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The Reliability of NH_4HCO_3 – DTPA for Simultaneous Extraction of P, K, Fe, Mn, Zn and Cu in Saudi Soils

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Abstract. NH_4HCO_3 – DTPA (AB – DTPA) was used to determine levels of extractable P, K, Fe, Mn, Zn and Cu in 54 Saudi soils of widely different properties. These same elements were concurrently determined in the soils by the routine testing methods adopted here. Statistical analysis yielded highly significant correlation coefficients (r) between the pairs of determinations for each of the nutrient elements tested, and suggested that AB–DTPA could be a very useful multielement extractant for Saudi soils.

Introduction

In chemical testing of soils for fertility evaluation, we aim to assess their status of the plant nutrients in relation to estimated critical levels. Worldwide experience has shown that no single chemical extractant is ideal for evaluating the status of different plant nutrients under a variety of soil conditions. This meant that the number of soil testing chemicals has grown to dramatic figures, and also that soil fertility evaluation proved to be rather tedious. Thus the need for chemicals with extracting ability for more than one plant nutrient became evident.

The DTPA soil test developed by Lindsay and Norvell [1-2] for simultaneous extraction of several micro nutrients proved to be a reliable soil test for the micro nutrients in alkaline and calcareous soils e.g. [3-5]. The NH_4HCO_3 – DTPA (AB–DTPA) test for simultaneous extraction of macro and micro nutrients [6] was also a step forward towards the desired objectives.

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In present investigation, AB–DTPA soil extraction for several plant nutrients was correlated with the levels of the nutrients extracted by the respective soil test in routine use for Saudi soils.

Materials and Methods

Soil samples were collected over wide territories in Saudi Arabia. Because it was necessary to represent in the study soils that reveal variations in chemical and physical properties, as well as in levels of the nutrient elements intended to study, extensive screening was done of the collected samples and 54 samples were ultimately selected. Table 1 supplies a summary of the ranges of chemical and physical properties of the soils and the analytical methods used. NH_4HCO_3 – DTPA (pH 7.8) method described by Soltanpour and Schwab [6] was used for the simultaneous extraction of P, K, Fe, Mn, Zn and Cu from the soils. The quantity of the nutrients extracted by this method was correlated with those extracted by Olsen's soduim bicarbonate test for P, ammonium acetate test for K and the Lindsay and Norvell DTPA test for the micronutrients Fe, Mn, Zn and Cu. Phosphorus in the extracts was determined colorimetrically by the ascorbic acid method of Murphy and Riley [7]; potassium and the microelements were determined by atomic absorption. The data were analysed statistically at the University Computer Center.

Table 1. Range and means of certain properties of the soils and the analytical methods used

Soil property	Range	Mean	Analytical methods
pH	7–8.55	7.70	Sat. soil paste [8]
Salinity (m.mho/cm)	0.3–20	8.40	Sat. paste extract [8]
$CaCO_3$ (%)	0.52–39.34	13.27	Calcimeter [9]
Organic matter (%)	0.06–4.76	0.99	Walkley – Black [9]
Clay (%)	4.00–58.60	14.90	Hydrometer [10]

Results and Discussion

Table 2 summarizes levels of the extractable nutrients derived by the routine testing methods (1) i.e. Olsen's soduim bicarbonte for P, ammonium acetate for K and DTPA alone for the microelements as well as the corresponding extractable levels of the nutrients by the AB–DTPA method (2). In general the routine test extractions were higher for the macroelements (P and K) compared to AB–DTPA. For the micronutrients, however, the AB–DTPA tended to extract more compared

to DTPA alone. This may be due to the extra ability of the NH_4^+ in the AB–DTPA mixture to replace the microelements in the exchange complex.

Table 2. Summary of nutrient contents of the soils as extracted by routine methods (1) and by AB–DTPA (2).

Observation	Levels of extractable nutrients* (PPM)			C.V. %
	Min.	Max.	Mean	
P (1)	0.25	62.00	9.82	132.54
P (2)	0.19	29.25	4.41	125.08
K (1)	16.4	893.0	208.65	75.77
K (2)	10.0	712.0	204.80	71.96
Fe (1)	1.4	32.00	5.51	86.03
Fe (2)	2.0	32.60	6.10	86.36
Mn (1)	1.1	17.2	5.25	66.95
Mn (2)	0.9	21.3	5.70	72.19
Zn (1)	0.14	6.3	1.22	123.43
Zn (2)	0.22	7.48	1.44	127.11
Cu (1)	0.25	4.55	0.90	87.41
Cu (2)	0.32	6.94	1.26	94.9

* Determinations were in triplicates.

Results of the computer linear regression analysis relating levels of the nutrient elements extracted by the routine tests (1) and by the AB–DTPA (2) methods are presented in Table 3. When the regression analysis was performed on the levels of extractable nutrients on absolute figure bases, the correlation coefficients (r) between the pairs of extractions (Table 3) ranged between 0.85 and 0.99 and were very highly significant (P = .01). The very high coefficients of variation (Table 2) may suggest that the data was not normally distributed i.e. that the levels of determinations obtained may have rested heavily on one side of the range. Under such situations, high correlation coefficients may not necessarily indicate high significance of the relationship performed. In order to resolve this, therefore, the correlation coefficients were calculated once more after the analytical data had been converted to a log transform (Table 3). The resulting r values still ranged between 0.816 and 0.971 and were very highly significant (P = .01). This is usually considered a more acceptable proof of the significance of the correlation analysis. These results indicate that the AB–DTPA method was equally efficient in extracting P, K, Fe, Mn, Zn and Cu

in the Saudi soils tested compared to the common methods of routine analyses. The result further strengthens the original findings of Soltanpour and Schwab [6] for Colorado soils and the subsequent ones of Havlin and Soltanpour [11] for Fe. The efficiency of the AB–DTPA as a soil test for phosphorus was recently confirmed by Labhestwar and Soltanpour [12]. Because AB–DTPA proved to be an excellent multielement extractnt, it may be a very useful soil test tool for Saudi soils.

Table 3. Correlation coefficients (r) for relating levels of the nutrients extracted by the routine testing methods (1) and by AB–DTPA (2)

	P (1)	K (1)	Fe (1)	Mn (1)	Zn (1)	Cu (1)
P (2)	0.85*** (0.866)***					
K (2)		0.985*** (0.911)***				
Fe (2)			0.970*** (0.816***)			
Mn (2)				0.963*** (0.971***)		
Zn (2)					0.992*** (0.956***)	
Cu (2)						0.972*** (0.931***)

*** Denotes very highly significant.
Figures in brackets represent the corresponding (r) values for log transforms.

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اعتمادية محلول بيكربونات الأمونيوم - دى - تى - بى - أى للاستخلاص المشترك لعنـاصر الفوسفور، البوتاسيوم، الحديد، المنجنيز، الخارصين والنحاس في ترب المملكة العربية السعودية

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ملخص البحث. استخدم المحلول لتقدير مستويات العناصر المذكورة في أربع وخمسين تربة اختلفت في صفاتها الكيميائية والفيزيائية وأيضًا في مستوى العناصر فيها.

تم تقدير مستوى العناصر في الترب بوساطة الطرق الكيميائية الروتينية المعتمدة محليًا لكل عنصر. وعند إجراء عمليات التوافق الإحصائي لمقارنة الاستخلاص بالطريقتين لكل عنصر ثبت أنهما يتوافقان معنويًا مما يعني أن هذا المحلول مؤهل للاستخلاص المشترك لعدة عناصر في ترب المملكة.