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Use of A Multi-ionic Extractant to Determine Available P, K, Na, Ca, and Mg in Acid Soils of Sri Lanka

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ABSTRACT. Soil tests are mainly used to assess the fertility status of agricultural soils and to measure the levels and availability of nutrient elements for various crops. Testing soils for available nutrients generally involves extraction with many single or double ionic extractants. A solution of ammonium bicarbonate containing diethylene triamine penta acetic acid (AB-DTPA) has been successfully used as a multi-element extractant for neutral and alkaline soils, but has not been tested for acidic soils. In this study, the potential of AB-DTPA extractant for determining available P, K, Ca, Mg and Na was assessed using 33 Sri Lankan soils with a pH range of 2.9 to 7.5. This method was compared with Olsen, Bray and ammonium acetate extraction procedures. Available P determined by AB-DTPA extraction showed a significant relationship with Olsen P ($r = 0.85^{***}$) and Bray-2 ($r = 0.83^{***}$). However, the amounts extracted by AB-DTPA method was significantly lower than that by Olsen and Bray-2 methods. Ammonium acetate extractable bases showed highly significant relationships with AB-DTPA extractable bases having correlation coefficient values of 0.97^{***}, 0.97^{***}, 0.98^{***} and 0.96^{***} for Ca, Mg, Na, and K, respectively. Results therefore indicated the potential of using AB-DTPA extractant to determine a range of available nutrients which would reduce cost and time in routine soil analysis.

INTRODUCTION

Testing soils for available nutrients is often necessary to assess the general fertility status of agricultural soils and to determine the nutrient availability for crops. Such information is used as a basis for determining the quantity of supplemental nutrients required to prevent economic loss of

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crops due to nutrient deficiency. Generally, available forms of nutrients in soils are extracted and assessed by using different extractants.

Presently in Sri Lanka available P is determined by various extractants depending on soil conditions. These include Olsen extractant (Olsen *et al.*, 1954), Bray 1 and Bray 2 extractants (Bray and Kurtz, 1945). Most of these extractants are suitable only for P extraction. Available K, Ca, Mg, and Na are usually determined by extracting soils with ammonium acetate (Schollenberger and Simmon, 1945), whereas micro-nutrients such as Fe, Mn, Cu and Zn are determined after extraction with EDTA or DTPA (Lindsay and Norvell, 1978). Thus, testing soils for available nutrients involve extraction of soils with many different single or double-ionic extractants depending on the number and nature of nutrients to be determined.

A multi-ionic extractant for P, K, Ca, Mg, Na, and micro-nutrients was introduced and tested for neutral and alkaline soils by Soltanpour and Schwab (1977). However, the suitability of this method for acidic soils has not been tested. In this method soils are extracted with a solution of ammonium bicarbonate (AB) containing DTPA to determine available nutrients as it is advantageous in terms of reduced cost and time taken for the analysis.

This study was carried out with the main objective of testing the suitability of AB-DTPA extractant in determining available P, K, Ca, Mg and Na for acidic soils collected from different locations in Sri Lanka.

MATERIALS AND METHODS

Surface soil samples (0-15cm depth) were collected from 33 different locations in Sri Lanka (Figure 1) including Alfisols, Inceptisols, Ultisols and Histosols. These soils were air-dried and passed through a 2 mm sieve before analysis. Soil pH was measured in 1:2.5 soil:1M KCl suspensions (Hesse, 1971).

Available P content of soils were determined by extracting soils with 0.5M $NaHCO_3$ (Olsen *et al.*, 1954), as well as by extracting with 0.03N NH_4F and 0.025N HCl solution (Bray and Kurtz, 1945). Concentration in the extracts was determined by molybdenum blue method (Murphy and Riley, 1962). Exchangeable Ca, Mg, Na, and K in 1M Ammonium Acetate were etermined using an Atomic Absorption Spectrophotometer (Perkin-Elmer 2380) as described by Schollenberger and Simmon (1945).

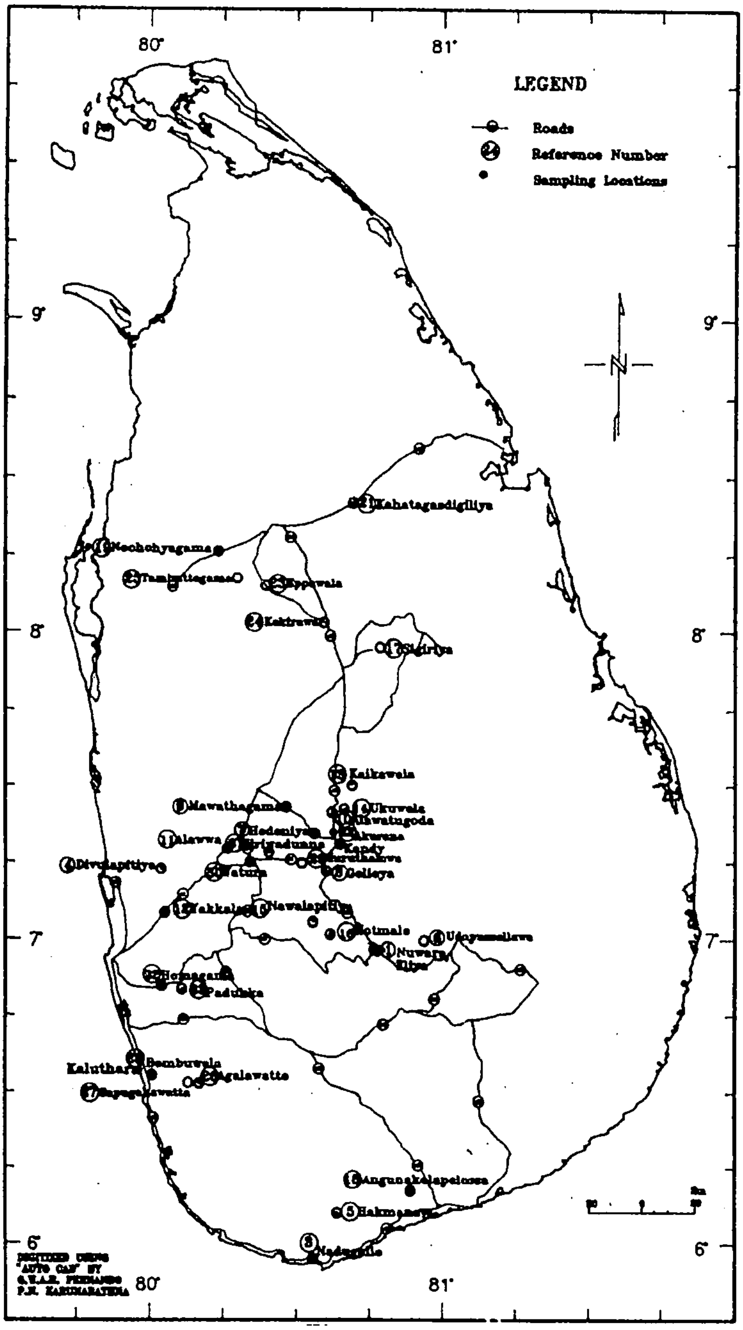

Figure 1. Sampling locations and the pH of the soils.

AB-DTPA extractant was prepared by dissolving DTPA in distilled water to obtain 0.005M DTPA and thereafter adding solid NH_4HCO_3 to obtain 1M NH_4HCO_3 solution. The pH of the solution was finally adjusted to 7.6 using sodium hydroxide. Fresh solutions were prepared daily for analysis, since ammonium bicarbonate solution is not stable for more than 24 hours. Available P, K, Na, Ca and Mg in the soils were determined by shaking 10.0 g of soil with 20.0 cm^3 of AB-DTPA extractant for 30 min using a horizontal mechanical shaker. Approximately 1 g of activated charcoal was added prior to shaking to decolourize the extract. Extract was then filtered through a Whatman No. 42 filter paper. Phosphorus in the extract was determined by the molybdenum blue method (Murphy and Riley, 1962), and Ca, Mg, Na and K in the extract were measured by Atomic Absorption Spectrophotometry.

Simple linear regression analysis was employed to compare the effectiveness of AB-DTPA method with Olsen and Bray methods in determining available P content. Relationships between P extracted by AB-DTPA method, with Olsen method and Bray method were obtained separately. Similarly, the effectiveness of AB-DTPA method in measuring exchangeable K, Na, Ca and Mg were compared with acetic acid method by obtaining relationships between K, Na, Ca and Mg extracted with AB-DTPA and with ammonium acetate (AA).

RESULTS AND DISCUSSION

Soil pH values and P extracted by different extractants are given in Table 1. The soils tested were strongly acidic to slightly alkaline with pH values ranging from 2.9 to 7.5. Most of the soils had pH values <5.0.

Quantity of P extracted by Olsen method and Bray 2 method were significantly greater ($p<0.001$) than the amount extracted by AB-DTPA method. This may be due to the high soil:extractant ratio (1:2) of AB-DTPA method as compared to Olsen (soil:extractant 1:20) and Bray (soil:extractant 1:10) methods. In addition, AB-DTPA extractant is slightly alkaline (pH=7.6) in reaction whereas Bray extractant is highly acidic (pH=3.5), and Olsen extractant is strongly alkaline (pH=8.3). Thus, Bray and Olsen extractants are capable of extracting higher quantities of phosphorus than slightly alkaline AB-DTPA extractant. However, P extracted by AB-DTPA method showed significant relationships with P extracted by Olsen method ($r=0.85^{***}$), and Bray method ($r=0.83^{***}$) indicating the possibility of replacing the more traditional methods of Olsen and Bray by the AB-DTPA method.

Table 1. Soil pH values and the extracted P (mg/kg soil) by different methods.

		Available Phosphorous (mg/kg)		
Soil	pH	Olsen Method	Bray Method	AB-DTPA Method
1	4.0	2	8	0.1
2	3.0	14	30	1.4
3	3.2	4	5	0.1
4	3.8	18	182	2.7
5	4.5	20	31	1.8
6	4.0	39	219	6.0
7	6.0	23	24	0.9
8	4.6	18	14	1.2
9	5.3	21	33	1.7
10	5.1	9	19	0.7
11	4.5	8	26	1.7
12	4.0	11	61	1.0
13	7.4	12	15	1.1
14	6.1	8	12	0.8
15	4.0	5	66	0.6
16	4.2	20	92	2.9
17	6.5	11	12	0.9
18	6.5	6	28	0.6
19	5.9	12	26	0.9
20	3.0	7	26	0.7
21	6.7	7	36	na
22	4.8	20	102	2.6
23	4.9	21	65	2.0
24	6.4	17	77	1.7
25	5.8	13	34	1.4
26	4.3	13	54	0.7
27	4.3	14	75	0.8
28	4.1	10	32	0.8
29	4.5	13	31	1.3
30	4.4	15	19	1.3
31	4.3	14	17	1.3
32	4.3	15	80	1.9
33	4.1	13	61	1.2

na-not available

Available Ca, Mg, Na, and K values determined by extracting with 1M ammonium acetate and AB-DTPA extractant are given in Table 2. The amounts of Ca and Mg extracted by AB-DTPA was significantly lower than the amounts extracted by ammonium acetate ($p=0.001$). Similar amounts of Na and K were extracted by both AB-DTPA and AA extractants.

Table 2. **K, Na, Mg and Ca (mg/kg soil) extracted by AA and AB-DTPA methods**

	K (mg/kg)		Na (mg/kg)		Mg (mg/kg)		Ca (mg/kg)	
Soil	AA	AB-DTPA	AA	AB-DTPA	AA	AB-DTPA	AA	AB-DTPA
1	40	61	10	10	13	6	29	9
2	7	5	52	44	116	42	431	34
3	5	5	101	93	237	89	278	34
4	25	20	21	10	24	8	124	33
5	17	13	29	22	49	18	519	422
6	98	94	19	8	48	19	242	31
7	14	13	27	15	177	67	412	375
8	48	34	48	38	191	69	673	586
9	71	68	25	30	348	135	714	684
10	34	26	52	56	246	89	745	699
11	40	41	46	25	62	23	296	196
12	29	38	18	9	33	6	89	23
13	46	49	36	26	706	212	na	1994
14	42	44	26	11	260	151	1412	844
15	72	82	9	21	39	17	165	19
16	12	19	13	12	54	19	204	6
17	58	58	136	132	375	142	1258	1124
18	50	53	28	23	393	150	904	1044
19	103	102	41	31	305	135	1230	942
20	38	39	162	156	161	35	1702	1570
21	63	58	110	93	603	246	882	825
22	76	71	36	36	191	75	403	515
23	52	49	24	26	239	111	591	635
24	59	60	62	61	496	202	1483	1373
25	78	86	106	104	475	168	1491	1337
26	31	29	22	19	32	7	120	33
27	29	34	18	17	14	7	88	16
28	na	59	20	19	24	9	184	49
29	54	65	27	32	181	66	519	394
30	62	58	21	32	74	31	321	244
31	69	73	34	30	61	23	259	152
32	34	40	20	14	11	5	90	14
33	56	63	22	29	29	11	126	28

AA - Ammonium Acetate method, AB-DTPA - Ammonium Bicarbonate DTPA method, na - not available

Highly significant relationships were observed for basic cations extracted by AB-DTPA method with those of ammonium acetate method having correlation coefficients of 0.97***, 0.97***, 0.98*** and 0.96*** for Ca, Mg, Na, and K, respectively.

Results of this study therefore indicate that AB-DTPA extractant is as suitable as Olsen and Bray extractants in assessing P availability, while it is as efficient as ammonium acetate in extracting Ca, Mg, K and Na. Bicarbonate ion in the AB-DTPA extractant is effective in extracting phosphate anion, whereas ammonium ion is responsible for displacing exchangeable basic cations such as Ca, Mg, Na and K from soil. In addition, presence of DTPA in AB-DTPA extractant makes it possible to use this extractant to evaluate available micronutrients such as Fe, Mn, Zn and Cu.

CONCLUSIONS

Use of AB-DTPA multi-element extractant in routine analytical work is advantageous as it reduces the cost and time taken for analysis since only a single extraction is involved. Whether the amount of available nutrients extracted by AB-DTPA method is really a measure of plant available nutrient content has to be assessed further in greenhouse and field experiments.

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