekly) doses helped to increase the production of organic carbon (C)...i.e. primary productivity levels of water (**Figure 2**). This increased efficiency of P fertilizers was attributed to maintaining a higher amount of P in the water phase due to smaller, more frequent applications.

Figure 2. Average gross production of organic C (mg C/m^3/hr) due to photosynthesis under different treatments. Notes: P 0, 12.5, 25 = P application rate, mg P/kg soil. M, F, and W = Monthly, Fortnightly, and Weekly applications, respectively.

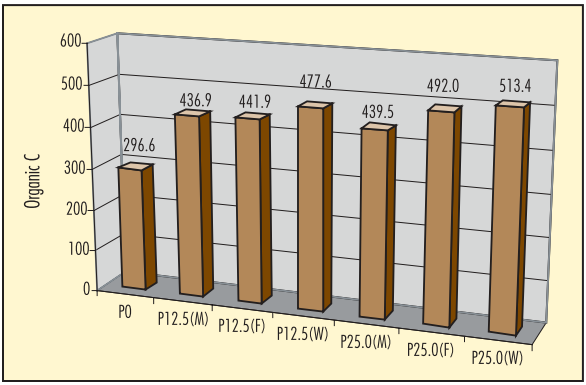

Table 1. Average effects of manure and lime application on gross primary productivity (mg C/m³/hr) of studied soil:water systems.

	P_0[1]	$P_{12.5}$	P_{25}
M_0[2]	71.1	100.9	122.5
$M_{5,000}$	114.4	136.6	149.9
$M_{5,000}$ plus ½ lime[3]	155.2	180.2	197.6

[1] P_0, $P_{12.5}$, $P_{25.0}$: Dose of P fertilizer, mg/kg
[2] M_0, $M_{5,000}$: Dose of manure, mg/kg
[3] 50% of state recommendation for lime

Table 2. Average gross primary production (mg C/m³/hr) under different treatments applied to fish pond soil-water systems.

	P_0[1]	$P_{12.5}$	P_{25}	$P_{37.5}$
K_0[1]	75.0	118.7	133.2	153.7
$K_{7.5}$	83.5	110.8	145.8	187.4
K_{15}	88.5	126.0	162.3	191.0

[1] P_0, $P_{12.5}$, $P_{25.0}$ and $P_{37.5}$, K_0, $K_{7.5}$ and K_{15} indicate doses (mg/kg) of P and K fertilizers.

Organic matter is known to increase the availability of applied P in submerged latosolic soils by restricting fixation of added P into Fe and Al phosphate forms due to reduction reactions and also chelating effects which inhibit the transformation of P into insoluble forms. Use of lime may supplement this benefit further by increasing the pH level of such pond soils which are predominantly acidic in nature. Under the present work programme, an attempt was made to study the effects of organic matter and lime application on the behavior of applied P in a simulated fish pond soil-water system with relation to the primary productivity of pond water. Since the pH levels of pond soils tend to increase moderately under submerged conditions, 50% of the recommended dose of lime was used for this study, which was calculated based on texture and pH of air dried soils. Results showed an improvement in gross primary productivity (GPP) levels of water owing to application of P fertilizer (**Table 1**). Values of GPP increased further with use of manure and lime.

In addition to P, K has also been observed to be a significant factor limiting fish pond productivity under red and lateritic soil zones (Neogy et al., 1994). Hence the effects of different combinations of P and K fertilizers on primary productivity of such pond water were assessed in the next phase of the study. Average GPP under these fertilizer treatments are presented in **Table 2**. Inclusion of K with each P fertilization dose increased GPP of fish food organisms in this soil-water system. Results indicated that with an increase in applied P the already K deficient soil likely became more limited and prevented primary producers from growing satisfactorily. Thus, while higher doses of P fertilizer tended to be beneficial for these ponds, inclusion of K in the fertilization schedule appeared to extract a higher benefit from added P.

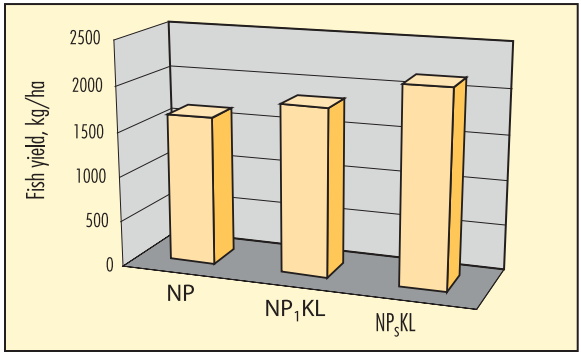

Figure 3. Fish yield levels under different P fertilization programmes, West Bengal. Notes: NP = 100-50 kg N-P_2O_5/ha/year split into monthly doses. NP_1KL = 100-100-30 kg N-P_2O_5-K_2O/ha/year split into monthly doses plus 100% of the state recommendation for lime application. $NP_SKL_{1/2}$ = 100-100-30 kg N-P_2O_5-K_2O/ha/year with P split into fortnightly doses plus 50% of state recommendation for lime application.

Fish yield values obtained under the three systems of pond fertilization are shown in **Figure 3**. Higher GPP levels of pond water resulting from the improved nutrient management schedule were responsible for better growth of fishes in the pond. Fish ponds treated with common practice (NP only) produced 1,550 kg/ha of fish. Use of the

higher, monthly split P dose with K and the state recommended dose of lime (NP_1 KL) produced 1,850 kg/ha (19.4% increment over common practice). The third option, which implemented smaller, more frequent split applications of P and K along with manure and 50% of the recommended dose of lime ($NP_sKL_{½}$), produced 2,080 kg/ha (34.2% increment over common practice).

Conclusion

Supply of adequate P nutrition to primary food organisms in fish ponds is a global problem owing to predominantly low availability of nutrients and rapid rates for fixation of applied P into insoluble forms. Knowledge generated in this study with regard to fish ponds of red and lateritic soil zones will be helpful in developing efficient P management practices for fish ponds located in other soil regions. **BCI**

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