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EFFECT OF INCUBATION ON SODIUM-BICARBONATE SOLUBLE PHOSPHORUS IN SOILS UNDER DIFFERENT MOISTURE AND PHOSPHORUS FERTILITY CONDITIONS

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The effect of incubation on $NaHCO_3$-soluble phosphate in two major soils of Bangladesh treated with water-soluble phosphate and incubated under different miosture saturations have been studied in a pot experiment. Available P recorded sharp rise due to the application of TSP both in RBT (Madhupur) and NCDGF (Digarkanda) soils after 1 day incubation. Then it showed a continuous and great decrease with the increase in incubation time up to 440 days, the rate of decrease being more noticeable in pots treated with TSP. Higher moisture saturation caused in most of the pots greater recovery of the native and added P into $NaHCO_3$-extractable P in both the soils. The changes in pH of the soils during incubation were less and appeared not to influence markedly on the dynamics of $NaHCO_3$-soluble P.

INTRODUCTION

Phosphorus being an integral part of many intricate metabolic processes, plays a vital role in crop production. But the availability of this element in soil is very critical owing to its rapid fixation into complex forms. Annual crops planted after the application of water-soluble phosphate fertilizer often recover only up to 20% of the phosphorus applied [1]. There are reports that the solubility of soil phosphorus is a function of time and soil moisture plays an important role in the avialability of both native and applied phosphorus [2,3]. Rice soils are often subjected to different moisture levels and such changes in moisture regime in rice field may influence the transformation of native as well as applied phosphorus affecting the P nutrition of the crop.

A large area of Bangladesh remains under water during monsoon season for several months of the year and there are scattered reports available in the country that many crops do not respond to phosphate application. It will be useful to know about the changes in availability of both native and fertilizer P under different moisture levels and with the passage of time.

The present piece of work was undertaken to study the changes in avialable P in two major soils of Bangladesh incubated under different moisture saturations and in the presence and absence of P fertilizer.

MATERIALS AND METHODS

The study was made by conducting a laboratory incubation experiment with two major soil types of Bangladesh, one red brown terrace (RBT) soil collected from Madhupur forest area and the other a noncalcareous dark grey floodplain (NCDGF) soil collected from Digarkanda, a village adjacent to the Bangladesh Agricultural University farm. The soil samples were collected at a depth of 0–15 cm. The samples were dried, ground and sieved to pass through a 2 mm sieve. Air dry soil sample equivalent to 500 g of oven dry soil was weighed into each pot. There were 8 treatment combinations each of which was represented by a pot. Soil sample collected from each soil type were treated with 0 and 150 ppm of P supplied as triple superphosphate (TSP) and were incubated under 65 and 100% moisture saturations under laboratory temperature. The moisture levels in the pots were maintained by weighing and watering the pots every alternate day. Each treatment was replicated 3 times. Thus, there were 120 pots for sampling after 1, 30, 60, 120 and 440 days of incubation using each time 24 pots representing one set of treatments. Sampling was done at each time interval with the help of a hollow glass tube so that a uniform soil material was obtained from each pot.

Available P in the soil samples was determined following Olsen's method in which the extraction was made with

0.5 M solution of $NaHCO_3$ (pH 8.5) and the colour was developed following the ascorbic acid method as proposed by John [4] .Soil pH was measured with the help of a pH meter in a 1:2.5 ratio of soil: water suspension [5]. The original soil samples were analyzed for pH, textural class, organic carbon, cation exchange capacity and $NaHCO_3$-soluble P. Mechanical analysis was carried out by pipette sampling method [6]. Cation exchange capacity was determined from the sodium acetate extract of the soils using flame photometer [7]. Organic carbon was determined volumetrically by wet oxidation method of Walkley and Black as described by Piper [6]. Phosphorus fixation capacity of soils was measured by shaking 2 g of soil sample (2 mm) in a centrifuge tube with 40 ml of standard P solution (20 ppm) for 2 hr and then measuring the change in P concentration in the solution as suggested by Hesse [8].

RESULTS AND DISCUSSION

Table 1 shows the characteristics of original soils. Results of studies on the changes of $NaHCO_3$-soluble phosphate in soils as affected by incubation under different P treatments and moisture saturations are reported in Table 2. Results show that the $NaHCO_3$-soluble P recorded sharp rise due to the application of TSP both in RBT (Madhupur) and NCDGF (Digarkanda) soils measured after 1 day incubation. The data in Table 2 also indicate that 100% moisture saturation caused greater recovery of the added P fertilizer into $NaHCO_3$-extractable P in both the soils. This was possibly due to the reduced fixation of added P under 100 % moisture saturation compared to its fixation under 65% moisture saturation. Incubation of the unfertilized pots under 100% moisture saturation also caused an increase in the $NaHCO_3$-soluble P compared to the results under 65% moisture saturation, the effect being more pronounced in RBT soil. Such an effect of 100% moisture saturation on the availability of native P was presumably due to the transformation of insoluble ferric phosphate to soluble ferrous phosphate or increased solubility of iron–, aluminium– and calcium phosphates as reported by Bromfield [9]. Basu and Mukherjee [10] also observed that waterlogging increased the avialability of P due to the transformation of iron–phosphate in soil. An increase in the availibility of native and added phosphate in flooded soils as compared to well–drained soils has been reported by several workers [11, 12]. In the present study there was no appreciable change in soil pH due to P treatment or moisture saturation after 1 day incubation.

After 30 days of incubation the $NaHCO_3$-soluble P in all the pots decreased considerably and the decrease was greater in pots treated with TSP and in pots incubated under 100% moisture saturation. The results indicate that there might have been higher transformation of applied P into insoluble forms. Mandal and Khan [13] reported that

Table 1. Characteristics of original soils.

Soil characteristics	RBT soil	NCDGF soil
Mechanical compositon:		
% Coarse sand (2.0 – 0.2 mm dia)	7.8	0.5
% Fine sand (0.2 – 0.02 mm dia)	39.6	16.2
% Silt (0.02 – 0.002 mm dia)	20.3	53.1
% Clay (below 0.002mm dia)	28.0	17.7
Textural class name	Sandy clay loam*	Silt loam*
pH	4.8	6.3
Cation exchange capacity (*me*/ 100 g soil)	9.2	12.0
Organic C (%)	0.52	0.48
Total P (ppm)	900	1100
$NaHCO_3$-soluble P (ppm)	6.0	22.0
P fixation capacity (% of added P)	53.5	27.3

*International system

the moist condition could maintain a higher amount of added P in the water soluble form than the submerged condition which may be due to the higher transformation of applied phosphate into other forms. Simpson and Williams [14] also noted that incubation for short periods at a higher moisture content reduced the subsequent plant uptake of phosphorus from recently applied monocalcium phosphate in several soils due to the change in the available P content of the soils on waterlogging and the relative composition of the inorganic forms of phosphorus in soils. Hoque and Sotakova [15] working with an acid (pH 4.8 KCl) brown clay loam soil observed that the available P (Egner's P) continuously decreased with the time of incubation and the decrease was more pronounced in soil samples treated with TSP. The pH values under the present study showed little decrease in pots incubated at 65% moisture saturation whereas, there was a slight increase in soil pH in pots under 100% moisture saturation.

Results of studies after 60 days of incubation show that the $NaHCO_3$-soluble P further decreased in all the pots and the decrease was much greater in TSP treated pots (Table 2). Of the pots receiving no TSP the $NaHCO_3$-soluble P suffered more decrease in NCDGF soil. It was further noted that the rate of decrease in available P was less pronounced in pots with higher moisture saturation. This was possibly due to the effect of continuous incubation of the samples under higher moisture saturation. Mandal [16]

Table 2. Effects of various treatments on pH and $NaHCO_3$-soluble P of soils at different incubation times.

Soil	Rate of P added (ppm)	Moisture saturation (%)	pH at different incubation times (days) 1	30	60	120	440	$NaHCO_3$-soluble P(ppm) at different incubation times (days) 1	30	60	120	440
RBT soil	P_0	65	5.6	5.2	5.0	4.6	4.8	6.7 ± 0.91	6.3 ± 0.42	5.7 ± 0.15	5.2 ± 0.42	5.0 ± 0.11
		100	5.8	6.1	6.2	6.0	5.8	8.6 ± 0.84	6.9 ± 0.82	6.7 ± 0.63	5.4 ± 0.61	5.1 ± 0.63
	P_{150}	65	5.6	5.0	5.1	5.0	5.3	26.0 ± 1.21	21.3 ± 1.22	11.5 ± 0.21	6.7 ± 0.17	5.2 ± 1.12
		100	5.7	6.2	6.3	5.9	6.0	28.8 ± 0.99	19.7 ± 2.46	11.8 ± 0.54	6.4 ± 0.62	5.1 ± 0.91
NCDGF soil	P_0	65	6.7	6.1	6.0	6.1	5.9	25.1 ± 0.85	22.3 ± 0.97	17.5 ± 0.81	16.6 ± 0.12	15.4 ± 1.07
		100	6.8	7.0	6.9	6.9	6.6	25.7 ± 1.24	21.6 ± 1.71	17.9 ± 0.19	16.8 ± 0.11	14.6 ± 0.05
	P_{150}	65	6.7	6.0	6.2	5.9	6.0	41.7 ± 2.51	35.7 ± 2.51	24.0 ± 2.74	16.9 ± 0.94	16.0 ± 0.67
		100	6.8	6.9	7.0	6.9	6.8	43.5 ± 3.60	36.0 ± 3.01	25.9 ± 2.01	19.4 ± 1.43	16.6 ± 0.01

reported that the available phosphorus in soil increased to a certain extent on waterlogging and the continuous submergence could bring about a significant increase in the extractable P content of those soils which were acidic in reaction and contained higher percentage of the total inorganically bound-P in the form of iron phosphate. There was no remarkable change in soil pH.

After 120 days of incubation the $NaHCO_3$-soluble P showed marked decrease in both the soils and the decrease was more pronounced in pots treated with TSP (Table 2). The pH values in most of the pots also suffered a little decrease.

The $NaHCO_3$-soluble P continued to decrease even after 440 days of incubation, but the amount of decrease was very less during incubation from 120 to 440 days (Table 2). In most cases such a decrease in $NaHCO_3$-soluble P was slightly higher in pots under 100% moisture saturation and in pots receiving the TSP treatment. Small changes in pH values were also observed after 440 days of incubation.

The data on $NaHCO_3$-soluble P therefore, indicates that with the increase in incubation time it decreases continuously, and the decrease in available P during incubation was so great that after 440 days of incubation the amount of this P both in fertilized and unfertilized pots was reduced to even lower than the values found in the original soil samples (Tables 1 and 2). The reduction in available P was the highest during 30 – 60 days of incubation. This is probably related to the transformation of more soluble soil phosphates into less soluble Fe and Al phosphates as reported by many workers [15, 17, 18, 19].

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