Evaluation of Some Methods for Multi-Nutrients Extraction as Soil Tests in Some Egyptian and Libyan Soils

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ABSTRACT

The aim of this study was to find a chemical solution that will extract an amount of all or most nutrients proportional to what a plant extract from soils of Egypt and Libya. To determine this, a laboratory and green house experiments were conducted. Twenty five soil samples were collected from the North Western coast of Egypt. Also, twenty soil samples were collected from different areas of North Eastern of Libya, to represent the calcareous soils of Egypt and Libya. Three chemical solution namely AB-DTPA (NH_4HCO_3), Mehlich-3, AB-3 (new solution prepared from NH_4HCO_3 + DTPA + NH_4NO_3 + HOAC) compared with the common soil test methods (NH_4OAC for K, Ca, Mg, $NaHCO_3$-P, DTPA-micronutrients and hot water for B) were used to simultaneously extract plant available K, Ca, Mg, P, Fe, Mn, Zn, Cu and B. The statistical analysis for the relationships between the extractable amounts obtained by these methods were determined by calculating the correlation coefficients (r). The results indicated a great advantages for determining the availability of K, Ca, Mg, P, Fe, Mn, Zn, Cu and B in one run.

To evaluate further the ability of the tested extractants to estimate the previous nutrients, the soil tests calibration using the corn plants were carried out. The statistical relationships between the extracted elements by the tested extractants and the uptake of these elements by the corn plants concluded that Mehlich-3 solution has superiority on the other two methods as a rapid and cheep routine test for these elements in the calcareous soil. However, field correlation and calibration studies are needed to confirm these results.

INTRODUCTION

Soil analysis for the determination of its physical and chemical characteristics has increased recently in order to arrive to the best use of these soils. Evaluation of soil fertility test is the most important aim of these analyses. The methods, being used for nutrients determination in soil are intended for extracting one single element or several elements simultaneously. In Egypt, as in other countries, the use of multi-elements extractants is important not only for reducing the costs needed for chemical laboratory supplies, but also for saving time and increasing the performance of the laboratory workers.

Soltanpour and Schwab (1977) evaluated a soil test (AB-DTPA) for simultaneous extraction as multi-nutrients. Also, Lindsay and Norvell (1978) evaluated and developed DTPA soil test for four micronutrients (Fe, Mn, Zn and Cu) in soils. Mehlich (1978) found that potassium, magnesium and calcium, in the new extractant were highly correlated with those extracted by neutral 1N NH_4OAc. Also, the phosphorus was highly correlated with that extracted with Olsen or Bray-1 and for micronutrient extracted with DTPA. Evans and McGuire (1990) compared several extraction soil test methods. They showed good correlations for all comparisons among extractants. Mehlich-1 and Mehlich-3 extractants were significantly correlated with the NH_4OAc extractant for exchangeable cations determinations.

El-Sheemy (1991) tested the efficiency of AB-DTPA method. He indicated that the levels of the nutrients extracted by the AB-DTPA soil test were highly correlated to those extracted by the standard methods for these nutrients. Schmisek *et al.* (1998) evaluated Mehlich-3 method as multi-nutrient extraction. They found that the Mehlich-3 extractant correlated well with P, K and Zn values obtained by the Olsen, NH_4OAc and DTPA extraction procedures, respectively. Also, Mehlich-3 extractant was some what correlated for Cu, but poorly correlated for Fe and Mn with DTPA-extractation. Zibral and Nemec (2000) compared different extraction methods for determination of available nutrients. They found a highly significant correlation between Mehlich-2 or Mehlich-3 methods for all nutrients ($r=0.97-0.99^{**}$) and the standard methods for macro and micronutrients.

The objective of this study was, therefore, to evaluate the use of three multi-nutrients extractants for macro and micronutrients under the conditions of Egyptian and Libyan soils. The study includes testing the correlation between the different multi-nutrients extractants and the specific solutions for these nutrients. Also, to evaluate these extractants by calibration using corn as test plant.

MATERIALS AND METHODS

Soil:

Forty – five soil samples (0 – 30 Cm) were collected from different areas at the North Western Coast of

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Table 2. The extraction methods used in the study.

Methods	Extractants	Elements									Soil to solution ratio	Shaking time (min)	Referance
		Ca	Mg	K	P	Fe	Mn	Zn	Cu	B			
Ammonium acetate	1N NH_4OAc pH 7.00	*	*	*							1:10	30	Jackson, 1973
AB-DTPA	M NH_4HCO_3 +0.005 M DTPA pH 7.5	*	*	*	*	*	*	*	*	*	1:2	15	Soltanpour and Schwab 1977
Mehlich-3	0.2M CH_3COOH+0.25 M NH_4NO_3+ 0.015M NH_4F+ 0.013M HNO_3+ 0.001m EDTA pH 2.5	*	*	*	*	*	*	*	*	*	1:10	5	Mehlich, 1984
Olsen	0.5M $NaHCO_3$ pH 8.5				*						1:2	30	Olsen *et al.*, 1954
Hot water	H_2O									*	1:2	30	Gupta 1967a
DTPA	pH 7.3					*	*	*	*		1:2	120	Lindsay and Norvell 1978
AB-3	1M NH_4HCO_3+ 0.005M DTPA+ 0.5M NH_4NO_3+ 0.5M HOAc	*	*	*	*	*	*	*	*	*	1:2	15	A modification of soltanpour extractant

Egypt and North Eastern Coast of Libya. The soil samples were air dried, ground, passed through 2 mm sieve. The main physical and chemical properties of the soils were determined according to standard methods outlined by Black *et al.*, (1965) and Jackson,(1973). The results obtained are shown in Table 1.

Phosphorus, potassium, calcium, magnesium, iron, manganese, zinc, copper and boron were extracted from the soil samples by different extractants as described obtained (Table 2). In the obtained extracts P was determined according to Murphy and Riley (1962), potassium by Flame spectrometer, calcium, magnesium, iron, zinc, manganese and copper were measured by Atomic Absorption Spectrophotometry, and boron was determined Spectrophotometry according to Jackson (1973).

Pot experiment:

The three multinutrients extractants namely AB-DTPA, Mehlich-3 and AB-3 were tested to fined out the best one that extracts an amount of the different nutrients proportional to what is measured plant. To determine this, pot experiment was carried out in the green house using plastic pots of 12 cm in diameters and 10 cm deep filled with 1 kg soil. One soil sample from the tested soils (soil No. 25) was selected and mixed with various rates of the different nutrients using balanced nutrient solution. The different rates of all the nutrients for each treatment are presented in (Table 3). Four seeds of corn (*Zea mays* .L) Giza-2 variety as a test plant were germinated per pot on 15 April, 2003. After one week the seedling were thinned to two plants per pot. The pots were watered daily with distilled water to keep soil moisture content at the field capacity.

After harvesting time (after four weeks) soil sample from each pot was taken, air dried, grounded passed through a 2 mm sieve and thoroughly mixed and analyzed for the different element using the tested

Table 1. Some physical and chemical properties of the tested Egyptian and Libyan soil samples.

Sample No.	Location	Texture	PH 1:2.5	EC dS/m 1:5	Soluble cations meq/L				Soluble anions meq/L			T-CaCO$_3$ %	O.M. %	CEC cmol/Kg
					Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	CO_3+HCO_3	Cl^{-}	$SO_4^{=}$			
							Egyptian soils							
1	Burg-El-arab	S.C.L.	8.32	0.57	3.45	1.42	0.94	0.18	1.66	3.46	0.84	22.38	0.61	10.04
2	Burg-El-arab	S.C.L.	8.30	1.49	6.90	2.96	5.40	0.27	1.33	11.06	2.57	18.77	0.48	11.50
3	El-hammam	S.L.	8.22	0.65	3.31	1.91	0.71	0.15	0.91	5.57	2.56	21.66	0.49	8.76
4	El-hammam	S.L.	7.88	0.53	2.62	2.03	0.81	0.25	0.99	1.92	2.79	19.49	0.28	14.42
5	El-alamine	S.	7.95	0.28	1.66	0.78	0.28	0.08	1.32	1.25	0.23	27.44	0.33	14.05
6	El-alamine	S.	7.97	0.30	1.93	0.62	0.27	0.06	1.33	0.77	0.78	29.60	0.33	10.59
7	Sidi-abdel	S.L.	8.04	0.25	1.38	0.59	0.25	0.12	0.83	1.06	0.47	25.99	0.48	11.32
8	Sidi-abdel	S.L.	8.01	0.25	1.52	0.34	0.35	0.10	0.76	1.15	0.45	32.49	0.48	13.14
9	Abna-El alwani	S.L.	8.32	0.26	1.38	0.94	0.45	0.08	1.33	1.06	0.46	39.71	0.77	11.86
10	Abna-El alwani	S.L.	8.66	0.25	1.66	0.54	0.35	0.06	1.16	0.96	0.49	39.71	0.67	16.25
11	Addabbah	S.L.	8.78	0.84	4.42	3.12	0.47	0.32	1.38	5.38	1.12	19.49	0.93	15.30
12	Addabbah	L.S.	8.74	0.24	1.38	0.59	0.28	0.08	1.16	0.96	0.21	15.88	0.61	16.52
13	Jalal village	L.S.	8.45	0.48	2.62	1.67	0.55	0.13	1.00	1.92	2.02	28.16	0.67	15.82
14	Jalal village	L.S.	8.80	0.46	2.84	1.65	0.40	0.16	1.00	1.73	1.98	39.71	0.67	15.47
15	El-zytona village	L.S.	7.89	0.29	2.21	0.69	0.12	0.08	1.49	0.84	1.13	31.05	0.48	13.73
16	El-zytona village	L.S.	8.07	0.25	1.24	1.20	0.12	0.08	1.00	0.58	1.11	43.32	0.77	10.26
17	Zawyt-Elawam	L.S.	8.02	0.26	1.38	0.94	0.30	0.10	1.16	0.96	0.60	32.49	0.77	15.82
18	Zawyt-Elawam	S.L.	8.77	0.22	1.10	0.73	0.37	0.12	1.00	0.96	1.27	23.83	0.75	14.08
19	Ras-El-hekma	L.S.	8.31	0.57	2.76	1.88	0.59	0.28	1.00	1.92	2.72	33.93	0.93	10.60
20	Ras-El-hekma	S.L.	8.83	0.41	2.07	1.41	0.25	0.20	1.33	2.30	0.34	27.33	0.66	13.73
21	Matrouh	S.	8.11	0.25	1.52	1.03	0.13	0.04	1.16	1.06	0.52	10.72	0.49	14.63
22	Matrouh	S.	8.12	0.18	0.97	0.77	0.10	0.08	1.19	0.48	0.44	6.50	0.33	7.74
23	Matrouh	S.L.	8.83	0.39	2.35	1.25	0.27	0.09	0.66	0.69	0.45	25.27	0.93	28.40
24	Zawyt El-awam	S.L.	8.49	0.45	2.35	1.18	0.45	0.17	0.69	1.92	1.00	30.32	1.07	34.43
25	Matrouh	S.L.	8.72	0.31	1.38	0.94	0.53	0.28	1.35	1.34	0.44	33.39	1.07	27.54
	Average		8.34	0.38	2.26	1.25	0.59	0.14	1.12	2.15	1.08	27.15	0.64	15.09
							Libyan soils							
26	Tanimlo	S.L.	8.74	2.02	3.04	3.93	13.00	0.28	2.88	8.83	8.54	40.43	0.93	18.99
27	Tanimlo	S.L.	8.68	1.62	3.86	2.75	4.50	0.20	2.88	9.02	2.45	44.46	0.77	10.73
28	Tanimlo	S.L.	8.60	1.43	3.54	1.28	4.50	0.27	2.81	12.48	1.45	48.73	2.93	16.52
29	El-bania	S.C.L.	8.25	1.20	3.45	1.77	7.50	0.13	3.72	6.84	2.29	0.72	2.56	23.95
30	El-bania	S.C.L.	8.13	0.24	1.38	0.71	0.40	0.11	1.14	0.96	0.50	0.70	1.81	37.17
31	Ain-mara	L.	8.13	0.22	1.52	0.68	0.13	0.04	0.83	0.67	0.87	2.17	2.70	24.70
32	Ain-mara	L.	8.22	0.16	1.10	0.41	0.13	0.06	0.73	0.67	0.30	11.25	2.50	28.08
33	Darna	S.L.	8.28	0.30	2.07	0.83	0.37	0.18	1.56	0.96	0.93	29.69	2.56	29.73
34	Darna	S.L.	8.18	0.35	2.21	0.92	0.42	0.18	1.04	1.92	0.77	7.94	3.50	30.56
35	Darna	S.L.	8.68	0.41	2.07	1.41	0.53	0.18	1.45	1.44	1.31	31.05	2.55	28.91
36	Martouba	S.L.	8.65	0.23	1.24	0.73	0.32	0.10	0.41	0.77	0.71	37.59	0.77	20.66
37	Martouba	S.L.	8.54	0.25	1.38	0.94	0.23	0.08	1.14	0.96	0.53	37.54	0.67	12.91
38	El-timimi	S.L.	8.20	0.60	3.04	2.53	0.47	0.10	1.04	4.51	0.59	46.21	0.77	15.49
39	Toubrik	S.L.	8.55	0.32	1.66	1.12	0.35	0.18	0.83	1.44	1.08	25.27	2.38	35.29
40	Toubrik	S.L.	8.61	0.27	1.38	0.92	0.27	0.20	1.04	0.96	0.79	15.16	2.50	39.26
41	El-timimi	S.L.	8.59	0.65	3.76	2.08	0.67	0.17	1.87	4.03	0.75	43.32	0.77	15.47
42	El-beida	L.S.	8.10	0.25	1.79	0.64	0.17	0.08	1.04	0.96	0.68	44.04	0.77	17.21
43	El-beida	L.S.	8.04	0.30	1.93	0.89	0.16	0.04	1.04	0.86	1.12	46.93	2.01	30.01
44	Shammas	S.	8.42	0.23	1.38	0.48	0.27	0.13	0.67	0.86	0.73	15.16	0.71	21.51
45	Shammas	S.	8.40	0.25	1.38	0.77	0.25	0.13	1.04	0.96	0.53	17.28	0.75	22.63
	Average		8.40	0.56	2.16	1.29	1.73	0.14	1.46	3.01	1.35	27.28	1.75	23.49

Table 3. The applied amounts of nutrients to soil for each treatment.

Nutrient	Nutrient rate, mg/kg soil.								
Nitrogen	0	55.00	110.00	165.00	220.00	275.00	330.00	440.00	550.00
Phosphorus	0	13.20	26.40	39.60	52.80	66.00	79.20	105.60	132.00
Potassium	0	33.20	66.40	99.60	132.80	168.00	199.20	265.60	332.00
Iron	0	0.75	1.50	2.25	3.00	3.75	4.50	6.00	7.50
Zinc	0	0.75	1.50	2.25	3.00	3.75	4.50	6.00	7.50
Manganese	0	0.70	1.40	2.10	2.80	3.50	4.20	5.60	7.00
Magnesium	0	0.25	0.50	0.75	1.00	1.25	1.50	2.00	2.50
Calcium	0	0.10	0.20	0.30	0.40	0.50	0.60	0.80	1.00
Copper	0	0.10	0.20	0.30	0.40	0.50	0.60	0.80	1.00
Sulphur	0	0.01	0.02	0.03	0.04	0.05	0.06	0.08	0.10
Boron	0	0.05	0.10	0.15	0.20	0.25	0.30	0.40	0.50
Molobdnium	0	0.05	0.10	0.15	0.20	0.25	0.30	0.40	0.50

extractants (AB-DTPA, Mehlich-3 and AB-3) as mentioned above. Also, the plants were cut 1 cm above the soil surface, washed by tap water followed by distilled water and dried at 65 C for 48 hours and the dry weights were recorded.

The plant materials were digested using H_2SO_4 and H_2O_2 mixture according to Lowther (1980). In the digest solution the different nutrients were determined according to Jackson, (1973) and the uptake of these nutrients were calculated.

The obtained results were analyzed statisticaly using the method of Draper and Smith (1967).

RESULTS AND DISCUSSION

The extractable Nutrients by Different Extractants:

1. Calcium

Table 4 showed the amounts of Ca extracted by the 4 methods, (ammonium acetate (NH_4OAc), Soltanpour (AB-DTPA), Mehlich-3 and AB-3) from the Egyptian and Libyan soils. The results revealed that the order of extractability of these extractants for Ca in soils was as follows: NH_4OAc > Mehlich-3 > AB-3 > AB-DTPA,. Ammonium acetate removed a high amounts of Ca from both soil groups, due to the fact that NH_4OAc is more efficient than other methods in dissolving Ca bound in organic compounds and 2 : 1 clay minerals (Cox *et al.*, 1993).

In the Egyptian soils, a significant correlation was found between the Ca amounts which passed into solution by NH_4OAc and that of AB-DTPA , Mehlich-3 and AB-3 methods.

The mathematical relationship between (X) the extracted Ca by NH_4OAc and (Y) the amount of Ca extracted by AB-DTPA, Mehlich-3 and AB-3 methods were established by the least squares method and found as follows:

$$Y_{AB\text{-}DTPA} = 4.20 + 0.33 \quad X_{NH4OAc} \quad (r = 0.63^{**})$$

$$Y_{Mehlich\text{-}3} = 1.44 + 0.59 \quad X_{NH4OAc} \quad (r = 0.91^{**})$$

$$Y_{AB\text{-}3} = 2.75 + 0.41 \quad X_{NH4OAc} \quad (r = 0.81^{**})$$

Table 4. Range and mean value of the extracted elements from the Egyptian and Libyan soil samples using the different extractants.

Extraction methods	Ca^{2+}	Mg^{2+}	K^{+}	P	Fe	Mn	Zn	Cu	B
	cmol/kg soil			mg/kg soil					
	Range and mean								
Egyptian soils									
NH_4OAc	13.6-54.7 (34.15)	5.20-18.2 (11.28)	6.55-31.0 (18.04)	--	--	--	--	--	--
$NaHCO_3$	--	--	--	4.06-30.6 (15.82)	--	--	--	--	--
DTPA	--	--	--	--	2.36-5.12 (3.68)	2.14-4.26 (3.17)	1.25-2.70 (1.95)	1.33-3.07 (2.14)	--
Hot water	--	--	--	--	--	--	--	--	0.24-2.12 (1.09)
AB-DTPA	7.98-28.1 (15.4)	2.66-8.44 (4.96)	8.00-44.1 (30.99)	2.66-12.2 (6.79)	2.88-10.4 (7.77)	2.88-6.90 (5.13)	1.60-3.25 (2.35)	1.64-3.50 (2.48)	0.53-1.16 (0.85)
Mehlich-3	8.64-38.0 (21.5)	2.88-12.7 (7.20)	15.7-48.9 (36.96)	2.66-18.9 (9.18)	2.11-6.60 (4.16)	2.76-8.52 (6.24)	1.90-3.90 (2.75)	2.03-4.30 (2.97)	0.88-1.88 (1.37)
AB-3	7.4-29.4 (16.6)	2.47-9.80 (5.53)	5.36-25.2 (12.12)	3.55-9.98 (6.23)	1.88-4.12 (3.02)	1.70-3.11 (2.43)	0.80-2.10 (1.33)	1.18-2.98 (1.91)	0.49-2.01 (0.94)
Libyan soils									
NH_4Oac	18.1-54.4 (32.97)	5.67-20.2 (11.04)	10.3-40.0 (27.76)	--	--	--	--	--	--
$NaHCO_3$	--	--	--	6.18-26.5 (12.12)	--	--	--	--	--
DTPA	--	--	--	--	2.02-6.10 (4.33)	2.40-4.90 (3.60)	1.57-2.90 (2.29)	1.78-3.30 (2.60)	--
Hot water	--	--	--	--	--	--	--	--	0.66-2.22 (1.30)
AB-DTPA	7.33-25.2 (14.9)	2.21-7.86 (4.74)	23.4-55.3 (38.9)	2.48-10.6 (5.17)	6.36-13.1 (9.46)	4.10-7.90 (6.07)	1.88-3.50 (2.77)	2.06-3.80 (2.95)	0.53-2.01 (1.02)
Mehlich-3	12.2-36.2 (21.88)	6.04-12.6 (7.08)	20.2-60.2 (42.93)	3.48-16.2 (6.84)	3.10-7.12 (5.12)	4.80-9.03 (7.05)	2.02-3.70 (2.87)	1.88-4.56 (3.48)	0.86-1.92 (1.50)
AB-3	8.91-28.2 (16.57)	2.75-9.59 (5.33)	7.32-33.0 (19.53)	3.20-8.77 (5.16)	1.66-5.33 (3.05)	1.80-3.76 (2.67)	1.04-1.93 (1.56)	0.87-2.70 (2.10)	0.50-1.76 (0.95)

For the Libyan soils, the corresponding mathematical relationships, were as follows:

$Y_{AB\text{-}DTPA} = 6.01 + 0.26 \quad X_{NH4OAc} \qquad (r = 0.59^{**})$

$Y_{Mehlich\text{-}3} = 5.79 + 0.48 \quad X_{NH4OAc} \qquad (r = 0.75^{**})$

$Y_{AB\text{-}3} = 0.18 + 0.49 \quad X_{NH4OAc} \qquad (r = 0.92^{**})$

2. Magnesium

Extractable Mg was estimated also in both soil groups as shown in Table 4. The order of magnitude of the values was : NH_4OAc > Mehlich-3 > AB-3 > AB-DTPA in Egyptian and Libyan soils. In the Egyptian soils, a significant correlation was found between the amounts of Mg which passed into solution by NH_4OAc and those of AB-DTPA, Mehlich-3, and AB-3 methods. The mathematical relationship between (X) the extracted Mg by NH_4OAc method and (Y) the amount of Mg extracted by AB-DTPA, Mehlich-3 and AB-3 methods were established as follows:

$Y_{AB\text{-}DTPA} = 2.48 + 0.45 \quad X_{NH4OAc} \qquad (r = 0.45^{**})$

$Y_{Mehlich\text{-}3} = 1.19 + 0.53 \quad X_{NH4OAc} \qquad (r = 0.76^{**})$

$Y_{AB\text{-}3} = 0.96 + 0.40 \quad X_{NH4OAc} \qquad (r = 0.78^{**})$

For the Libyan soils, the corresponding relationships, were as follows:

$Y_{AB\text{-}DTPA} = 1.70 + 0.27 \quad X_{NH4OAc} \qquad (r = 0.69^{**})$

$Y_{Mehlich\text{-}3} = 1.38 + 0.51 \quad X_{NH4OAc} \qquad (r = 0.85^{**})$

$Y_{AB\text{-}3} = 0.20 + 0.46 \quad X_{NH4OAc} \qquad (r = 0.98^{**})$

3. Potassium

Potassium extracted by the four methods, including NH_4OAc, is shown in Table 4. The order of magnitude of the extracted K in the different extractants was as follows: Mehlich-3 >AB-DTPA > NH_4OAc > AB-3 in the Egyptian or Libyan soils.

The mathematical relationship between (X) the extracted K by NH_4OAc method and (Y) the amount of K extracted by AB-DTPA, Mehlich-3 and AB-3 methods were established for the Egyptian soils as follows:

$Y_{AB\text{-}DTPA} = 13.03 + 1.00 \quad X_{NH4OAc} \quad (r = 0.91^{**})$

$Y_{Mehlich\text{-}3} = 21.01 + 0.88 \quad X_{NH4OAc} \quad (r = 0.82^{**})$

$Y_{AB\text{-}3} = 1.00 + 0.61 \quad X_{NH4OAc} \quad (r = 0.83^{**})$

For the Libyan soils, also, the mathematical relationships, were as follows:

$Y_{AB\text{-}DTPA} = 13.83 + 0.90 \quad X_{NH4OAc} \quad (r = 0.94^{**})$

$Y_{Mehlich\text{-}3} = 16.31 + 0.91 \quad X_{NH4OAc} \quad (r = 0.91^{**})$

$Y_{AB\text{-}3} = -2.96 + 0.80 \quad X_{NH4OAc} \quad (r = 0.92^{**})$

4.Phosphorus

The available phosphorus was extracted by seven methods including sodium bicarbonates as a standard method. The results of available P are presented in Table 4. The order of magnitude of P extracted from the Egyptian or Libyan soils was as follows: Olson > Mehlich-3 > AB-DTPA > AB-3. For the Egyptian soils, the mathematical relationship between (X) the extracted P by Olsen method and (Y) the amount of P extracted by AB-DTPA, Mehlich-3 and AB-3 methods were found as follows:

$Y_{AB\text{-}DTPA} = 1.24 + 0.35 \quad X_{NaHCO3} \quad (r = 0.98^{**})$

$Y_{Mehlich\text{-}3} = 2.62 + 0.41 \quad X_{NaHCO3} \quad (r = 0.85^{**})$

$Y_{AB\text{-}3} = 3.15 + 0.19 \quad X_{NaHCO3} \quad (r = 0.89^{**})$

For the Libyan soils, the mathematical relationships, were as follows:

$Y_{AB\text{-}DTPA} = 0.93 + 0.34 \quad X_{NaHCO3} \quad (r = 0.95^{**})$

$Y_{Mehlich\text{-}3} = 0.11 + 0.55 \quad X_{NaHCO3} \quad (r = 0.96^{**})$

$Y_{AB\text{-}3} = 2.49 + 0.22 \quad X_{NaHCO3} \quad (r = 0.76^{**})$

5.Iron

The available Fe was extracted by seven methods including DTPA as a standard method (Table 4). The extracting power of the employed reagents could be arranged in the order: AB-DTPA > Mehlich-3 > DTPA >AB-3 in the Egyptian or Libyan soils. The high efficiency of AB-DTPA solution to extract higher amounts of Fe from the studied soils could be due to the chelating effect of DTPA. chelating reaction was described by Hafez *et al.*,(1992). For the Egyptian soils, the mathematical relationship between (X) the extracted Fe by DTPA method and (Y) the amount of Fe extracted by the other methods were established by the least squares method and found as follows:

$Y_{AB\text{-}DTPA} = 0.85 + 1.84 \quad X_{DTPA} \quad (r = 0.70^{**})$

$Y_{Mehlich\text{-}3} = 0.26 + 1.05 \quad X_{DTPA} \quad (r = 0.67^{**})$

$Y_{AB\text{-}3} = -4.07 + 0.82 \quad X_{DTPA} \quad (r = 0.88^{**})$

For the Libyan soils, also, the mathematical relationships, were as follows:

$Y_{AB\text{-}DTPA} = 1.95 + 1.73 \quad X_{DTPA} \quad (r = 0.96^{**})$

$Y_{Mehlich\text{-}3} = 0.86 + 0.98 \quad X_{DTPA} \quad (r = 0.85^{**})$

$Y_{AB\text{-}3} = -0.46 + 0.81 \quad X_{DTPA} \quad (r = 0.79^{**})$

6.Manganese

The results of Table 4 shows that the used extractants varies markedly in their ability to extract Mn from the Egyptian and Libyan soils. The average amounts of Mn extracted by the different extractants methods from the Egyptian or the Libyan soils declined in the following order Mehlich-3 > AB-DTPA > DTPA > AB-3. It is clear that Mehlich-3 extractant was the highest efficient method as compared to the other methods. For the Egyptian soils, the mathematical relationship between (X) the extracted Mn by DTPA method and (Y) the amount of Mn extracted by the other extractants were established as follows:

$Y_{AB\text{-}DTPA} = 0.32 + 1.51 \quad X_{DTPA} \quad (r = 0.83^{**})$

$Y_{Mehlich\text{-}3} = 0.22 + 0.89 \quad X_{DTPA} \quad (r = 0.87^{**})$

$Y_{AB\text{-}3} = 0.56 + 0.59 \quad X_{DTPA} \quad (r = 0.84^{**})$

For the Libyan soils, the corresponding mathematical relationship were as follows:

$Y_{AB\text{-}DTPA} = 1.21 + 1.34 \quad X_{DTPA} \quad (r = 0.91^{**})$

$Y_{Mehlich\text{-}3} = 0.24 + 1.90 \quad X_{DTPA} \quad (r = 0.96^{**})$

$Y_{AB\text{-}3} = 0.54 + 0.59 \quad X_{DTPA} \quad (r = 0.76^{**})$

7..Zinc

Table (4) show the amounts of zinc extracted by DTPA, AB-DTPA, Mehlich-3 and AB-3 methods from the Egyptian and Libyan soils. The efficiency of the different extractants could be arranged in the order: Mehlich-3 > AB-DTPA > DTPA > AB-3. In the Egyptian soils, the mathematical relationship between (X) the extracted Zn by DTPA method and (Y) the amount of Zn extracted by the other methods were established as follows:

$Y_{AB\text{-}DTPA} = 0.27 + 1.06 \quad X_{DTPA} \quad (r = 0.85^{**})$

$Y_{Mehlich\text{-}3} = 0.67 + 1.06 \quad X_{DTPA} \quad (r = 0.72^{**})$

$Y_{AB\text{-}3} = 0.10 + 0.63 \quad X_{DTPA} \quad (r = 0.81^{**})$

For the Libyan soils, the corresponding mathematical relationship were as follows:

$Y_{AB\text{-}DTPA} = 0.08 + 1.71 \quad X_{DTPA} \quad (r = 0.99^{**})$

$Y_{Mehlich\text{-}3} = 0.13 + 1.19 \quad X_{DTPA} \quad (r = 0.98^{**})$

$Y_{AB\text{-}3} = 0.35 + 0.52 \quad X_{DTPA} \quad (r = 0.84^{**})$

8.Copper

For the Egyptian or Libyan soils, the values of extractable Cu by the different extractants could be arranged in the following order: Mehlich-3 >AB-DTPA > DTPA > AB-3, (Table 4). For the Egyptian soils, the mathematical relationship between (X) the extracted Cu by DTPA method and (Y) the amount of Cu extracted by the other methods were established as follows:

$Y_{AB\text{-}DTPA} = 0.20 + 1.06 \quad X_{DTPA} \quad (r = 0.97^{**})$

$Y_{Mehlich\text{-}3} = 0.26 + 1.25\ X_{DTPA}$ (r = 0.92**)

$Y_{AB\text{-}3} = 0.05 + 0.86\ X_{DTPA}$ (r = 0.79**)

For the Libyan soils, the corresponding mathematical relationships, were as follows:

$Y_{AB\text{-}DTPA} = 0.08 + 1.10\ X_{DTPA}$ (r = 0.91**)

$Y_{Mehlich\text{-}3} = 0.19 + 1.41\ X_{DTPA}$ (r = 0.81**)

$Y_{AB\text{-}3} = -0.18 + 0.87\ X_{DTPA}$ (r = 0.85**)

9. Boron

Table (4) show the amounts of boron extracted by hot water (HW), AB-DTPA, Mehlich-3 and AB-3 extractants from the Egyptian and Libyan soils, The hot water extractant is the standard method extract the available boron. For the Egyptian or Libyan soils, the results revealed that the order of extractability of the different extractants for B in soils was as follows: Mehlich-3 > HW > AB-3 > AB-DTPA. In the Egyptian soils, the mathematical relationship between (X) the extracted B by H.W. method and (Y) the amount of B extracted by the other methods were established as follows:

$Y_{AB\text{-}DTPA} = 0.60 + 0.22\ X_{H.W}$ (r = 0.64**)

$Y_{Mehlich\text{-}3} = 0.90 + 0.42\ X_{H.W}$ (r = 0.59**)

$Y_{AB\text{-}3} = 0.20 + 0.67\ X_{H.W}$ (r = 0.72**)

For the Libyan soils, this mathematical relationships, were as follows:

$Y_{AB\text{-}DTPA} = 0.62 + 0.30\ X_{H.W}$ (r = 0.57**)

$Y_{Mehlich\text{-}3} = 0.88 + 0.48\ X_{H.W}$ (r = 0.62**)

$Y_{AB\text{-}3} = -0.60 + 0.26\ X_{H.W}$ (r = 0.59**)

From these data, it could be concluded in general that AB-DTPA, Mehlich-3 and AB-3 extractants has a great advantage as it can be used for determing the availability of Ca, Mg, K, P, Fe, Mn, Zn, Cu and B in soil in one run.

To evaluate the ability of the tested extractants (AB-DTPA, Mehlich-3 and AB-3) to estimate plant available Ca, Mg, K, P, Fe, Mn, Zn, Cu and B, the soil tests were calibrated using corn plants, and summarized as follows:

1. Calcium

The Ca uptake of corn plants increased significantly with increasing Ca application rate in soil and ranged from 0.044 to 0.250 g/pot with an average of 0.116 g/pot. The relationship between Ca uptake of corn plants and extractable Ca with the different extractants (Fig. 1) was linear and highly correlated. The correlation coefficients between Ca extracted by AB-DTPA, Mehlich-3 and AB-3 and Ca uptake were 0.84**, 0.89** and 0.82** respectively.

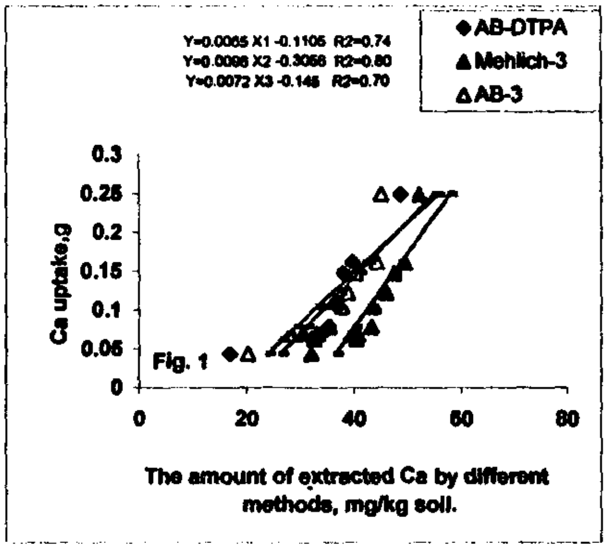

Fig 1. The relationship between Ca uptake, (g/pot) and extracted Ca by different methods, mg/kg soil, where X1= AB-DTPA, X2= Mehlich-3, X3= AB-3.

2. Magnesium

The Mg uptake in the corn plants significantly, increased with Mg application up to 2.5 mg/kg soil and ranged from 0.058 to 0.375 g/pot. Highly significant correlation coefficients were found between Mg extracted by the extractants: NH_4Oac, Mehlich-3 and AB-3 and Mg uptake by corn plants (0.83**, 0.91** and 0.75**,respectively).The relationship between Mg uptake (Y) and extractable Mg with NH_4Oac, AB-DTPA, Mehlich-3 and AB-3 extractants (X) were linear and highly correlated (Fig.2).

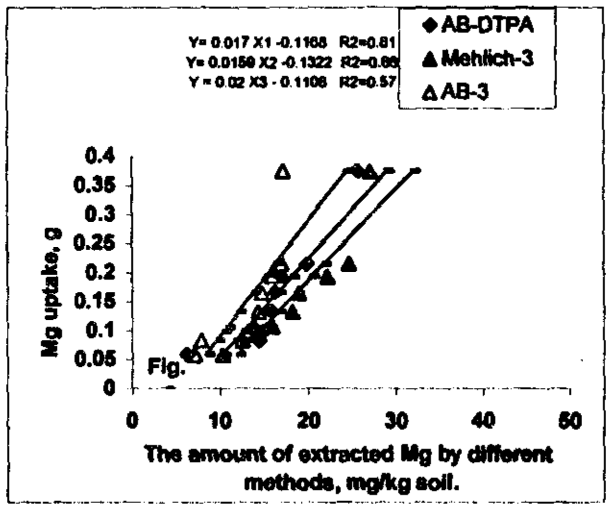

Fig 2. The relationship between Mg uptake, (g/pot) and extracted Mg by different methods, mg/kg soil, where X1= AB-DTPA, X2= Mehlich-3, X3= AB-3.

3. Potassium

The potassium application affected the K uptake by plants and the K extracted by the AB-DTPA, Mehlich-3 and AB-3 extractants. The K uptake increased from 0.05 to 0.182 g/pot, as K rate increased from zero to 332 mg/kg soil. The relationship between K uptake and extractable K with different extractants were evaluated. The r values obtained for the linear relationship between soil K extracted with AB-DTPA, Mehlich-3 and AB-3 and K uptake were (0.92**, 0.95** and 0.97**, respectively). The relationship between K uptake and extractable K was expressed by a straight line equations for the different extractants, (Fig.3).

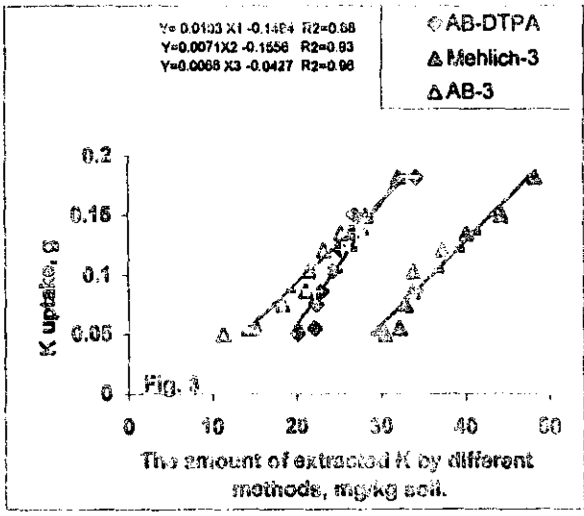

Fig 3. The relationship between K uptake, (g/pot) and extracted K by different methods, mg/kg soil, where X1= AB-DTPA, X2= Mehlich-3, X3= AB-3 .

4. Phosphorus

Phosphorus uptake by corn plants significantly increased from o.023 to 0.95 g/pot as P rate increased from zero to 132.0 mg/kg soil. Phosphorus uptake of corn plants was significantly correlated with the amount of P extracted by AB-DTPA, Mehlich-3 and AB-3 (r= 0.86**, 0.86** and 0.86**, respectively). The relationship between P uptake and extractable soil P were given in Fig. 4 for the different extractants.

5. Iron

Iron uptake by corn plants significantly increased from 0.862 to 2.269 g/pot with an average of 1.39 with increasing iron rate from 0 to 7.50 mg/kg soil. The extractable-Fe by AB-DTPA, Mehlich-3 and AB-3 extractants were increased as result of increasing Fe rates. AB-DTPA extractable Fe increased from 6.14 to 15.67 mg/kg soil with an average of 11.18 mg/kg soil. On the other hand, Mehlich-3 extractable Fe ranged from 3.86 to 8.24 mg/kg soil with an average of 5.67 mg/kg soil and AB-3 extractable-Fe ranged from 1.66 to 5.73 mg/kg soil with an average of 3.88 mg/kg soil.

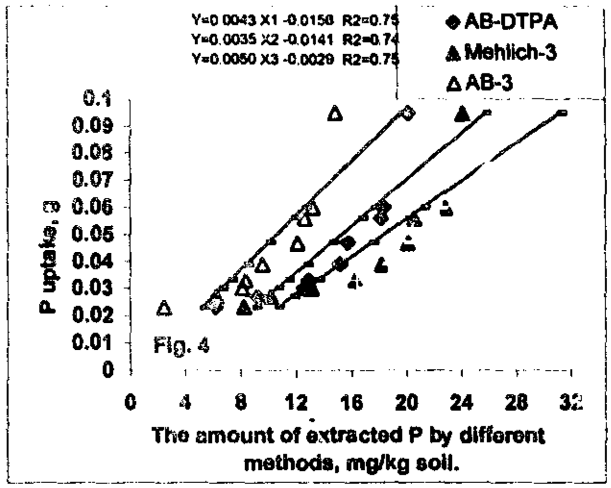

Fig 4. The relationship between P uptake, (g/pot) and extracted P by different methods, mg/kg soil, where X1= AB-DTPA, X2= Mehlich-3, X3= AB-3.

Highly significant correlation coefficients were found between the amount of iron extracted byAB-DTPA, Mehlich-3 and AB-3 extractants and Fe uptake (r = 0.92**, 0.98** and 0.93**, respectively). The relationship between Fe uptake and the different methods were found in (Fig. 5)

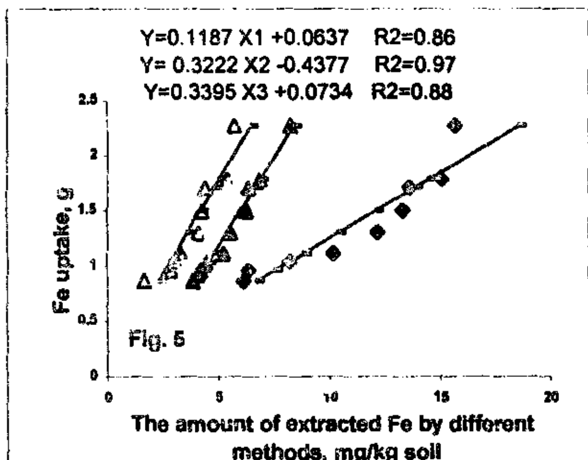

Fig 5. The relationship between Fe uptake, (g/pot) and extracted Fe by different methods, mg/kg soil, where X1=AB-DTPA, X2=Mehlich-3, X3=AB-3.

6.Manganese

Manganese uptake by corn plants increased significantly, with Mn application up to 7.0 mg/kg soil. It ranged from 0.170 to 0.513 g/pot with an average of 0.30 g/pot. Highly significant correlation coefficients were found between Mn extracted by AB-DTPA, Mehlich-3 and AB-3 and Mn uptake (r=0.95**, 0.94** and 0.88**, respectively). A linear relationship between Mn uptake by corn plants (Y) and Mn extracted by the various extractants (X) were presented in (Fig. 6).

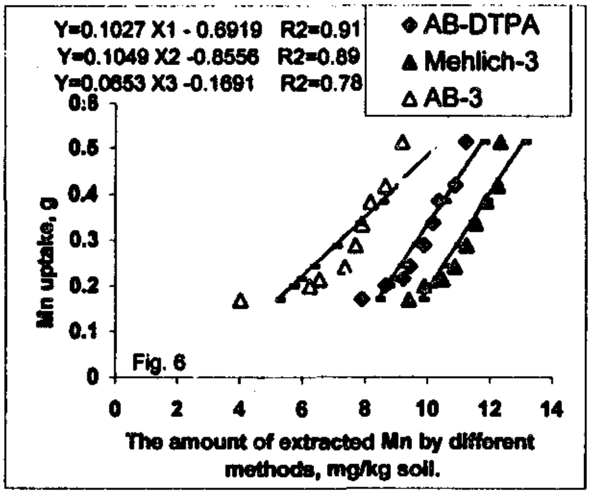

Fig 6. The relationship between Mn uptake, (g/pot) and extracted Mn by different methods, mg/kg soil, where X1=AB-DTPA, X2=Mehlich-3, X3=AB-3.

7.Zinc

Zinc uptake by corn plants significantly increased from 0.190 to 0.607 g/pot with increasing Zn rate in soil up to 7.50 mg/kg soil. Also, the extractable-Zn from the soil by the different methods was affected by soil Zn application. Highly significant correlation coefficients were found between Zn extracted by AB-DTPA, Mehlich-3 and AB-3 and Zn uptake (r=0.93**, 0.97** and 0.85**, respectively). A linear relationship between Zn uptake by corn plants (Y) and Zn extracted by the various extractants (X) were presented in (Fig. 7).

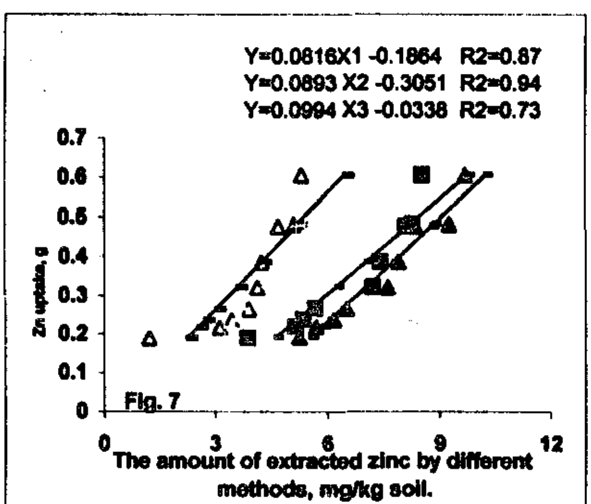

Fig 7. The relationship between Zn uptake, (g/pot) and extracted Zn by different methods, mg/kg soil, where X1=AB-DTPA, X2=Mehlich-3, X3=AB-3.

8.Copper

The copper uptake by corn plants significantly increased from 0.039 to 0.113 g/pot with increasing Cu rate in soil up to 1.0 mg/kg soil. Highly significant correlation coefficients were found between Cu extracted by AB-DTPA, Mehlich-3 and AB-3 and Cu uptake (r=0.99**, 0.93** and 0.97**, respectively). A linear relationship between Cu uptake by corn plants (Y) and Cu extracted by the various extractants (X) were presented in (Fig. 8).

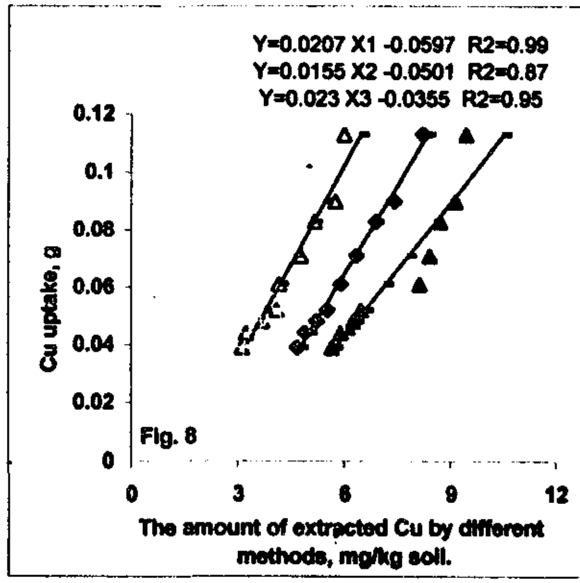

Fig 8. The relationship between Cu uptake, (g/pot) and extracted Cu by different methods, mg/kg soil, where X1=AB-DTPA, X2=Mehlich-3, X3=AB-3.

9.Boron

The B applications has significant effect on B uptake which ranged from 0.027 to 0.107 g/pot. Highly significant correlation coefficients were found between B extracted by AB-DTPA, Mehlich-3 and AB-3 and B uptake (r=0.92**, 0.93** and 0.88**, respectively). A linear relationship between B uptake by corn plants (Y) and B extracted by the various extractants (X) were presented in (Fig. 9).

From the obtained results, it can be seen that AB-DTPA, Mehlich-3 and AB-3 (new extractant) soil test gave significant correlation coefficients with uptake of all the tested nutrients. Hence, these solution have a great advantage as it can be used for determining the availability of Ca, Mg, K, P, Fe, Mn, Zn, Cu and B in soil in one run, and thus offering a rapid and cheep routine tests for these nutrients in the calcareous soils of Egypt and Libya.

With regarding to the correlation coefficients values obtained between the nutrients uptake of corn plants and the extracted amounts from soil, it could be concluded also, that Mehlich-3 solution has superiority over the other two methods, (Table 5).

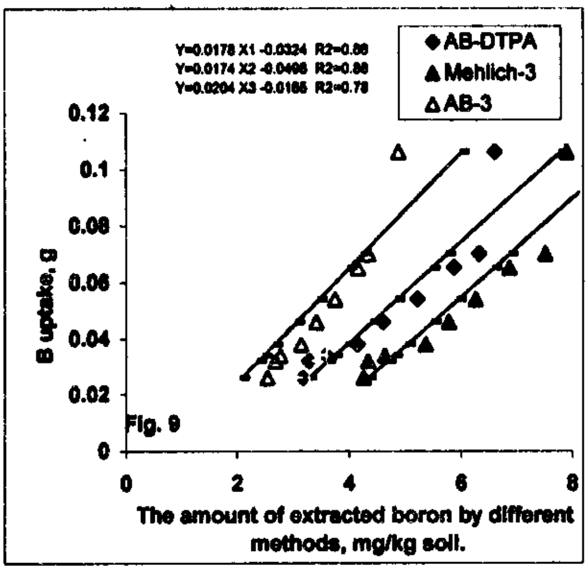

Fig 9. The relationship between B uptake, (g/pot) and extracted B by different methods, mg/kg soil, where X1=AB-DTPA, X2=Mehlich-3, X3=AB-3 and X4=Hot water.

Table 5. The correlation coefficient values between the nutrients uptake of corn plants and the extracted nutrients by the different methods.

Nutrients	Extraction methods		
	AB-DTPA	Mehlich-3	AB-3
Calcium	0.90**	0.97**	0.88**
Magnesium	0.93**	0.92**	0.70**
Potassium	0.85**	0.89**	0.97**
Phosphorus	0.83**	0.82**	0.85**
Iron	0.87**	0.96**	0.89**
Manganese	0.98**	0.97**	0.99**
Zinc	0.95**	0.98**	0.88**
Copper	0.69**	0.90**	0.96**
Boron	0.88**	0.90**	0.93**

However, field correlation and calibration studies are needed to confirm these results. Also, to establish the critical levels of the different nutrients for the important crops.

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الملخص العربي

تقييم بعض الطرق لاستخلاص عناصر غذائية متعددة لتقدير المتاح من هذه العناصر في بعض الأراضي المصرية والليبية

ماهر جورجي نسيم، ماجدة أبوالمجد حسين، جمال سعيد أحمد درياق

أجريت هذه الدراسة لإيجاد محلول كيميائي لاستخلاص العناصر الغذائية كلها أو معظمها من الأراضي المصرية والليبية ولتحديد ذلك اجريت تجارب معملية وتجربة صوب وقد تم جمع ٢٥ عينة من الساحل الشمالي الغربي لمصر و٢٠ عينة من مساحات مختلفة من الساحل الشمالي الشرقي لليبيا وذلك لوجود الأراضي الجيرية في كلا من مصر وليبيا. وقد تم تحضير ٣ محاليل كيميائية هي AB-DTPA (NH_4HCO_3) و Mehlich-3 وAB-3 (محلول جديد حضر من NH_4HCO_3+DTPA+NH_4NO_3+HOAC) استخدمت للمقارنة بطرق اختبار التربة الأخرى (خلات الأمونيوم لاستخلاص البوتاسيوم والكالسيوم والماغنسيوم وبيكربونات الصوديوم لاستخلاص الفسفور وDTPA لاستخلاص العناصر الصغرى والماء الساخن لاستخلاص البورون)، لاستخلاص المتاح للنبات من البوتاسيوم والكالسيوم والماغنسيوم والفسفور والحديد والمنجنيز والزنك زالنحاس والبورون واستخدم التحليل الاحصائي لايجاد علاقة بين الكميات المستخلصة بهذه الطرق وتحديد معامل الارتباط بينها.

وقد أوضحت النتائج امكانية تحديد المتاح من البوتاسيوم والكالسيوم والماغنسيوم والفسفور والحديد والمنجنيز والزنك والنحاس والبورون بمحلول استخلاص واحد. ولتقييم وتأكيد قدرة هذه المستخلصات تم عمل معايرة لاختبارات التربة باستخدام نبات الذرة وعمل علاقات احصائية بين المستخلص من التربة والممتص بالنبات من هذه العناصر بواسطة نبات الذرة، وقد تم استنتاج أن محلول مهلك-٣ هو الأفضل من المحلولين الآخرين كمحلول متعدد الاستخلاص سريع ورخيص يمكن استخدامه في الأراضي الجيرية ، يجب اجراء دراسات حقلية على محاصيل مختلفة لتأكيد هذه النتائج تحت ظروف الأراضي الجيرية.