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Evaluation of Some Micronutrient Chemical Extractents

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THE CURRENT work was carried out to investigate and evaluate some extracting agents commonly used for determining available Fe, Mn, Zn, and Cu. Also, the influence of soil parameters on the extractable amounts of the studied elements was considered. The investigation involved 40 surface (0 -50 cm) soil samples, 20 of them are calcareous and the others are alluvial. The obtained results showed that:-

1 - Fe, Mn, Zn and Cu extracted with DTPA ranged from 1.74- 13.0; 2.38, 22.28; 0.32 - 10.52 and 0.3 - 2.82 mg kg^{-1}, respectively in the calcareous soils, while in the alluvial soils the values ranged from 0.24-12.9; 6.2-19.2; 0.32-10.52 and 0.9-6.70 mg kg^{-1}, respectively.

2 - Fe, Mn, Zn and Cu extracted with HCl ranged from 0.45-0.55; 0.1-10.65; 0.04-0.5 and 0.1-0.45 mg kg^{-1}, respectively, in the calcareous soils. .In the alluvial soils the values ranged from 0.02-0.6; 10.8 -38.9; 0.05- 0,65 and 0.05-0.40 mg kg^{-1}, respectively.

3 - Fe, Mn, Zn and Cu extracted with NH_4OAc ranged from 0.1-1.5 0.9 - 21.1; 0.2 - 10.land 0.1 - 0.6 mg kg , respectively, in the calcareous soils, while in the alluvial soils the values ranged from 0.10-1.3; 1.9 -18.9 ; 0.5 - 1.6 and 0.3 - 0.8 mg kg^{-1} , respectively.

4 -Fe, Mn, Zn and Cu extracted with NH_4OAc ranged from 0.1 - 0.6; 0.6 - 63.1; 0.1 - 9.3 and 0.1 - 0.4 mg kg^{-1}, respectively, in the calcareous soils. In the alluvial soils, the values ranged from 0.1 -0.4; 60.0 - 84.0; 0.1 - 0.9 and 0.1 - 0.8 mg kg^{-1}, respectively.

5 - Fe, Mn, Zn and Cu extracted with H_20 ranged from 0.2-4.45; 0.1 - 0.5; 0.03 - 0.17 and 0.1-0.45 mg kg^{-1}, respectively, in the calcareous soils. In the alluvial soils, they ranged from 0.2-1.55; 0.05-0.25 ; 0.04-0.75 and 0.1 - 0.5 mg kg^{-1} , respectively.

The role of the soil variables, *e.g.* particlesize distribution, pH, organic matter contents and $CaCO_3$ % on availability of the considered elements varied depending on type of the soil extractant and the element to be studied.

Values of the correlation coeffeients between the uptake of each of the studied nutritive elements and the extractable amounts of the considered elements indicated a variable efficiency of each extracting agent dependent on the evaluated element itself.

Keywords : H_2O , DTPA, HCL, NH_4Ac.

Values of available micronutrient elements vary depending on soils characteristics and type of the extracting agent.

El-Taukhy (1987) indicated a highly significant and positive correlation between available Fe and each of clay and organic matter, while the correlation was negative with sand.

El-Demerdash *et al.* (1991) reported a highly positive sifnificant correlation between $CaCO_3$ % and extractable Mn by each of EDTA (r =0.359**) and NH_4 OAc + HQ (r = 0.600**). They added that organic matter was positively significant correlated with EDTA (r = 282*) and NH_4 HCO_3 + ETPA (r = 0.796**) extracable Mn. Also, Abd El-Kader (2000) found a negatively highly significant correlations between DTPA extractable Mn and soil pH. Barakat (1989) in his study on the alluvial soils of Egypt found positive and highly significant correlations between DTPA extraxtable Zn and each of silt % and organic matter content. On the other hand, he obtained a negative and significant correlation between DTPA-extractable Zn and BC. In the calcareous soils, Abdel-Razik (1999) found negative and highly significant correlation between available Zn and soil pH (r = 0.412**). Also, Abd BI-Kader (2000) reported that DTPA-extractable Zn was positively and highly significantly correlated with each of $CaCO_3$ %, O.M %, silt %, clay % and CEC but negatively and highly significantly correlated with sand %.

Barakat (1989) found positive and highly significant correlations between DTPA-extractable Cu and each of silt + clay and O.M %. Moreover, he found that DTPA-extractable Cu was negatively and highly significantly correlated with sand %. Abdel-Razik (1999) pointed out positive and highly significant correlation between DTPA-extractable Cu and silt % in the calcareous soils. Abdel-Kader (2000) found that the DTPA-extractable Cu was positively and highly significantly correlated with each of $CaCO_3$ %, O.M % and CEC and positively significantly correlated with silt %, clay %. On the other hand, available Cu correlated negatively and highly significantly with sand.

Holah (1977) indicated that the average values of available iron were 5.3 mg kg^{-1} in the Nile alluvial soils and 4.6 mg kg^{-1} in the sandy ones. Mohamed (1990) found that the available iron ranged between 6.0 and 20.0 mg kg^{-1} in the alluvial soils and 1.4 to 7.6 mg kg^{-1} in the calcareous ones. El-Demerdash *et al.* (1991) reported that the extraction power of iron by some employed extracting agents, in most soils, could be arranged in the following order:- HC1 > NH_4CO_3 + DTPA> EDTA ≥ NH_4OAc > DTPA>H_2O .

Taha (1980) found that DTPA extractable Mn ranged between 5.5 and 26.5 mg kg^{-1} in the alluvial soils. Mohamed (1990) reported that the chemically extractable Mn ranged between 2.2 - 6.6 mg kg^{-1} and 0.6 - 4.6 mg kg^{-1} in the alluvial and calcareous soils, respectively.

El- Toukhy (1987) showed that DTPA-extractable Zn range from 0.8 to 10.6 mg kg^{-1} with an average of 1.98 mg kg^{-1}. Mohamed (1990) reported that extractable Zn ranged between 0.4 - 2.4 mg kg^{-1} and 0.2 - 1.2 mg kg^{-1} in the alluvial and calcareous soils, respectively. Hegazy *et al* . (1991) reported that the BDTA + $CaCl_2$, DTPA and AB + DTPA extracted about 5.6,6.3 and 7.2 % of total Zn from the alluvial soils, 11.2,4.8 and 12 % of total Zn from sandy soils and about 10.8, 9.4 and 15 % of total Zn from the calcareous ones, respectively.

Hegazy *et al* . (1991) found that the BDTA + $CaCl_2$, DTPA and AB + DTPA extractants, however, extracted about 14.0, 12.9 and 16.4 % of the total Cu from the calcareous ones, respectively. Badawy (1992) reported that the values of DTPA extractable Cu in 28 samples of the soils of Egypt varied in a narrow range between 1.05 and 4.86 mg kg with an average of 3.39± 0.08 mg kg^{-1} while those of HNO_3 extractable Cu varied between 5.3 and 11.55 mg kg with an average of 8.08 ± 0.13 mg kg^{-1} .

Material and Methods

This work was carried out to elucidate the available levels of some micronutrients (Fe, Mn, Zn and Cu) in some soils of Egypt using different extracting agents. The reliabilty of the different used extractants was estimated through calculating the simple correlation between uptake of the considered element by barley plant (*Hordeum vulgare*) and its extractable amount by extracting agent.

Fourty surface soil samples (0 - 25 cm) representing alluvial and highly calcareous soils were collected. Twenty alluvial soil samples (from No. 21 to No.40) were taken from Monofia Governorate. Twenty highly calcareous soil samples (from No.1 to No.20) were taken from northern western coast at Burg El- Arab (1 - 17) and El-Fayoum Governorate (18 -20). Table1 shows some physical and chemical properties of the studied soils which were determined according to the standerad methods outlined (Piper 1950) .

The soil samples were air dried, crushed and passed through a 2mm sieve, and stored in plastic jars for laboratory analyses.

A greenhouse experiment with three replicates were conducted. Fifteen grains of barley (Giza 128) were germinated in 400 g portions of the studied soils along with 50 g of acid washed sand spread on its surface and packed unformly in plastic pots. After complete emergance, the seedlings were thinned to ten plants per pot. During the growth period, soil moisture content was maintained at field capacity using distilled water. The plants were harvested after 45 days from sowing, oven dried at 70°C, weighted, wet digested and analyzed for total Fe, Mn, Zn and Cu content. The studied micronutrients in the different soil extractants and the plant digest solutions were determined by atomic absorptions spectrophotometer.

Available contents of Fe, Mn, Zn and Cu in soils were extracted using the following regantes : -

a) Redistilled water at a soil to water ratio 1:5 (Black, 1965).
b) 0.025 % hydroquinon in ammonium acetate of pH 7.0 (Sherman *et al.*, 1942).
c) 0.005 M DTPA, pH 7.3 (Lindsay and Norvel, 1978).

All the different forms of micronutrients were determined using SP. 1960 Atomic Absorption Spectrophotometer.

Statistical analysis of trace elements- results were carried out in the Scientific Computation Center,Agric. Research Center, Giza according to Piskunon (1969).

TABLE 1. Some physical and chemical properties of the studied soils .

Prof. No.	Location	Soil type	Depth (cm)	Particle size distribution % C.S	F.S	Silt	clay	Textural class	O.M %	$CaCO_3$ %	pH	CE dSm^{-1}	Soluble cations (me/L) Ca^{2+}	Mg^{2+}	Na^+	K^+	Soluble cations (me/L) Cl^-	$CO_3^=$	HCO_3^-	$SO_4^=$
1	Borg El-Arab	Calcareous	0 - 20	90.9	6.0	1.0	2.1	S	0.28	94.0	8.3	1.6	5.2	2.0	8.0	0.30	10.0	-	3.8	1.7
2	"		0 - 20	62.3	20.6	4.0	13.1	S.L.	0.35	63.5	7.8	2.5	8.2	7.1	10.0	0.70	14.0	-	4.8	1.2
3	"		0 - 20	26.2	42.6	14.1	17.0	S.C.L.	0.29	58.2	8.1	1.9	4.6	8.6	5.0	0.90	14.0	-	4.0	1.1
4	"		0 - 20	34.6	46.3	6.1	13.0	S.L.	0.31	34.8	7.9	60.6	31.2	194	306	0.10	511	-	2.5	17.8
5	Bahig		0 - 15	1.8	45.0	22.1	31.1	Light C.	0.36	35.2	8.1	1.4	4.1	2.2	6.5	0.30	8.0	-	4.2	0.90
6	Dear Mina		0 - 20	18.2	40.7	13.9	27.2	S.C.	0.29	56.2	8.3	3.0	9.3	6.0	14.2	0.50	17.0	-	4.8	8.2
7	"		0 - 20	13.0	41.9	18.1	27.1	Light C.	0.35	39.9	7.8	1.4	6.7	2.0	4.6	0.40	7.0	-	5.2	1.5
8	"		0 - 20	10.3	46.6	18.0	25.1	S.C.	0.31	43.8	8.0	1.9	8.2	5.5	4.5	0.90	6.0	-	8.8	4.3
9	El-Hammam		0 - 20	56.2	28.7	4.5	10.6	S.C.	0.28	62.2	8.0	6.8	28.3	28.8	8.9	1.8	44.0	-	4.0	21.6
10			0 - 20	74.5	12.4	2.1	11.1	L.S.	0.29	65.2	8.3	1.1	6.2	1.5	2.9	0.60	6.0	-	3.4	1.8
11	"		0 - 20	63.6	21.3	4.0	11.1	L.S	0.26	33.5	8.4	0.90	5.2	0.5	2.8	0.20	4.0	-	3.8	1.1
12	"		0 - 20	70.6	18.2	4.5	6.6	L.S	0.28	36.5	8.2	1.8	7.7	3.0	7.2	0.50	7.0	-	2.6	8.8
13	"		0 - 20	68.1	20.8	4.0	7.1	L.S.	0.13	30.0	8.3	0.55	4.0	0.40	0.8	0.30	1.0	-	3.8	0.70
14	"		0 - 15	83.6	5.3	2.1	7.0	L.S.	0.28	33.5	8.3	1.8	10.8	1.4	5.1	0.80	12.0	-	3.0	3.1
15	El-Hammam		0 - 20	56.8	30.0	2.6	10.3	L.S.	0.26	34.8	8.6	1.7	4.2	2.5	9.9	0.70	12.0	-	4.0	1.3
16	King Maryot		0 - 25	12.8	46.1	16.5	24.6	S.C.L.	0.37	27.9	7.8	3.4	12.4	6.0	14.4	0.60	15.0	-	7.4	11.0
17	"		0- 25	12.5	44.4	17.9	25.2	S.C.	0.30	42.9	8.2	1.9	5.7	3.5	9.8	0.40	10.0	-	4.2	5.2
18	Tamia		0 - 15	17.2	54.2	15.5	13.9	S.L	0.40	19.5	7.2	17.8	28.4	27.8	184	3.0	182	-	2.6	58.1
19	"		0 - 15	38.1	15.9	8.5	17.1	S.L.	0.77	16.6	7.3	71.5	27.4	247	270	3.7	535	-	4.5	9.6
20	Com Oshim		0 - 15	24.2	39.8	22.7	13.1	S.L.	0.18	21.2	7.4	81.0	125.7	170	1150	18.8	1266	-	4.0	195
21	Ashmun	Alluvial	0 - 20	17.6	17.4	22.0	43.0	C.	2.4	3.2	7.8	1.6	5.2	4.0	5.9	0.78	10.0	--	3.2	2.6
22	"		0 - 25	7.4	32.6	15.0	45.0	C.	1.5	4.1	8.1	0.56	2.6	1.5	1.7	0.10	2.0	-	2.0	1.8
23	Minuf		0- 25	16.1	27.9	21.0	35.0	C.L.	2.2	3.0	7.9	2.2	6.2	7.0	10.1	0.38	8.0	-	3.2	12.6
24	"		0 - 25	10.5	25.5	15.0	50.0	C.	2.0	3.1	8.2	0.98	2.6	4.5	3.2	0.15	5.0	--	3.0	2.5
25	EL - Bagur		0 - 25	12.0	20.5	22.5	45.0	C.	2.0	3.1	8.2	1.2	3.1	4.5	4.1	0.40	6.0	--	3.4	2.8
26	"		0 - 25	13.0	29.5	22.5	35.0	C.L.	1.6	2.2	8.0	0.68	3.1	3.5	0.83	0.10	3.0	-	2.6	2.0
27	"		0 - 25	30.0	22.6	22.5	25.0	S.C.L.	1.9	2.6	8.2	1.0	2.1	6.1	3.5	0.35	4.0	-	4.2	3.8
28	Shibin El-Kome		0 - 25	10.5	31.5	20.5	37.5	C.L.	2.4	1.9	8.0	1.1	4.2	5.0	2.4	0.50	4.0	-	5.2	2.9
29	"		0 - 25	12.8	29.7	15.0	42.5	C.	2.1	3.3	8.1	2.2	2.6	12.7	7.8	0.40	9.0	--	2.8	11.7
30	"		0 - 25	8.2	19.4	17.5	55.0	C	1.7	2.8	7.9	4.5	11.4	13.0	21.8	0.50	20.0	--	2.2	24.5
31	Quweisna		0 - 25	9.9	17.7	22.5	50.0	C	2.2	3.3	7.8	1.6	5.7	8.6	3.2	0.57	7.0	-	3.2	7.8
32	Berket El- Sabe		0 - 25	12.8	24.8	20.0	42.5	C	2.3	3.2	8.1	3.3	9.4	11.0	14.1	0.38	9.0	-	3.7	22.2
33	"		0 - 25	6.3	16.3	35.0	42.5	C	1.3	2.5	8.2	0.69	3.1	0.96	3.1	0.10	4.0	-	3.0	0.32
34	Tala		0 - 25	4.0	13.5	30.0	52.5	C.	1.7	2.4	8.2	1.4	5.2	4.0	4.0	0.20	4.0	-	2.6	6.7
35	Tala		0 - 25	11.3	21.3	17.5	50.0	C.	1.8	3.7	7.9	3.2	22.9	7.7	2.3	0.48	4.0	-	2.0	27.3
36	Tala		0 - 25	13.1	22.0	23.0	42.0	C.	2.0	2.5	8.2	1.2	4.7	2.5	3.4	0.48	3.0	-	3.2	4.9
37	El-Shuhada		0 - 25	7.80	19.7	17.5	55.0	C.	1.7	2.7	8.3	0.71	2.6	3.1	2.0	0.40	3.0	-	3.2	1.8
38	"		0 - 25	10.1	17.4	20.0	52.5	C.	1.9	2.2	8.2	1.5	4.7	7.1	4.0	0.40	7.0	-	3.5	5.6
39	"		0 - 25	9.5	25.0	27.5	38.0	C.	1.9	2.6	8.1	0.92	4.7	2.5	2.2	0.57	3.0	-	2.2	4.7
40	El-Sadat		0 - 20	42.2	12.6	19.0	26.3	C.	1.5	0.69	7.9	0.69	2.6	3.0	2.2	0.42	4.0	-	4.2	0.04

L. S. = Loamy sand S = Sand S.L. = Sandy Loam C = Clay S C L = Sandy Clay Loam C S = Coarse sand F S. = Fine sand

Results and Discussion

Extraction of the available contents of the studied micronutrients

Several methods have been proposed for extraction of what could be considered available Fe, Mn, Zn and Cu. The most important methods are DTPA, 0.1 N HCl solution, ammonium acetate of pH 7.0 and distilled water (Hegazy *et al.* 1991; Barakat, 1989 and Abdel Kader, 2000).

DTPA-extractable micronutrients

Data illustrated in Tables 2-5 represent the amount of DTPA extractable Fe, Mn, Zn and Cu from the studied soil samples. The amounts of DTPA extractable-Fe ranged from 1.14 to 13.34 mg kg^{-1} in the calcareous soils. The corresponding values of Mn ranged from 2.30 to 22.28 mg kg^{-1} soil where those of Zn ranged from 0.32 to 52 mg kg^{-1} and those of Cu fluctated between 0.30 to 2.82 mg kg^{-1}.

Considering the amounts of the abovementioned DTPA extractable micronutrients from the alluvial soils, data in Tables 2- 5 reveal that Fe, ranged from 0.24 to 11.80 mg kg^{-1} . Mn, Zn and Cu were found within the ranges of 6.2 to 19.12, 0.62 to 3.24 and 0.90 to 6.70 mg kg^{-1}, respectively. These results are similar to those of Tadross (1997) and Abd El-Kader (2000). Variations among the results found by the authors and the aformentioned investigators might be attributed to variation in physical and chemical properties of the investigated soils besides of the variations in the agricultural management of the used soils, *e.g.* fertilization, irrigation and pestsides controlling which add different quantities of Fe, Mn, Zn and Cu to the soils.

HCl-extractable micronutrients (Tables 2-5)

Values of Fe, Mn, Zn and Cu extracted with HCl ranged from 0.04 to 0.55,0.1 to 10.65,0.04 to 0.5 and 0.1 to 0.45 mg kg^{-1}, respectively in the calcareous soils. In the alluvial soils, the coresponding values were 0.02 to 0.6, 10.8 to 38.9, 0.05 to 0.65 and 0.05 to 0.4 mg kg^{-1} , respectively.

NH_4 OAc-extractable micronutrients (Tables 2-5)

Values of NH_4 OAc extractable Fe varied from 0.1 to 1.50 mg kg^{-1} in the calcareous soils. The corresponding values of Mn, Zn and Cu in the same soils ranged from 0.9 to 21.05,0.2 to 10.1 and 0.1 to 0.6 mg kg^{-1} soil, respectively.

The amounts of the abovementioned nutrients in the alluvial soils fluctuated between 0.1 to 1.3,1.9 to 18.9,0.5 to 1.6 and 0.3 to 0.8 mg kg^{-1}, respectively.

TABLE 2. Extractability of available iron using different methods of extraction.

Sample No.	Location	Soil type	Depth	Extractable iron (mg/kg) using				
				DTPA	0.1 N HCl	NH_4OAc pH 7.0	NH_4OAc+ 0.2% hydroquinone	Distilled water
1	Borg El-Arab	Calcareous	0 - 20	1.1	0.10	0.10	0.20	1.5
2	"		0 - 20	3.5	0.20	0.90	0.20	1.5
3	"		0 - 20	2.0	0.05	0.40	0.20	1.5
4	"		0 - 20	4.8	0.35	0.50	0.20	4.5
5	Bahig		0 - 15	5.6	0.05	0.30	0.20	2.9
6	Dear Mina		0 - 20	2.3	0.70	0.70	0.10	1.4
7	"		0 - 20	5.4	0.10	1.10	0.30	2.0
8	"		0 - 25	3.7	0.10	0.90	0.10	2.4
9	El-Hammam		0 - 20	1.7	0.10	0.40	0.20	0.65
10	"		0 - 20	2.1	0.40	0.60	0.50	0.90
11	"		0 - 20	1.8	0.10	0.30	0.20	0.55
12	"		0 - 20	2.6	0.05	0.60	0.60	0.90
13	"		0 - 20	1.8	0.05	0.20	0.10	0.50
14			0 - 15	2.6	0.55	0.60	0.20	0.80
15	El-Hammam		0 - 20	2.4	0.60	0.70	0.30	0.95
16	King Maryot		0 - 25	13.0	0.25	0.40	0.10	1.1
17	"		0- 25	2.8	0.05	0.30	0.10	0.45
18	Tamia		0 - 15	10.6	0.05	0.20	0.20	0.20
19	"		0 - 15	13.3	0.05	0.10	0.10	0.20
20	Com Oshim		0 - 15	4.6	0.04	1.5	0.20	0.35
21	Ashmun	Alluvial	0 - 20	10.1	0.10	0.50	0.30	0.30
22	"		0 - 25	8.3	0.04	0.40	0.20	0.30
23	Minuf		0- 25	0.34	0.15	0.20	0.10	0.95
24	"		0 - 25	0.24	0.20	0.30	0.30	0.65
25	EL - Bagur		0 - 25	6.9	0.20	0.30	0.20	0.95
26	"		0 - 25	12.9	0.20	0.90	0.30	0.25
27	"		0 - 25	10.8	0.40	0.60	0.20	0.60
28	Shibin El-Kome		0 - 25	10.6	0.55	0.60	0.20	0.80
29	"		0 - 25	9.0	0.50	0.70	0.30	0.85
30	"		0 - 25	11.8	0.40	0.60	0.10	0.68
31	Quweisna		0 - 25	9.1	0.20	0.10	0.20	0.25
32	Berket El- Sabe		0 - 25	9.7	0.02	0.20	0.20	0.45
33	"		0 - 25	11.3	0.20	0.20	0.20	0.20
34	Tala		0 - 25	11.1	0.30	0.40	0.30	0.65
35	Tala		0 - 25	11.8	0.50	0.60	0.50	0.85
36	Tala		0 - 25	9.4	0.60	0.60	0.40	1.3
37	El-Shuhada		0 - 25	5.6	0.25	1.30	0.30	1.6
38	"		0 - 25	10.3	0.25	0.30	0.30	0.55
39	"		0 - 25	5.6	0.20	0.50	0.30	0.60
40	El-Sadat		0 - 20	2.8	0.20	0.50	0.30	0.60

TABLE 3. Extractability of available manganese using different methods of extraction.

Sample No.	Location	Soil type	Depth	Extractable manganese (mg/kg) using				
				DTPA	0.1 N HCl	NH_4OAc pH 7.0	NH_4OAc + 0.2% hydroquinone	Distilled water
1	Borg El-Arab	Calcareous	0 - 20	3.5	2.8	2.9	0.60	0.25
2	"		0 - 20	11.0	0.75	5.0	44.8	0.25
3	"		0 - 20	13.2	0.30	12.5	24.8	0.10
4	"		0 - 20	11.9	10.6	11.0	32.2	0.20
5	Bahig		0 - 15	22.3	0.25	21.0	53.9	0.35
6	Dear Mina		0 - 20	2.3	0.80	1.8	15.9	0.20
7	"		0- 20	5.3	0.20	1.2	19.9	0.25
8	"		0 - 25	6.0	0.25	0.90	8.3	0.50
9	El-Hammam		0 - 20	3.4	0.30	1.3	6.0	0.15
10	"		0- 20	3.3	4.0	6.5	10.6	0.10
11	"		0- 20	2.4	0.40	1.8	19.0	0.15
12	"		0- 20	2.8	0.20	1.9	11.5	0.10
13	"		0- 15	2.4	4.9	1.4	18.1	0.15
14			0 - 20	5.3	1.9	2.2	4.9	0.10
15	El-Hammam		0- 20	4.7	4.9	1.5	7.2	0.15
16	King Maryot		0 - 25	13.8	0.10	1.1	63.1	0.10
17	"		0- 25	6.3	0.10	1.4	7.9	0.50
18	Tamia		0 - 15	8.8	1.9	7.5	9.5	0.10
19	"		0 - 15	9.6	4.0	8.5	15.5	0.20
20	Com Oshim		0 - 15	8.6	1.0	4.8	15.9	0.14
21	Ashmun	Alluvial	0 - 20	12.9	27.6	6.0	60.0	0.20
22	"		0 - 25	13.0	10.8	2.2	62.0	0.15
23	Minuf		0- 25	12.6	29.2	4.0	70.0	0.10
24	"		0 - 25	14.2	32.1	4.2	66.0	0.15
25	EL - Bagur		0 - 25	10.0	25.3	2.1	64.1	0.10
26	"		0 - 25	11.0	33.1	4.1	69.1	0.10
27	"		0 - 25	10.1	35.1	8.7	70.0	0.15
28	Shibin El-Kome		0 - 25	6.2	30.8	2.1	84.0	0.15
29	"		0 - 25	11.5	37.1	1.9	78.9	0.25
30	"		0 - 25	9.6	37.1	41.4	65.0	0.20
31	Quweisna		0 - 25	9.9	38.9	5.5	62.4	0.10
32	Berket El- Sabe		0 - 25	10.2	13.0	2.4	81.9	0.10
33	"		0 - 25	6.2	17.0	3.4	80.0	0.10
34	Tala		0 - 25	19.1	12.0	18.9	81.0	0.10
35	Tala		0 - 25	15.4	28.6	10.1	74.0	0.15
36	Tala		0 - 25	14.9	35.2	9.3	69.0	0.10
37	El-Shuhada		0 - 25	10.8	32.2	105	78.0	0.10
38	"		0 - 25	16.2	35.1	14.7	82.0	0.10
39	"		0 - 25	13.3	31.1	11.2	81.0	0.05
40	El-Sadat		0 - 20	13.5	35.1	8.7	70.9	0.10

TABLE 4. Extractability of available zinc using different methods of extraction.

Sample No.	Location	Soil type	Depth	Extractable zinc (mg/kg) using				
				DTPA	0.1 N HCl	NH_4OAc pH 7.0	NH_4OAc+ 0.2% hydroquinone	Distilled water
1	Borg El-Arab	Calcareous	0 - 20	2.5	0.05	2.1	1.0	0.05
2	"		0 - 20	2.6	0.05	2.2	1.8	0.05
3	"		0 - 20	2.3	0.05	1.7	1.2	0.04
4	"		0 - 20	10.5	0.04	10.1	9.3	0.15
5	Bahig		0 - 15	1.3	0.05	0.80	0.40	0.10
6	Dear Mina		0 - 20	0.38	0.05	0.20	0.10	0.05
7	"		0 - 20	0.32	0.05	0.20	0.10	0.10
8	"		0 - 25	0.98	0.05	0.40	0.20	0.10
9	El-Hammam		0 - 20	0.92	0.05	0.60	0.50	0.05
10	"		0 - 20	0.94	0.10	0.60	0.30	0.05
11	"		0 - 20	1.8	0.04	1.4	1.2	0.10
12	"		0 - 20	0.72	0.04	0.60	0.40	0.17
13	"		0 - 20	0.80	0.10	0.70	0.10	0.04
14			0 - 15	0.96	0.05	0.80	0.70	0.04
15	El-Hammam		0 - 20	1.0	0.05	0.80	0.60	0.05
16	King Maryot		0 - 25	0.88	0.15	0.60	0.10	0.05
17	"		0 - 25	0.58	0.04	0.40	0.10	0.04
18	Tamia		0 - 15	0.86	0.20	0.70	0.30	0.15
19	"		0 - 15	2.4	0.30	0.90	0.80	0.30
20	Com Oshim		0 - 15	2.3	0.50	1.1	0.90	0.3
21	Ashmun	Alluvial	0 - 20	0.62	0.05	0.50	0.20	0.10
22	"		0 - 25	1.4	0.40	1.1	0.90	0.05
23	Minuf		0- 25	1.8	0.10	0.80	0.60	0.10
24	"		0 - 25	2.8	0.15	0.90	0.30	0.15
25	EL - Bagur		0 - 25	0.98	0.05	0.80	0.10	0.15
26	"		0 - 25	0.92	0.15	0.70	0.10	0.05
27	"		0 - 25	1.2	0.40	0.90	0.60	0.05
28	Shibin El-Kome		0 - 25	1.6	0.15	0.90	0.10	0.05
29	"		0 - 25	3.2	0.50	1.00	0.80	0.10
30	"		0 - 25	2.3	0.20	0.90	0.50	0.04
31	Quweisna		0 - 25	2.5	0.20	1.0	0.40	0.10
32	Berkēt El- Sabe		0 - 25	2.2	0.25	1.1	0.30	0.05
33	"		0 - 25	0.94	0.45	0.80	0.50	0.75
34	Tala		0 - 25	1.7	0.20	1.0	0.40	0.05
35	Tala		0 - 25	1.9	0.25	1.2	0.60	0.05
36	Tala		0 - 25	1.8	0.45	0.90	0.50	0.05
37	El-Shuhada		0 - 25	1.6	0.15	1.3	0.30	0.05
38	"		0 - 25	2.9	0.65	1.6	0.80	0.05
39	"		0 - 25	1.0	0.70	0.70	0.60	0.04
40	El-Sadat		0 - 20	0.2	1.40	1.4	0.30	0.04

TABLE 5. Extractability of available copper using different methods of extraction.

Sample No.	Location	Soil type	Depth	Extractable copper (mg/kg) using				
				DTPA	0.1 N HCl	NH_4OAc pH 7.0	NH_4OAc+ 0.2% hydroquinone	Distilled water
1	Borg El-Arab	Calcareous	0- 20	0.30	0.10	0.10	0.10	0.10
2	"		0- 20	0.42	0.15	0.30	0.30	0.15
3	"		0- 20	0.46	0.45	0.60	0.50	0.16
4	"		0 - 25	0.82	0.20	0.60	0.30	0.20
5	Bahig		0 - 15	1.2	0.15	0.30	0.30	0.15
6	Dear Mina		0 - 20	0.76	0.15	0.30	0.30	0.15
7	"		0- 20	0.64	0.20	0.60	0.40	0.20
8	"		0 - 25	0.62	0.20	0.50	0.40	0.20
9	El-Hammam		0 - 20	0.84	0.15	0.50	0.40	0.15
10	"		0- 20	0.86	0.15	0.50	0.40	0.15
11	"		0- 20	0.78	0.20	0.50	0.40	0.20
12	"		0- 20	0.71	0.15	0.40	0.40	0.15
13	"		0- 20	0.80	0.15	0.50	0.30	0.20
14			0 - 20	0.80	0.20	0.40	0.30	0.20
15	El-Hammam		0- 20	0.94	0.20	0.50	0.30	0.15
16	King Maryot		0 - 25	1.3	0.25	0.50	0.30	0.20
17	"		0- 25	0.56	0.25	0.50	0.30	0.20
18	Tamia		0 - 15	1.5	0.24	0.50	0.10	0.45
19	"		0 - 15	2.8	0.22	0.50	0.36	0.35
20	Com Oshim		0 - 15	1.1	0.08	0.50	0.42	0.30
21	Ashmun	Alluvial	0 - 20	3.8	0.30	0.80	0.40	0.45
22	"		0 - 25	4.0	0.20	0.60	0.30	0.30
23	Minuf		0- 25	4.4	0.15	0.70	0.30	0.50
24	"		0 - 25	5.5	0.30	0.60	0.30	0.40
25	EL - Bagur		0 - 25	2.8	0.10	0.50	0.30	0.35
26	"		0 - 25	0.90	0.05	0.30	0.30	0.35
27	"		0 - 25	3.4	0.10	0.60	0.40	0.40
28	Shibin El-Kome		0 - 25	4.1	0.10	0.50	0.40	0.45
29	"		0 - 25	4.8	0.20	0.80	0.80	0.50
30	"		0 - 25	5.6	0.40	0.60	0.50	0.50
31	Quweisna		0 - 25	4.0	0.30	0.60	0.40	0.45
32	Berket El- Sabe		0 - 25	5.6	0.10	0.60	0.30	0.45
33	"		0 - 25	3.8	0.15	0.50	0.20	0.30
34	Tala		0 - 25	5.9	0.15	0.70	0.20	0.35
35	Tala		0 - 25	6.7	0.15	0.60	0.30	0.35
36	Tala		0 - 25	3.4	0.25	0.50	0.30	0.40
37	El-Shuhada		0 - 25	2.3	0.20	0.60	0.30	0.35
38	"		0 - 25	3.0	0.25	0.60	0.30	0.40
39	"		0 - 25	3.9	0.15	0.50	0.10	0.10
40	El-Sadat		0 - 20	3.0	0.25	0.60	0.30	0.45

NH_4OAc + hydroquinone extractable micronutrients (Tables 2-5)

The amounts of NH_4OAc + hydroquinone extractable Fe, Mn, Zn and Cu were relatively lower in the calcareous than the alluvial soils. The ranges of these elements, in respective, were 0.1 to 0.6,0.6 to 63.1,0.1 to 9.3 and 0.1 to 0.4 mg kg^{-1} in the calcareous soils. The corresponding ranges of the aforementioned micronutrients in the alluvial soils were 0.1 to 0.4,60.0 to 84.0,0.1 to 0.9 and 0.1 to 0.8 mg kg^{-1}, respectively.

Distilled water extractable micronutrients (Tables 3- 6)

Values of water extractable Fe, Mn, Zn and Cu ranged from 0.2 to 4.45, 0.1 to 0.5, 0.03 to 0.17 and 0.1 to 0.45 mg kg^{-1} in the calcareous soils. The values of water extractable Fe, Mn, Zn and Cu from the alluvial soils located within the ranges 0.2 to 1.55, 0.05 to 0.25, 0.04 to 0.75 and 0.1 to 0.5 mg kg^{-1}, respectively.

The extracting power of the employed extractants

The differences in the amounts of extractable micronutrients manifest the effectiveness of the studied extractants for releasing these micronutrients in forms could be considered available for plant . Yet it is worthy to indicate that type of the extracting agent is not the only factor that affects the amount extracted from each element, but also physical and chemical properties of the considered soils are of major concern in this respect.

The previously mentioned data reveal that the extracting power of the employed extractants for Fe can be arranged in the following order :- DTPA > H_2O > NH_4OAc > HCL > NH_4OAc + hydroquinone .

This means that DTPA was more superior than the other used ones. This finding stands in well agreement with those of Hassanain *et al.* (1980) . However, this trend is to, a great extent, different from that revealed by results of El-Denzerdashe *et al.* (1991) which were, for most of the tested soils, HCI > NH_4OAc > DTPA> H_2O.

With regard to the amounts of Mn extractable by the different studied extractants, the following descending order was detected in the calcareous soils:- NH_4OAc+ hydroquinone > DTPA> NH_4OAc> HCl> H_2O.

TABLE 6. Dry matter yield (g /pot) and micronutrient (Fe, Mn, Zn and Cu) concentration (µg/g) and uptake (mg/g) by barley plants .

Sample No.	Location	Soil type	Dry matter (g/pot)	Fe		Mn		Zn		Cu	
				Conc. (µg/gram)	Uptake (µg/pot)	Conc. (µg/gram)	Uptake (µg/pot)	Conc. (µg/gram)	Uptake (µg/pot)	Conc. (µg/gram)	Uptake (µg/pot)
1	Borg El-Arab	Calcareous	1.06	208	219	48	49	7	7	9	12
2	"		1.13	175	197	38	43	11	12	5	5
3	"		0.67	158	105	61	41	15	10	7	4
4	"		-	-	-	-	-	-	-	-	-
5	Bahig		0.41	277	113	66	27	27	11	6	2
6	Dear Mina		0.50	218	109	53	26	42	21	7	4
7	"		0.79	181	141	49	39	27	21	5	4
8	"		0.97	158	153	48	47	26	25	8	8
9	El-Hammam		0.37	196	72	44	16	30	11	6	2
10	"		0.30	170	50	32	10	13	4	6	2
11	"		0.48	157	75	89	43	23	11	7	3
12	"		0.50	125	62	42	21	30	15	6	3
13	"		0.30	268	79	61	18	84	25	8	2
14			0.45	178	86	54	24	75	34	9	4
15	El-Hammam		0.53	161	83	52	29	95	50	8	4
16	King Maryot		1.31	216	177	45	61	75	98	8	10
17	"		0.65	167	108	89	58	85	55	8	5
18	Tamia		1.05	300	316	39	42	93	100	11	12
19	"		-	-	-	-	-	-	-	-	-
20	Com Oshim		-	-	-	-	-	-	-	-	-
21	Ashmun	Alluvial	1.14	437	496	73	83	87	99	20	15
22	"		0.96	279	266	70	67	67	64	9	9
23	Minuf		1.51	297	447	90	135	68	103	12	17
24	"		1.49	228	341	97	145	80	119	8	9
25	EL - Bagur		1.83	216	395	66	120	66	121	9	16
26	"		1.61	503	808	68	109	84	134	10	16
27	"		1.46	458	668	75	110	75	109	9	13
28	Shibin El-Kome		1.25	263	330	65	106	83	104	10	13
29	"		1.35	197	266	66	90	87	117	11	15
30	"		1.42	275	391	90	128	69	107	10	14
31	Quweisna		1.47	377	554	67	94	73	107	11	16
32	Berket El- Sabe		1.69	179	303	71	120	75	127	10	16
33	"		1.30	194	252	92	120	54	70	10	13
34	Tala		1.67	265	443	92	153	89	147	11	20
35	Tala		2.15	327	703	77	165	86	185	11	23
36	Tala		1.36	515	700	83	112	70	95	9	12
37	El-Shuhada		1.46	634	926	73	107	77	112	10	15
38	"		3.02	575	1167	81	165	24	48	10	20
39	"		1.22	243	296	67	81	71	86	12	15
40	El-Sadat										

This means that NH_4OAc hydroquinone was the most effective extractant for Mn in the calcareous soils. Likewise, it was also found that the same extractant could extract more amounts of available Mn than the other methods did from the alluvial soils. However, the order of the extracting agent differed somewhat from that observed in the calcareous soils since the efficiency of the extracting agents followed the descending order :

NH_4OAc + hydroquinone > HCl > DTPA> NH_4 OAc >H_2O.

The superiority of NH_4OAc + hydroquinon over the other extracting agent was reported also by Hegazy *et al* (1991) for the alluvial and sandy soils, while in the calcareous soils, the same authors revealed that this extracting agent was less efficient though its efficiency remained more than most of the other used extracting agents. El- Demerdashe *et al.* (1991), on the other hand, indicated the superiority of DTPA over NH_4OAc + hydroquinone for extracting available manganese.

The comparison between powerful of the methods used for extracting available Zn revealed the following descending order: -

DTPA > NH_4OAc > NH_4OAc + hydroquinone > HCl>H2O.

Hegazy *et al (*1991) found that AAAC + EDTA was more efficient than DTPA for extracting Zn from sandy, calcareous and alluvial soils and attributed their finding to the lower initial pH of AAAC + EDTA (4.65).

The data presented in Tables 2-5 revealed that DTPA extracted more Cu than any of the other used extracting agents. Distilled water was the weakest agent in this concern in the calcareous soils whereas HCl was the weakest one in the alluvial soils. Thus two different orders characterized powerful of Cu-extracting agents, *i.e.* (1) in the calcareous soils: -

DTPA > NH_4OAc > H_2O >NH_4OAc + hydroquinone > HCl.
(2) in the alluvial soils:-
DTPA > NH_4OAc > H_2O >NH_4OAc + hydroquinone> HCl.

Effect of soil properties on extractability of Fe, Mn, Zn and Cu

Effect of soil pH

Statistical data commonly revealed a negative effect of $CaCO_3$ on extractability of Fe, Mn, Zn and Cu, however, such an effect was not significant except in case of HCl extractable Fe and H_2O-extractable Cu where significant correlations were found between each of them and soil pH (r = -0.356* and 0.341*, respectively). Also, a highly significant correlation was detected between DTPA extractable Fe and soil pH.

The negative effect of soil pH on extractability micronutrients was also found by many investigators such as Stevenson (1986), Singh and Raj (1992), Iwaski *et al.* (1993), Maji *et al.* (1993), Tadros (1997) and Abd El-Kader (2000).

Effect of soil content of soluble salts

Soil content of soluble salts expressed in EC of the soil paste extract did not show, generally, a significant effect on extractability of Fe, Mn, Zn and Cu, however positively and highly significant correlations could be achieved between it and each of DTPA, NH_4OAc and NH_4OAc+hydroquinone extractable Zn (r=0.4532*, 0.441 and 0.492*, respectively).

Effect of soil texture

The soil content of the sand fraction seemed to be of neglected effect on extractability of Zn. However, this fraction could be correlated significantly with NH_4OAc+hydroquinone and HCl extractable Fe (r=0.336* and 0.395); HCl extractable Mn (r=0.356*); DTPA extractable Cu (r= 0.313*). It also could be correlated with H_2O extractable Mn at a high level of significancy (r=0.422**). The negative relation between the soil content of the sand fraction and extractability of the micronutrients was reported by many investigators (Tisdale *et al*, 1985; Shuman, 1985; Tadross, 1997 Abd El-Kader 2000). On the other hand, positive influnces of either clay or silt fraction were observed on extractability of Fe (Perez *et al.*, 1994; Dahne and Shukla, 1995 and Abd El-Kader, 2000),Mn (Preveen *et al.*, 1993.; Perez *et al.*, 1994; Tadross, 1997), Zn (Sheeja *et al.*, 1993; Dhane and Shukla, 1995; Abd El-Kader,2000) and Cu (El-Toukhy, 1987, Preveen *et al.*, 1993; Abd El-Kader, 2000).

Effect of soil content of $CaCO_3$

A negative relation could be detected due to $CaCO_3$ on availability of Fe, Mn, Zn and Cu. Statistical revealed highly significant and negative correlations between $CaCO_3$ and each of DTPA extractable Fe and Cu (r=0.647** and -0.7 16**, respectively); HCl-extractable Mn and Zn (r=0.689 ** and -0.588 **, respectively) and NH_4OAc+hydroquinone extractable Mn (r=0.714**). The depressive effect of $CaCO_3$ on extractability of Fe was reported by Kishk *et al.* (1980), Hafez *et al.* (1992) and Tadross (1997). Such an effect might be attributed to the influence of soil content of $CaCO_3$ on increasing rate of conversion of Fe^{+3} to Fe^{+2} oxide which is less readily available (Loepprt and Clerke, 1984). Also, negative correlations were found between $CaCO_3$ and each of Mn (El-Demerdashe *et al.*, 1991 and Abd El- Kader, 2000), Zn (Sheeja *et al.*, 1993; El-Hussieny, 1995) and Cu (Rabie *et al.*, 1989).

Unlike the depressive effect of $CaCO_3$ on the extractability of Fe, Mn, Zn and Cu shown above, the $CaCO_3$ seemed to be of a positive effect on H_20 extractable Fe, Mn and Cu (r= 0.416,* 0.431* and 0.797**).

Effect of soil content of organic matter

The organic matter content of soil was correlated positively with each of DTPA extractable Fe, Mn and Cu (r = 0.5247 ** and 0.4878** and 0.8488**, respectively); HCl extractable Mn and Zn (r = 0.8928** and 0.4352**, respectively). NH_4OAc extractable Cu (r = 0.5409*); NH_4OAc+ hydroquinone extractable Mn (r = 0.8694**) and H_2O extractable Cu (r = 0.7931**) at high level of significancy. H_2O extractable Mn was correlated significantly but negatively with soil content of organic matter (r = - 0.3298*).

These results agree to some extent, with those of El-Toukhy (1987), Dhane and Shukla (1995) and Tadross (1997). Stevaneon (1986) who reported that the action of organic matter can be attributed to its ability in lowering soil pH and to the formation of metal chelates.

Biological evaluation of the methods used for extracting Fe, Mn, Zn and Cu

Data in Table 5 show values of plant uptake of different studied micronutrients. Values of correlation coefficients revealed that only DTPA extractable Fe was correlated highly significantly with Fe uptake (r = 0.574**). This finding is expected since the DTPA soil test (Lindsay and Norvell 1978) has been widely accepted for the routine estimation of plant available Fe. Geiger and Loeppert (1986) attributed that to the ability of DTPA to extract labile forms of Fe from the soil as the plant is able to extract the same labile Fe forms.

Values of correlation coefficients reveal that DTPA, HCl and NH_4OAc + hydroquinone extractable Mn were correlated highly significantly with values of Mn uptake. However, these correlation coefficients indicate to the superiority of the NH_4OAc +hydroquione over the other extracting agents for estimating available Mn.

Correlation coefficient values illustrate that non of the used extracting agents except for HCl extractant, could be considered a reliable agent for estimating available Cu. HCl extractable Cu although was correlated significantly with Cu uptake, yet it seems better to investigate other methods for determining available Cu in such soils under study (Iwasaki *et al.*, 1993, Maji *et al.*, 1993, and Abd El Kader, 2000).

DTPA extractable Zn seemed to be the most favorite extractant for available Zn, H_2O and NH_4OAc extractable for Zn but to lower extents.

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تقييم بعض المستخلصات الكيمائية للعناصر الغذائية الصغرى

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أجرى هذا العمل لبحث وتقييم بعض المستخلصات الشائعة فى تقدير الحديد والمنجنيز والنحاس والزنك الميسرين وأيضا تأثير بعض خواص التربة على الكميات المستخلصة من العناصر موضع الدراسة. وقد تضمن البحث ٤٠ عينة تربة سطحية (صفر-٥٠سم) عشرون منها جيرية والباقى روسوبية ويمكن تلخيص أهم النتائج التم تم التحصل عليها فيما يلى :-

١-تراوحت قيم الحديد والمنجنيز والزنك والنحاس المستخلصة بواسطة DTPA من ١,٧٤-١٣ ,٢,٣٨-٢٨ ,٢٢ ,٣٢ ر-٠٥٢ , ١ ,٣ر- ٢,٨٢ مليجرام/كيلو جرام على الترتيب فى الأراضى الجيرية فى حين أنه فى الأراضى الرسوبية تراوحت هذه القيم بين ٢٤ر-٩ر١٢- ٢ر٦-٢ر١٩ ,٣٢ر - ٥٢ ,١٠، ٩ر-٦,٧ مليجرام/كيلو جرام على الترتيب .

٢- تراوحت قيم الحديد والمنجنيز والزنك والنحاس المستخلصة بواسطة حامض HCL من ٤٥ر -٥٥ر ،١ر-١٠,٥٦ ،٤٠ر -٥ر ، ١ر-٤٥ر مليجرام/كيلو جرام على الترتيب فى الأراضى الجيرية بينما تراوحت القيم المقابلة فى الأراضى الرسوبية بين ٠٢ر-٦ر ، ١٠,٨ - ٣٨,٩ ، ٥٠ر- ٦٥ر ، ٥٠ر - ٤ر مليجرام / كيلو جرام على الترتيب.

٣- تراوحت قيم الحديد والمنجنيز والزنك والنحاس المستخلصة بواسطة خلات الامونيوم بين ١ر-٥ر١ ,٩ر-٢١,١ ، ٢ر-١ ,١٠ ،١ر-٦ر مليجرام/كيلو جرام على الترتيب فى الأراضى الجيرية بينما تراوحت هذه القيم فى الأراضى الرسوبية بين ١ر-١,٣ ،١,٩ -١٨,٩ ،٥ر-١,٦ ،٣ر-٨ر مليجرام /كيلو جرام على الترتيب.

٤- تراوحت قيم الحديد والمنجنيز والزنك والنحاس المستخلصة بواسطة خلات الامونيوم والهيدركينون بين ١ر-٦ر٦،ر-١و٦٣ ,١و-٩,٣ ،١ر-٤ر مليجرام/كيلو جرام على الترتيب بينما تراوحت هذه القيم فى الأراضى الرسوبية بين ١ر-٤ر، ٦٠-٨٤، ١ر-٩ر ، ١ر-٨ر مليجرام/كيلو جرام على الترتيب.،

٥- تراوحت قيم الحديد والمنجنيز والزنك والنحاس المستخلصة بواسطة الماء ٢ر-٤٥,٤ ، ١ر-٥ر ، ٣٠ر-١٧ر ، ١ر - ٤٥، مليجرام/كيلو جرام فى الأراضى الجيرية بينما تراوحت هذه القيم فى الأراضى الرسوبية بين ٢ر-٥٥,١ ، ٥٠ر- ٢٥ر، ٠٤ر - ٧٥ر ، ١ر -٥ر مليجرام/كيلو جرام على الترتيب .

اختلف دور خصائص التربة موضع الدراسة وهي التوزيع الحجمى للحبيبات ورقم الحموضة ومحتوى التربة من كل من المادة العضوية وكربونات الكالسيوم على تيسر العناصر موضع الدراسة باختلاف مستخلصات التربة المستخدمة والعنصر موضع الدراسة. أوضحت قيم معاملات الارتباط بين المختص من كل من العناصر موضع الدراسة والكمية المستخلصة من العنصر من التربة باستخدام المستخلصات موضع الدراسة الى اختلاف كفاءة هذه المستخلصات باختلاف العنصر موضع التقدير.