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EFFECT OF SOIL PROPERTIES ON THE EXTRACTION OF PHOSPHORUS FROM SOME REPRESENTATIVE BANGLADESH SOILS

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Abstract

The present investigation was undertaken to identify some soil properties regulating P extractability by seven extractants in eleven selected soils of Bangladesh. The ability of the exctractants to extract soil P followed the order: 0.5M $NaHCO_3$ (pH 8.5) > 0.25N $NaHCO_3$-0.01M EDTA-0.01M NH_4F > 0.03N NH_4F + 0.1N HCl > 0.03N NH_4F + 0.025N HCl > 0.002N H_2SO_4 > 100g NaOAc in 30 ml CH_3COOH/liter > 1M NaCl (at pH 3.0). The best correlation was found between P_{HS} and P_{NaCl} (r = 0.917, P = 0.001). For acid soils (pH < 7.0) the amounts of phosphorus removed by different extractants were positively correlated with their organic carbon content . The soils were classified on the basis of the soil properties studied.

Introduction

Phosphorus occurs in soils in inorganic and organic forms, the relative proportion of which varies with the organic matter content of the soil, but usually the organic forms predominate. This element tends to accumulate in the finer fractions of soil and thus increases as the clay content increases. Phosphorus availability is very critical and phosphorus itself is a double critical element. Both at low (<6.0) and at high pH (>7.5) it becomes unavailable due to the formation of Fe/Al phosphate and Ca phosphate respectively (1).

Many chemical techniques for measuring the available soil phosphorus have been suggested during the past century. The solubility of soil phosphate in water or in dilute solutions of a neutral salt (such as $CaCl_2$) is affected by many factors, some of the most important ones are types of soil and the kinds and the amount of organic matter present (2). Soil test extractants can be placed into various categories according to their chemical nature (3). Several methods involving the use of dilute mineral acid, neutral salt solutions and alkaline solutions have been proposed for assessing P availability status. Often, a method found useful for one area has proved less satisfactory for other areas,

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suggesting that the difficulty in assessing P availability in soils is a consequence of diverse physical and chemical characteristics of the soil.

In Bangladesh, pH varies widely in different soils. As a result, phosphorus availability is quite restricted (4). The present investigation was initiated to evaluate seven commonly used P extractants in order to identify some factors regulating P extractability of eleven extensively occurring representative soil series of Bangladesh and to classify the soils on the basis of those properties.

Materials and Methods

The soil samples were collected at depths of 0-15 cm from the surface and were dried, ground and passed through a 2 mm sieve for mechanical analysis and through a 0.6 mm sieve for various chemical analyses. Some of the physical and chemical properties of the soils are given in Table 1.

Table 1. Some properties of the soil samples under study.

Soil Series	pH	Texture	CEC meq %	O.C. (%)	Total N %	C:N ratio	O.M. (%)	Avail N ppm	avail K meq %
Noadda	5.4	SiCl	7.3	0.31	0.08	3.9	0.53	42.7	0.13
Ranisankail	5.3	SL	4.6	0.51	0.04	12.7	0.87	30 0	0.27
Ghatail	6.5	C	21.8	1.11	0.13	8.5	1.91	44.2	0.15
Mirsarai	4.9	SiC	21.8	1.34	0.13	10.3	2.31	50.1	0.19
Pirgacha	4.9	SL	7.9	1.07	0.09	11.9	1.85	45.7	0.20
Chandina	4.7	SiCL	10.6	1.68	0.11	15.3	1.68	63.4	0.50
Sonatala	5.3	SiL	7.3	0.94	0.09	10.9	1.62	50.1	0.16
Khadimnagar	5.2	SCL	13.2	1.08	0.12	9.0	1.87	72.2	0.19
Kalma	5.1	SiC	18.5	1.84	0.19	9.7	2.17	48.6	0.38
Chandra	5.3	CL	7.3	1.08	0.09	12.0	1.87	35.4	0.22
Tejgaon	6.0	L	5.9	0.77	0.07	11.8	1.33	28.0	0.15

Particle size distribution was measured by hydrometer method as described by Day (5) and the textural classes were determined following the USDA system (6). Soil pH was measured electrochemically using a glass electrode at a soil:

water ratio of 1:2.5. Organic carbon was determined by wet oxidation method (7). Total nitrogen was determined by alkali distillation of the Kjeldahl digest as described by Jackson (8). CEC was determined by using neutral 1N NH_4OAc method (9). Available soil K was measured by flame photometer at 769 nm. The methods of Bray and Kurtz no. 1 (Bray P_1) (10), Bray and Kurtz no. 2 (Bray P_2) (10), Troug (P_{HS}) (11), Morgan (P_{MG}) (12), Olsen *et al.* (P_{NHC}) (13), Hunter (P_{AS}) (14) and Anam *et al.* (P_{NaC1}) (15) were used to extract available P of the soils. Available P in the extracts were determined using either $SnCl_2$ or Ascorbic acid as the reductant (8,16).

Results and Discussion

Soil test methods. The amounts of available phosphorus extracted by different methods used in the present study are presented in Table 2. It is apparent from this Table 2 that the amounts of P extracted from a particular

Table 2. Extractable soil P (ppm) by different methods.

Soil Series	Bray no.1	Bray no.2	P_{HS}	P_{MG}	0.5M $NaHCO_3$	P_{AS}	1M NaCl
Noadda	2.39	2.66	0.35	0.78	30.59	5.18	0.09
Ranisankail	33.12	32.59	5.07	0.70	58.96	44.93	0.69
Ghatail	0.73	1.33	0.18	1.04	50.54	3.54	0.17
Mirsarai	5.45	8.65	0.35	0.62	38.57	12.07	0.17
Pirgacha	68.50	62.84	4.37	0.57	59.85	58.75	0.52
Chandina	44.28	28.66	6.99	1.73	128.12	342.14	0.52
Sonatala	5.85	11.97	1.05	0.41	53.20	8.64	0.09
Khadimnagar	2.46	2.00	0.35	0.36	38.57	5.18	0.09
Kalma	58.19	25.27	3.15	1.94	96.20	438.91	0.52
Chandra	3.92	4.66	0.35	0.29	42.56	6.91	0.09
Tejgaon	27.46	31.26	8.74	1.24	63.84	29.38	1.38
Mean	22.94	19.26	2.81	0.88	60.09	86.97	0.39

soil by different extractants as well as by a particular extractant from different soils differed appreciably, depending on the soils and the extractants used. The amounts of P ranged from 0.73 to 68.50, 1.33 to 62.84, 0.29 to 1.94, 30.59 to 128.12, 3.45 to 438.91 and 0.09 to 1.38 ppm with Bray P_1, Bray P_2, P_{HS}, P_{MG}, P_{NHC}, P_{AS} and P_{NaCl} respectively. Barring few exception, the extractants' ability to extract P followed in general the order $P_{NHC} > P_{AS} >$ Bray $P_2 >$ Bray $P_1 > P_{HS} > P_{MG} > P_{NaCl}$.

The best correlation was found between P_{HS} and P_{NaCl} (r = 0.917) followed by the correlation between Bray P_1 and Bray P_2 (r = 0.902), P_{NHC} and P_{AS} (r = .879) and Bray P_2 and P_{HS} (r - 0.711) (Table 3). The better correlation values indicate that although the ability for P extraction was different for the different extractants, their trends of P displacement from soil to solution were approximately similar for the pair of extractants. The relationship between the amounts of P extracted by any pair of extractants is not necessarily linear.

Table 3. Correlation coefficients (r) among the seven P extraction methods.

Extractable P	'r' value	Extractable P	'r' value
Bray P_1 to Bray P_2	0.902 a	P_{HS} to P_{MG}	0.541 (ns)
Bray P_1 to P_{HS}	0.655 b	P_{HS} to P_{NHC}	0.653 b
Bray P_1 to P_{MG}	0.540 (ns)	P_{HS} to P_{AS}	0.393 (ns)
Bray P_1 to P_{NHC}	0.675 b	P_{HS} to P_{NaCl}	0.917 a
Bray P_1 to P_{AS}	0.664 b	P_{MG} to P_{NHC}	0.820 a
Bray P_1 to P_{NaCl}	0.532 (ns)	P_{MG} to P_{AS}	0.861 a
Bray P_2 to P_{HS}	0.711 a	P_{MG} to P_{NaCl}	0.473 (ns)
Bray P_2 to P_{MG}	0.241 (ns)	P_{NHC} to P_{AS}	0.879 a
Bray P_2 to P_{NHC}	0.448 (ns)	P_{NHC} to P_{NaCl}	0.408 (ns)
Bray P_2 to P_{AS}	0.311 (ns)	P_{AS} to P_{NaCl}	0.226 (ns)
Bray P_2 to P_{NaCl}	0.616 c		

a = P < 0.001, b = P < 0.02, c = P < 0.05

Soil properties and fertility status. Soil series are classified based on pH, organic matter and CEC (4). Accordingly, Nodda, Ranisankail, Mirsarai, Pirgacha, Chandina, Sonatala, Khadimnagar, Kalma and Chandra belonged to strongly acidic while Ghatail and Tejgaon to moderately acidic soils. Likewise, based on organic matter content, Chandina and Sonatala were in the low to medium, Noadda and Ranisankail in the very low and the remainder of the soils in the medium range of organic matter. Huq (17) commented that most agricultural soils of Bangladesh have low organic matter content. Based on CEC, Pirgacha, Chandina, and Khadimnagar fell in the medium range. Ghatail, Mirsarai and Kalma in the high range and the rest of the soil series fell in the low range. The available P of all the soil series used in the present investigation were low for Truog extractant (P_{HS}) according to (4). The highest value for total N was 0.19% for Kalma series soil and the lowest value was 0.04% for Ranisankail series soil (Table 1). The total N in most Bangladesh soils ranges from 0.01 to 0.18% (18). The present findings are consistent with the reported values.

Effect of soil properties on the extractable P. Correlation between extractable P and two selected soil properties were examined with a view to identify the soil factors involved in the regulation of P extraction (Table 4).

Table 4. Correlation coefficients of extractable P with soil properties.

Extractable P	pH	Organic C
Bray P_1	-0.425 (ns)	0.400 (ns)
Bray P_2	-0.337 (ns)	0.104 (ns)
P_{HS}	-0.077 (ns)	0.075 (ns)
P_{MG}	-0.002 (ns)	0.558 (p = 0.05)
P_{NHC}	-0.332 (ns)	0.662 (p = 0.05)
P_{AS}	-0.410 (ns)	0.746 (p = 0.001)
P_{NaCl}	-0.176 (ns)	-0.052 (ns)

[Total soil (n) = 11; pH (H_2O) = 4.7 to 6.5; ns = not significants]

Except P_{AS}, P_{NHC} and P_{MG} all extractable P values for all soils did not correlate with any of the selected soil properties. The amount of P extracted by different extractants showed no significant correlation with pH suggesting that pH effect is not attributable to the reversible adsorption of P by clays with increasing pH up to around neutrality. The other extractable P_S except P_{AS}, P_{MG} and P_{NHC} were not significantly correlated with organic carbon. The pH of the representative soils were generally low. The significant positive correlation between P_{AS} and organic carbon suggests that organic matter complexation with phosphorus did not exist at the low soil pH. As a result, P_{AS} extractant easily extracted the organic matter associated phosphorus. Khan *et al.* (19) suggested that the variation of inorganic phosphate was significantly related to organic carbon contents and negatively but non-significantly with pH of some sub-humid tropical soils of Bangladesh. Variation in inorganic phosphates in the soil with the soil properties have also been shown by other workers (20,21).

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