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Phosphorus Releasing Power of Soils as Influenced by Organic and Inorganic Amendments

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Abstract: A laboratory experiment was conducted at Bangladesh Rice Research Institute in 2001 to know the phosphorus-releasing pattern of soils in repeated extraction and to find out the effects of organic and inorganic amendments on solution P releasing power of soils under submerged condition. Three composite soil samples (0-15 cm) were collected from the cultivated rice field of Sreepur, Gazipur (Aeric haplaquept) (pH 4.8), BRRI Farm, Gazipur (Vertic haplustept) (pH 6.2) and Benerpota, Satkhira (Haplaquept) (pH 7.5). The soils were different in texture, organic matter and available P content. The soil samples were incubated under submerged condition in plastic pots amending with cowdung (CD) and Poultry Manure (PM) each at the rate of 5 g kg^{-1}, Triple Super Phosphate (TSP) 12.5 mg kg^{-1} and a control with out any amendment. Taking 3 replications the pots were placed in the laboratory under room temperature (28±2°C) in Completely Randomized Design (CRD) arrangement. At the 3rd week after incubation, the release of solution P (extracted with 0.01 M $CaCl_2$) was determined with repeated extraction for 8 times. In all the soils, the concentration of solution P in poultry manure amended sample was greater than the others. The release of solution P was not much influenced by the soil amendment. The solution P in the first extraction was found highest in all treatments, which gradually decreased in subsequent extraction but from 4th to 8th extractions, the P was found identical. The total amount of solution P released in 8 extractions was found highest with poultry manure amendment yielding 0.24, 0.13 and 0.10 ppm for Satkhira, BRRI and Sreepur soil, respectively. The contribution of cowdung and TSP was almost identical in the tested soils and was lower than poultry manure treated samples. The exponential relationship between solution P and number of extraction hold good for all three soils. The co-efficient of determination (r^2) of the exponential equation for BRRI soil was 0.8571 to 0.9404 ($p<0.005$) followed by Satkhira soil 0.8487 to 0.899 and the lowest in Sreepur soil 0.767 to 0.8781.

Key words: Release pattern, solution phosphorus, rice soils, organic and inorganic amendments

INTRODUCTION

Phosphorus (P), the second most important and major nutrient elements, often limits crop production even in low land conditions when soil supplying power becomes restricted. Solution P is the immediate readily available form of P in soil and the soils tends to maintain an equilibrium concentration of solution P with the adsorbed P. Plant takes up inorganic P (Pi) from the soil solutions; P makes up only a minimum fraction of total soil P. The concentration of P in the soil solution varies from 0.1 to 1 mg L^{-1}[1]. Solution P is rapidly replenished by P from labile inorganic P (Pi) minerals and by bio-chemical mineralization of labile organic P (Po). The amount of P available to plants is determined by the pool size of labile Pi, the transformation rates between labile and slowly reacting Pi and the amount cycling rate of mineralizable Po[2]. Nair *et al.*[3] used water soluble P and Melich-1 extractable P as indicators of the potential for P to be released from manure impacted soils. A portion of the Pi sorbed by Fe and Al oxides can be reversibly released to replenish Pi in soil solution, although desorption of Pi is slower than sorption of Pi [4]. In any rice soils, solution P tends to increase to some extent following flooding and it continues for a number of days or weeks; but it sub sequentially decreases, although not necessary returning

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to the pre flooding level[5]. There are large differences between soils in these effects. Ponnamperuma[6] reported that the increase in solution P due to flooding was highest in sandy calcareous soils, moderate in acid sandy soils low in Fe, small in neutral clay soils and least in acid ferralitic clay soils. However, information regarding P- releasing power of acid, neutral and alkaline soils amended with chemical P fertilizer (TSP) and organic manures under submerged condition is not well documented in Bangladesh. The present study was therefore, undertaken (I) to know the phosphorus-releasing pattern of acid, neutral and alkaline soils under repeated extractions and (ii) to find out the effects of organic and inorganic amendments on P releasing power of soils under submerged condition.

MATERIALS AND METHODS

Three surface (0-15 cm) soil samples were collected from cultivated rice field in December 2000 after T. Aman harvest. The sampling sites were Sreepur (Gazipur), BRRI Farm (Gazipur) and Benerpota (Satkhira). Physical and chemical properties of the experimental soils were presented by Shil *et al.*[7].

Each of the three composite soil samples was ground and passed though 2 mm sieve. A portion of 2 kg of soil sample was taken in polythene bags. To the respective bags, cowdung (CD) and Poultry Manure (PM) both at the rate of 5 g kg^{-1} and TSP 12.5 mg kg^{-1} was added followed by 500 mL distilled water. Only 500 mL water was added to the control treatment. After one night the water formed a semi moist belt in the bag. The soil sample in the semi moist belt was mixed thoroughly first with the added TSP or manure and this soil mixture was blended thoroughly with the remaining soils of the bag. The soils from the bag were placed in plastic pots containing sufficient amount of O_2-free de-ionized water to make water logging. The pots were placed at the BRRI Soil Science Laboratory and were incubated under room temperature (28±2°C).

At the 3rd week after incubation 10 g soil sample was taken into 50 mL centrifuge tube and then shaken with 30 mL of 0.01M $CaCl_2$ extract end to end for 30 minutes. Then the tubes were immediately centrifuged at 15000 rpm for 10 min. The supernatant was then passed through a Whatman No. 1 filter paper. After that, 8 mL of extracting solution were taken in to 25 mL test tube. Then 1 mL of distilled water and 1 mL of colour reagent was added. Then available P (in ppm) was calculated following Murphy and Riley[8] method. To estimate the P release pattern of the treated soils, this procedure was continued for 8 times by shaking, centrifuging, filtering and analyzing of filtrates for P. The data was analyzed statistically using IRRISTAT Package.

RESULTS AND DISCUSSION

In Sreepur soil (pH 4.8), in the 1st extraction the control soil showed 0.021 ppm solution P (Table 1). However, the application of TSP, cowdung or even poultry manure did not increase solution P in this soil significantly. This concentration was decreased from 2nd extraction and further reduced at 3rd extraction and then continued more or less static up to 8th extraction. The total amount of solution P was obtained in 8 repeated extractions were 0.086, 0.085, 0.081 and 0.103 ppm for control, TSP, cowdung and poultry manure treated soil, respectively.

In BRRI soil (pH 6.2), the solution P in first extraction was the highest in all the treatments, which gradually decreased in subsequent extraction. From fourth to eighth extractions the solution P was similar. The effect of TSP, cowdung and poultry manure on repeated extraction of solution P was not significant in BRRI soil. However, in most of the extractions, poultry manure was found to yield consistently greater amount of solution P. The concentration of solution P in the first extraction, in control soil, was 0.028 ppm and in the poultry manure treated soil it was 0.035 ppm. The solution P concentration

Table 1: Solution P released during 8 extractions in Sreepur soil at 22 Days After Submergence (DAS)

	Number of extractions								
Treatments	1st	2nd	3rd	4th	5th	6th	7th	8th	Total
	Solution P (ppm)								
Control	0.021	0.015	0.008	0.008	0.011	0.008	0.005	0.007	0.086
TSP	0.025	0.017	0.007	0.007	0.009	0.008	0.006	0.006	0.085
CD	0.021	0.015	0.008	0.007	0.009	0.009	0.006	0.006	0.081
PM	0.027	0.018	0.013	0.012	0.012	0.010	0.006	0.008	0.103
LSD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	

Table 2: Solution P released during 8 extractions in BRRI soil at 22 Days After Submergence (DAS)

	Number of extractions								
Treatments	1st	2nd	3rd	4th	5th	6th	7th	8th	Total
	Solution P (ppm)								
Control	0.028	0.020	0.012	0.009	0.011	0.009	0.007	0.007	0.104
TSP	0.029	0.020	0.011	0.011	0.012	0.011	0.010	0.008	0.113
CD	0.027	0.019	0.011	0.010	0.014	0.009	0.008	0.008	0.106
PM	0.035	0.024	0.013	0.012	0.013	0.013	0.008	0.011	0.129
LSD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	

Table 3: Solution P released during 8 extractions in Satkhira soil at 22 Days After Submergence (DAS)

	Number of extractions								
Treatments	1st	2nd	3rd	4th	5th	6th	7th	8th	Total
	Solution P (ppm)								
Control	0.039	0.028	0.018	0.015	0.018	0.016	0.010	0.011	0.155
TSP	0.036	0.027	0.017	0.014	0.016	0.016	0.016	0.011	0.153
CD	0.045	0.031	0.019	0.017	0.017	0.017	0.017	0.017	0.180
PM	0.053	0.040	0.027	0.023	0.026	0.025	0.021	0.022	0.237
LSD (0.05)	0.011	0.008	0.005	0.004	0.009	0.005	0.007	0.008	

in the TSP and cowdung treated soil was 0.029 and 0.027 ppm, respectively. In the second extraction, the solution P concentration in control soil dropped to 0.020 ppm. In the TSP and cowdung-amended soil, the solution P concentration was 0.020 and 0.019 ppm, while in poultry manure treated soil, the solution P was 0.024 ppm. In the 3rd extraction, the concentration of solution P further dropped in the soil of all treatments. The control soil yielded only 0.012 ppm P and the poultry manure treated soil gave 0.013 ppm. The concentration of solution P in TSP and cowdung treated soil was the same (0.011 ppm). The level of solution P at the fourth extraction was slightly lower than that of third extraction in all the treatments of BRRI soil. The solution P concentrations in fifth, sixth, seventh and eighth extractions were almost similar to that found in fourth extraction. The total amount of solution P released by eight extractions was 0.104 ppm for the control soil, which increased to 0.113 ppm for the soil treated with TSP and that in soil treated with cowdung was 0.106 ppm. The BRRI soil treated with poultry manure gave 0.129 solution P in eight repeated extractions (Table 2).

The concentration of solution P in Satkhira soil (pH 7.5) was greater than that of Sreepur and BRRI farm soil (Table 3). In the first extraction, the control of the Satkhira soil gave 0.039 ppm P, a similar P concentration was also found in the soil treated with TSP. The solution P for Satkhira soil treated with cowdung tended to increase to 0.045 ppm, which was statistically similar to that of control and TSP treated soil. The application of poultry manure increased the solution P concentration to 0.053 ppm. Like in other two soils, solution P in Satkhira soil too decreased in second extraction. In the second extraction, the solution P concentration in control soil was 0.028 ppm and in the soil treated with TSP and cowdung showed 0.027 and 0.031 ppm, respectively. In the second extraction too, the soil treated with poultry manure gave significantly higher P concentration (0.040 ppm) than others. The solution P concentration in the third extraction decreased from that of second extraction, but the soil treated with poultry manure still gave significantly greater P concentration than others. The poultry manure treated soil maintained its superiority over other treatment in terms of solution P up to eighth extractions. The solution P concentration in the poultry manure treated Satkhira soil, in eighth extraction, was about 0.022 ppm compared to 0.011 ppm of both in control and TSP treatments and 0.017 ppm for the soil treated with cowdung. The total solution P concentration in eight extractions in Satkhira soil was the lowest (0.155 ppm) with the control treatment. The Satkhira soil treated with TSP, cowdung and poultry manure gave 0.153, 0.180 and 0.237 ppm solution P, respectively.

It was revealed that, the amount of total solution P released was found highest in Satkhira soil followed by BRRI soil and the lowest in Sreepur soil, which might be due to the differences in initial pH, organic matter content, available P and parent material of the soils. These results further implied that, P releasing power of strongly acid soil was much lower than neutral to slightly alkaline soils under submerged condition even if they are treated with organic and inorganic amendments. The mineralization of Po can raise Pi in soil solution, but the Pi can be rapidly sorbed on Fe and Al oxides[9]. Bio solid amendments were likely to increase P concentration in the soil solution of the amended soil[10]. Repeated extraction with resin strip, one soil showed to decrease the strip P concentration in nine extractions, while other showed the same value in only four extractions, which suggests that under similar agronomic condition the release of soil P will be differed

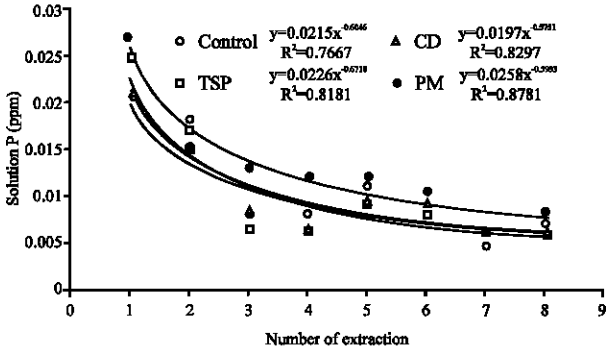

Fig. 1 : Effect of TSP, cow dung and poultry manure on the release of solution P in eight repeated extraction by 0.01 M $CaCl_2$ solution from Sreepur soil

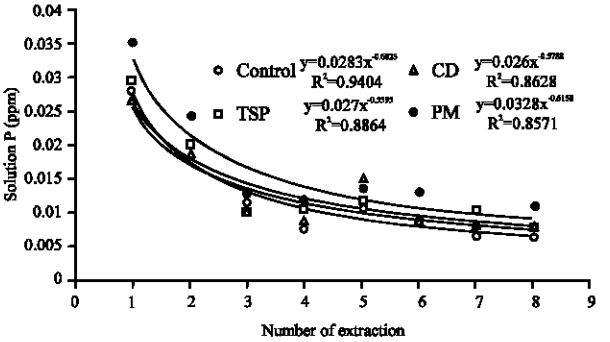

Fig. 2 : Effect of TSP, cow dung and poultry manure on the release of solution P in eight repeated extraction by 0.01 M $CaCl_2$ solution from BRRI soil

due to soil types[11]. Solution P tends to increase due to flooding and it continues for a number of days or weeks and then it subsequently decreases[5]. Increase in solution P due to flooding was highest in sandy calcareous soils moderate in acid sandy soils low in Fe, small in neutral clay soils and least in acid ferralitic clay soils[6].

The release of solution P with successive extractions is described by an exponential-type relationship (Fig. 1-3), as represented by:

$$C_L = aN^{-b} \quad (1)$$

Where:

C_L = Solution P
a and b = Constants
N = Number of extraction

Constant 'a' of this relationship represents solution P obtained with single extraction. Constant 'b' of this relationship describing successive solution P release represents the rate of P release per extraction of soil. A decrease in constant 'b' indicates a decrease in the rate of

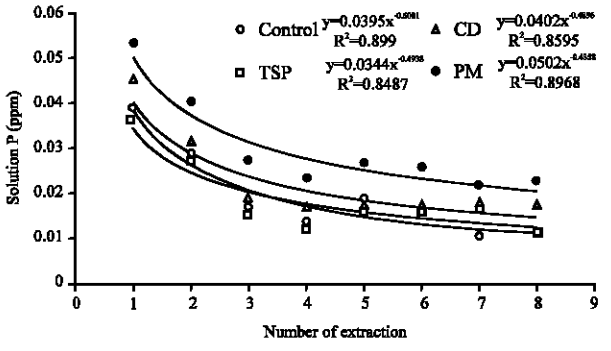

Fig. 3 : Effect of TSP, cow dung and poultry manure on the release of solution P in eight repeated extraction by 0.01 M $CaCl_2$ solution from Satkhira soil

P release with successive extraction of soil. Rana[12] also used quadratic equation for describing the relationship between added P and solution P.

The coefficient of determination (r^2) of the exponential equation for Sreepur soil was 0.7667 to 0.8781 (Fig. 1). The intercept 'a' for the control soil was found 0.0215, which was increased due to TSP and poultry manure amendment figuring as 0.0226 and 0.0258, respectively but reduced to 0.0197 for cowdung. The constant b for the control soil was –0.6046, which was reduced to -0.6718 for TSP amended soil. However, the highest 'b' value -0.5751 was derived from cowdung treated soil followed by poultry manure (-0.5933).

The coefficient of determination (r^2) of the exponential equation for BRRI soil was 0.8571 to 0.9404 ($p<0.005$). The 'a' constant of the control soil was 0.0283, which was increased to 0.0328 for poultry manure treated soil. The soil treated with TSP and cowdung provided 'a' value as 0.027 and 0.026, respectively. For the control of BRRI soil, b was -0.6823, which increased to-0.6158 for poultry manure (Fig. 2). The application of cowdung further increased the b value to -0.5788 and the highest b -0.5595 was obtained with the TSP treated soil.

The exponential relationship between solution P and number of extraction (Eq. 1) also hold good for Satkhira soil (Fig. 3). The constant 'a' of the control soil was 0.0395, which was slightly higher than the soil treated with TSP. The soil treated with cowdung and poultry manure showed a value as 0.0402 and 0.0502, respectively. For Satkhira soil, b ranged from -0.608 to -0.4358. The lowest b was found with the control soil and the highest with soil treated with poultry manure. The TSP and cowdung treated soil showed b as -0.4938 and -0.4896, respectively.

It can be concluded that, the P releasing power of acid soil was much lower than neutral to slightly alkaline soils and the amount of P supplied through organic

amendment did not increase solution P significantly, therefore, environmental hazard of P through eutrophication in our soils can be minimized.

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