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Forms and distribution of phosphorus in some acid soils of Manipur and Assam

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Abstract

Different forms of phosphorus and their distribution were studied in the five selected acid soils of Manipur and Assam. Manipur soils had a relatively high content of total P although total P content of the soils in general, was low. Iron bound phosphorus was the most abundant and calcium bound phosphorus the least. Organic-P accounted for a relatively high content of the total P in the surface soils. Residual-P showed an increase down the profile.

Additional keywords : Total phosphorus, inorganic phosphorus, organic phosphorus

Introduction

Phosphorus deficiencies are very common in acid soils of India in general, and north eastern region (NER) in particular. The acid soils of NER are poor in base status and have sub-surface aluminium toxicity (Sen *et al.* 1997a) that induces fixation of phosphorus. According to Coleman *et al.* (1960), one cmol(p+) kg^{-1} of soil exchangeable aluminium can fix about 70 ppm of phosphorus. The information on phosphorus status and its horizon-wise distribution in soils of NER is scanty. The present investigation was, therefore, undertaken to study the various forms of phosphorus and its distribution in the representative profiles of major acid soils of the states of Manipur and Assam.

Materials and methods

Five representative pedons, two from Manipur and three from Assam, were selected (Table 1). The soils belong to Typic Hapludalf (Pedon 1), Typic Kanhapludult (Pedon-2), Typic Kanhaplohumult (Pedon 3), Typic Hapludult (Pedon 4) and Typic Dystrochrept (Pedon 5) at subgroup level and occupy an area of 512, 15, 441, 6.4 and 19.7 hectares, respectively (Sen *et al.* 1997 b, 1999).

Horizon-wise soil samples were collected, dried, sieved and analysed for pH, particle size distribution, organic carbon and cation exchange capacity (CEC) using standard methods. Total phosphorus (T-P) was estimated by sodium carbonate digestion followed by extraction with 6 *N* HCl, (Jackson 1958), and organic phosphorus (Org-P) was estimated by the method of Mehta *et al.* (1954). The fractions of soil phosphorus were determined using the modified methods of Chang and Jackson (1957).

Table 1. Some soil properties and forms of phosphorus in soils

Hori-zon	Depth (m)	pH	Organic carbon (%)	Cation exchange capacity [(cmol(p+)kg^{-1}]	Clay (%)	Total P (mg/kg)	Forms of P (%)				
							Al-P	Fe-P	Ca-P	Org. P	Res. P
Pedon 1 : Typic Hapludalfs (Sikargaon, Assam)											
A	0.00-0.15	6.5	0.72	5.3	21.5	239	17.6	32.4	8.6	31.1	10.3
Bt_1	0.15-0.50	6.0	0.39	5.9	31.5	137	20.3	32.8	8.5	20.3	16.1
Bt_2	0.50-0.69	5.5	0.45	7.7	37.0	168	23.4	29.2	8.6	17.4	21.4
Bt_3	0.69-1.15	5.1	0.33	7.3	29.5	168	24.5	27.5	7.1	11.0	29.9
Pedon 2 : Typic Kanhapludults (Jirighat, Assam)											
A	0.00-0.20	4.6	1.30	6.8	7.2	191	14.8	24.7	5.7	27.7	27.1
Bt_1	0.20-0.50	4.7	0.60	6.6	14.8	175	16.7	25.0	6.6	22.8	28.9
Bt_2	0.50 0.95	4.9	0.50	8.1	22.8	120	21.1	28.7	6.8	17.0	26.4
BC	0.95-1.36	4.9	0.40	8.1	18.2	123	21.9	28.8	7.7	10.2	31.4
Pedon 3 : Typic Kanhaplohumults (Jorabat, Assam)											
A	0.00-0.14	5.0	2.20	10.9	48.5	294	12.5	37.7	6.4	29.9	13.5
Bt_1	0.14-0.33	5.0	1.60	10.5	50.5	270	18.6	37.0	5.5	23.3	15.6
Bt_2	0.33-0.55	5.1	1.00	8.5	62.0	199	21.2	34.4	5.1	17.8	21.5
Bt_3	0.55-1.20	5.2	0.70	7.7	65.5	181	21.0	28.1	4.2	14.2	32.5
Pedon 4 : Typic Hapludults (Pallel, Manipur)											
A	0.00-0.19	5.3	2.28	10.8	32.8	457	17.6	29.5	6.1	36.2	10.6
Bt_1	0.19-0.42	5.1	0.73	10.1	63.4	283	19.2	26.4	5.1	21.9	27.4
Bt_2	0.42-0.71	5.2	0.51	10.9	60.4	240	20.0	21.5	4.3	19.2	35.0
Bt_3	0.71-0.95	5.2	0.37	11.0	57.6	291	21.6	17.3	3.8	18.6	38.7
Pedon 5 : Typic Dystrochrepts (Suangpeh, Manipur)											
A	0.00-0.17	4.9	2.50	13.8	32.2	429	17.1	30.6	4.8	38.3	9.2
Bw_1	0.17-0.35	4.9	0.80	11.0	42.3	320	17.8	27.7	4.4	18.8	31.3
Bw_2	0.35-0.50	4.8	0.40	13.0	55.8	288	21.2	26.3	3.7	17.3	31.5
Bw_3	0.50-0.70	5.0	0.40	11.2	47.6	291	23.3	29.9	3.5	12.0	41.3

Results and discussion

The soils were acidic with pH ranging from 4.7 to 6.5 in the surface and 4.6 to 6.0 in the sub-soils. These acidic soils are developed from sedimentary and metamorphic rocks of varying ages and contain high exchangeable aluminium with poor base saturation (Sen *et al.* 1996, 1997a). The soils contain appreciable amounts of organic carbon that ranges from 0.72 to 2.50 per cent in the surface and gradually decreased down the depth. In most of the profiles, clay enrichment in subsoils was observed indicating the presence of an argillic horizon. The soils were low in T-P content, ranging from 190.7 to 456.7 mg kg^{-1} for the surface and 120.9 to 320.3 mg kg^{-1} for the subsoils. Prasad *et al.* (1986) however, reported higher T-P content in similar soils of Meghalaya. It was relatively higher in Manipur soils than those of Assam which may be because of geology of the soils. The aluminium-bound phosphorus (Al-P) ranges from 12.5 to 17.6 per cent in the surface and 16.7 to 24.5 per cent in the subsoils. The Al-P content showed a regular increase down the profile indicating cumulative accumulation of aluminium in the subsoils through precipitation of aluminium with phosphorous. Sen *et al.* (1997a) also observed downward increase of exchangeable aluminium in the acid soils of NER.

Table 2. Correlation coefficient between forms of P and soil properties

pH	O.C.	CEC	Clay	TP	Al-P	Fe-P	Ca-P	Org-P	Res-P
pH									
O.C.	–0.18								
CEC	–0.45	0.42							
Clay	–0.03	–0.05	0.51*						
TP	–0.09	0.69*	0.76*	0.27					
Al-P	0.16	–0.71*	–0.11	0.23	–0.39				
Fe-P	0.19	0.46	–0.08	–0.03	0.03	–0.24			
Ca-P	0.56*	–0.10	–0.72*	–0.61*	–0.49	0.03	0.37		
Org-P	0.12	0.83*	0.19	–0.33	0.60*	–0.76*	0.26	0.16	
Res-P	–0.39	–0.71*	0.08	0.26	–0.31	0.49	–0.68*	–0.52*	–0.77*

*Significant

The Fe-P was found to be the major constituent of the inorganic phosphorus and ranged from 24.7 to 37.7 per cent of the T-P in the surface soil and 17.3 to 37 per cent in the subsoils. Unlike Al-P, Fe-P did not show any definite trend of distribution with depth. In general, it decreased slightly (Pedons 3, 4 and 5). The Ca-P contributing least to the T-P ranged from 5.7 to 8.6 per cent in the surface and 3.5 to 8.5 per cent in the subsoils but decreased with depth except for pedon 3. Since the soils are highly weathered, the proportion of calcium phosphate under acidic environment is expected to decrease resulting in an increase in iron and aluminium phosphate. The organic phosphorous (org-P) accounted for 27.7 to 38.3 per cent of the total soil phosphorous in the surface soils and 10.2 to 23.3 per cent in the subsoils. The surface horizons had exceptionally high content of org-P due to the presence of more organic matter in surface soils. Residual phosphorus (Res-P) content also contributed substantially which ranged from 9.2 to 27.1 per cent in the surface soils and 15.6 to 41.3 per cent of T-P in subsoils. The Res-P content increased with depth, indicating its greater fixation in the subsoils.

The relative abundance of the different forms of phsophorus followed a trend as Fe-P>Al-P>Res-P>Ca-P. The T-P had a significant positive relationship (Table 2) with organic carbon (r=0. 69) and CEC (r=0.76) whereas, Al-P had a significant negative correlation with org. C (r= – 0.71). Calcium-P showed significant positive correlation with pH (r=0.56) and negative correlation with CEC (r= – 0.72) and clay (r = – 0.61). Organic bound P exhibited a significant positive correlation with organic carbon (r = 0.83) and total P (r = 0.60) and a significant negative correlation with Al-P (r = – 0.76). Residual P showed negative and significant correlation with organic carbon (r = 0.71), Fe-P (r = – 0.68), Ca-P (r = – 0.52) and organic P (r = – 0.77). Poor correlation between clay content and T-P, presumably indicated poor inherent P-status of the clay size particles. Further, the decrease in total P content down the profile indicated that the soils are inherently poor in P. Presence of sesquioxides generally renders the soils more susceptible to P-fixation under acidic environment. Therefore, the maintenance of organic phosphorus content of the soils accounting for 29.9 to 38.3 per cent of the total phosphorus in surface horizons is of great practical importance in crop management.

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