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DETERMINATION OF POTASSIUM EXTRACTION FREE ENERGY OF SOME SOILS IN EGYPT

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ABSTRACT: ***Eight surface soil samples (0-30 cm) were selected from different sites of Egypt to determine the free energy of extracted K amounts. The obtained data reveal that the amounts of soluble K ranged between 0.04 and 6.38 me/l, these amounts associated with soil salinity level. The $CaCl_2$ extractable K contents from the soil samples under consideration ranged between 0.15-1.60 me/100gm soil. These obtained data show a greater depletion in case of high values of EC. In additions, free energy values (∆ F) of K extractions were calculated and the obtained results indicate that the released K amounts from the studied soils are insufficient to cover K requirements for grown plants, and in turn these soils are in need to be fertilized with K.***

Key words: ***Extracted K, free energy, soils of Egypt.***

INTRODUCTION

It was recognized that potassium (K) is absorbed in large quantities by plant roots than any other cation. Some soils are rapidly depleted by cropping, so that the supply of K to plant roots becomes a very important process. K plays a major role in photosynthesis, water and nutrients transformation, enzyme synthesis and rate of plant respiration. In this respect, Mohamedin et al. (2003) and Abdel Mawly and El Sharkawy (2004) showed that crop yield and K-use efficiency were significantly increased as a result of increasing available soil potassium levels as compared to control treatment. Some previous studies were carried out on the characteristics of the more easily replaceable potassium and other nutrients, and their relationship to plant uptake.

Woodruff (1955 a&b) introduced the K quantity as a measure of the free energy of exchange of K by Ca in the soil as follows:

$$\Delta F = RT \ln [Ak / \{A (Ca + Mg)\}^{0.5}].$$

Where:

R is gas constant, T is absolute temperature and A refers to the ion activities in solution.

The Δ F is proportional to the difference in the chemical potential of K and Ca in the solid phase and it is considered to be a measurement of the instantaneous availability of potassium. Energy exchange values can be categorized into:

a) **- 3500 to - 4000 calories are associated with K deficiency for plants.**

b) **- 2500 to - 3000 calories represent suitable balance between K and Ca.**

c) **- 2000 calories or more are associated with excessive amounts of K in solution to amounts of Ca that are present.**

The current work aimed at evaluating K supplying power capacity of some soils of Egypt.

MATERIALS AND METHODS:

Eight surface soil samples (0-30) were selected from different locations in Egypt. Some physical and chemical properties of the studied soil samples were determined as follows:

a) **Particle size distribution was determined using the international pipette method (Kilmer and Alexander, 1949).**

b) **Soil pH in soil paste, salinity as expressed in ECe (ds/m) and soluble ions (cations and anions in me/l) were determined in soil paste extract according to Jackson (1973).**

c) **The successive extractions were carried out using 0.01 N $CaCl_2$ (Hagin and Feigenbaum, 1962), where a portion of 5 gm of each soil were treated with 50 ml 0.01 N $CaCl_2$ solution, shaken for 15 minutes and then centrifuged. The supernatants were used for determining Ca, Mg and K. This process was repeated several times until the K concentration in the last three successive extracts reached a constant value.**

RESULTS AND DISCUSSION:

1- Some physicochemical properties of the studied soil samples:

Data in Table (1) show that the pH values were slightly alkaline and ranged from 7.83 to 8.73. The salinity values as expressed by the electrical conductivity (EC) were extremely high in Siwa and moderate in Luxor where the rest soil samples were non saline (According to Richards, 1954).

Data in table (2) indicate that the textural classes of the investigated soil samples varied from one location to another.

Table (1): Chemical analysis of the studied soil samples

Location	pH	EC (ds/cm)	soluble anions (meq/l)			soluble cations (meq/l)			
			HCO_3^-	Cl^-	$SO_4^=$	Ca^{++}	Mg^{++}	Na^+	K^+
Siwa	7.87	42.97	6.20	407.0	12.68	50.2	36.30	335.0	6.38
Luxor	8.36	6.96	1.76	7.08	60.40	41.00	4.48	21.56	2.20
Shandawel	8.46	0.39	2.40	6.44	10.35	1.61	1.25	16.12	0.17
Tushka	8.14	0.43	1.52	2.40	0.23	1.45	0.66	1.16	0.88
Mattana	8.73	0.99	2.72	6.60	0.31	2.50	0.41	6.68	0.04
Kharga	8.22	1.13	1.08	6.40	4.58	7.52	1.25	2.38	0.91
Qanater	7.95	1.77	2.00	2.00	13.57	8.85	4.48	3.84	0.40
Beni-suef	7.83	1.78	2.60	6.00	10.24	9.00	4.38	5.00	0.46

Table(2):Particle size distribution and textural classes of the studied soil samples.

Location	Particle size distribution %				Textural class
	C.Sand	F.Sand	Silt	clay	
Siwa	76.30	6.20	10.10	7.40	Loamy sand
Luxor	58.29	14.20	15.29	12.21	Loamy sand
Shandawel	13.18	44.32	15.20	27.30	Sandy clay loam
Tushka	58.44	19.20	5.06	17.30	Sandy loam
Mattana	34.60	47.30	10.70	7.40	Loamy sand
Kharga	73.66	4.07	10.20	12.16	Loamy sand
Qanater	4.15	15.15	25.02	55.68	Clay
Beni-suef	2.45	45.50	19.22	32.83	clay loam

2-The extractable K amounts by 0.01 N $CaCl_2$ solution:

The K amounts (me/100 gm soil) removed by repeated extraction with 0.01 N $CaCL_2$ were determined and presented in Table (3) and Fig. (1). Data in Table (3) show that the alluvial soils contain considerable amounts of extractable K. Also, it noticed that the highly saline soils show a greater depletion in available K. The variation in the vertical axes was due to the first extracted amounts of K from different soil samples.

Garman (1957) suggested that the change of the slopes of such curves could be used as an indication of three forms of K, the steep part represents the depletion of soluble and easily exchangeable K, the transitional part represents the strongly adsorbed and exchangeable K and the lower part represents the slow release of K from mineral structure.

Table (3): Extracted K amounts (me/100 gm soil) from the studied soil samples by repeated extraction with $CaCl_2$

Extraction No.	*Extracted K (me/100 gm soil)*							
	Siwa	*Luxor*	*Shandawel*	*Tushka*	*Mattana*	*Kharga*	*Qanater*	*Beni-suef*
1	1.600	0.720	0.170	0.440	0.150	0.640	0.333	0.255
2	0.180	0.310	0.100	0.166	0.043	0.215	0.215	0.170
3	0.070	0.130	0.050	0.090	0.037	0.105	0.155	0.110
4	0.050	0.090	0.047	0.078	0.033	0.070	0.085	0.083
5	0.043	0.072	0.043	0.047	0.033	0.050	0.080	0.070
6	0.037	0.057	0.030	0.043	0.033	0.047	0.070	0.050
7	0.037	0.042	0.030	0.043	-	0.043	0.057	0.047
8	0.037	0.042	0.030	0.043	-	0.043	0.057	0.047
9	-	0.042	-	-	-	0.043	0.057	0.047

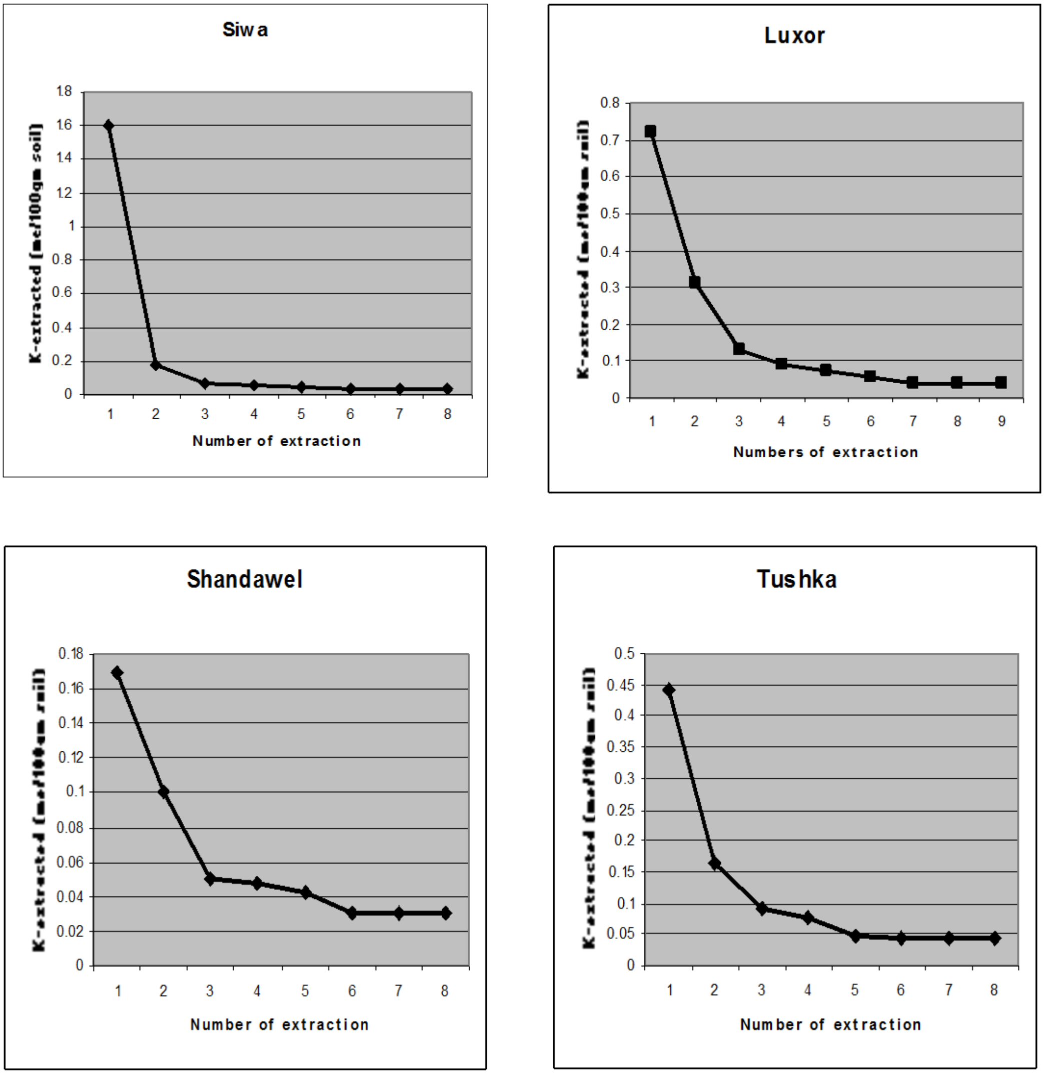

Fig.(1): Relation between number of extraction and amounts of K-extracted by 0.01 $CaCl_2$ from the investigated soil samples.

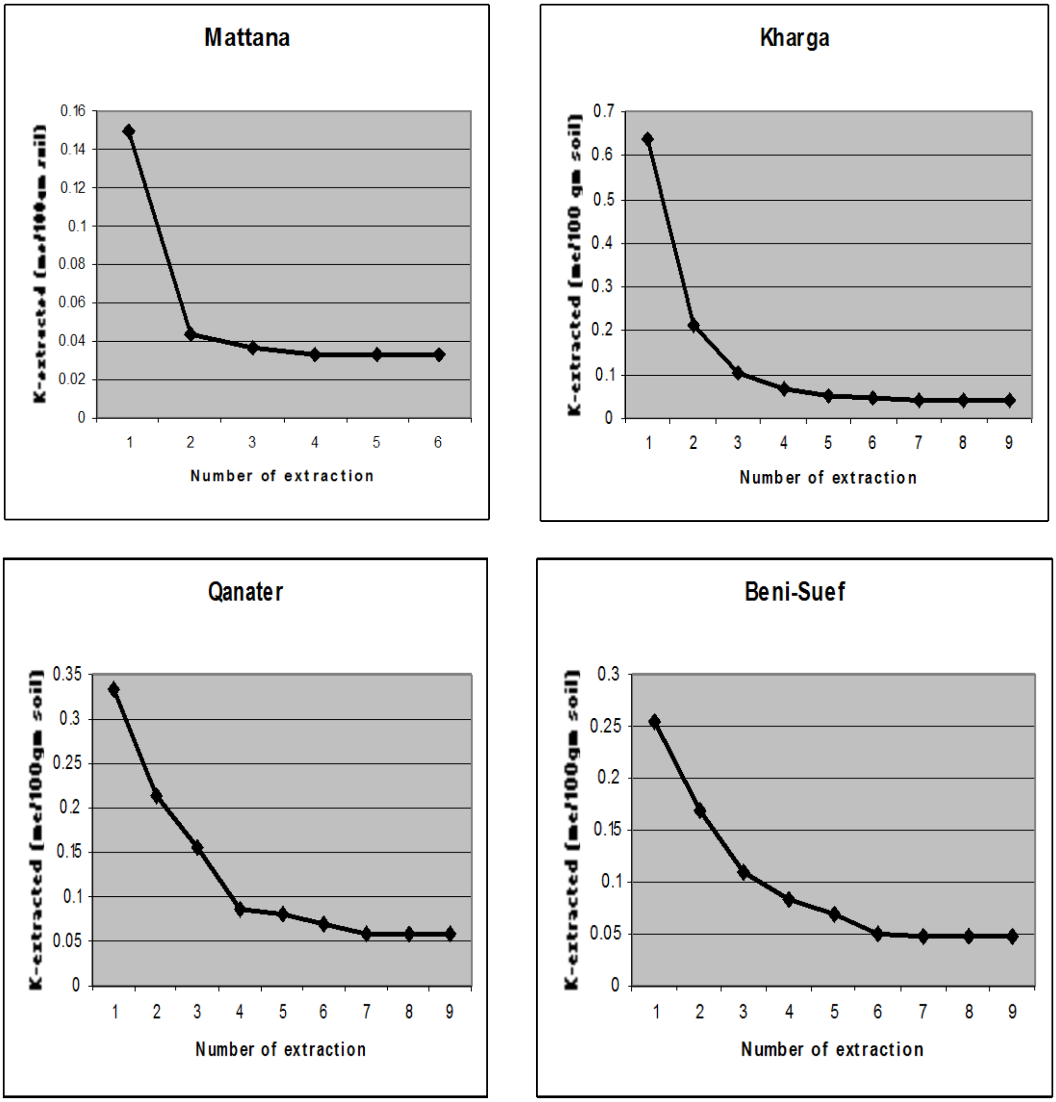
Mattana
K-extracted (me/100gm soil)
Number of extraction
Kharga
K-extracted (me/100 gm soil)
Number of extraction
Qanater
K-extracted (me/100gm soil)
Number of extraction
Beni-Suef
K-extracted (me/100gm soil)
Number of extraction

Fig.(1): Con.

3- Free energy of extracted K amounts:

Free energy values in calories / (mol) $^{0.5}$ were calculated and presented in Table (4) and Fig.(2). Woodruff (1955 a & b) suggested that the ∆ F values of – 3500 calories / (mol) $^{0.5}$ or less are associated with K deficiency for plants. Data in Table (4) and Fig.(2) indicate that the investigated soils reached the critical value [– 3500 calories / (mol) $^{0.5}$] at the second extraction except Beni-Suef and Shandawel , i.e. the released K amounts of these soils are insufficient to grow plants requirements.

As a conclusion, these soils are in need for K fertilization, particularly upon the prevailing extensive cropping patterns.

Table (4): The free energy values [∆ F in calories / (mol) $^{0.5}$] of the extracted K amounts from the studied soil samples.

Extraction No.	*The free energy values [∆ F in calories / (mol)$^{0.5}$]*							
	Siwa	*Luxor*	*Shandawel*	*Tushka*	*Mattana*	*Kharga*	*Qanater*	*Beni-suef*
1	-2589	-2981	-3711	-3115	-3095	-2814	-3274	-3503
2	-3838	-3478	-4027	-3682	-4456	-3535	-3535	-3674
3	-4424	-3995	-4440	-4061	-4546	-3962	-3731	-3927
4	-4626	-4220	-4477	-4174	-4614	-4202	-4107	-4118
5	-4714	-4374	-4744	-4448	-4614	-4411	-4119	-4169
6	-4804	-4486	-4744	-4501	-4614	-4441	-4206	-4397
7	-4804	-4668	-4744	-4501	-	-4494	-4329	-4434
8	-4804	-4668	-	-4501	-	-4494	-4329	-4434
9	-	-4668	-	-	-	-4494	-4329	-4434

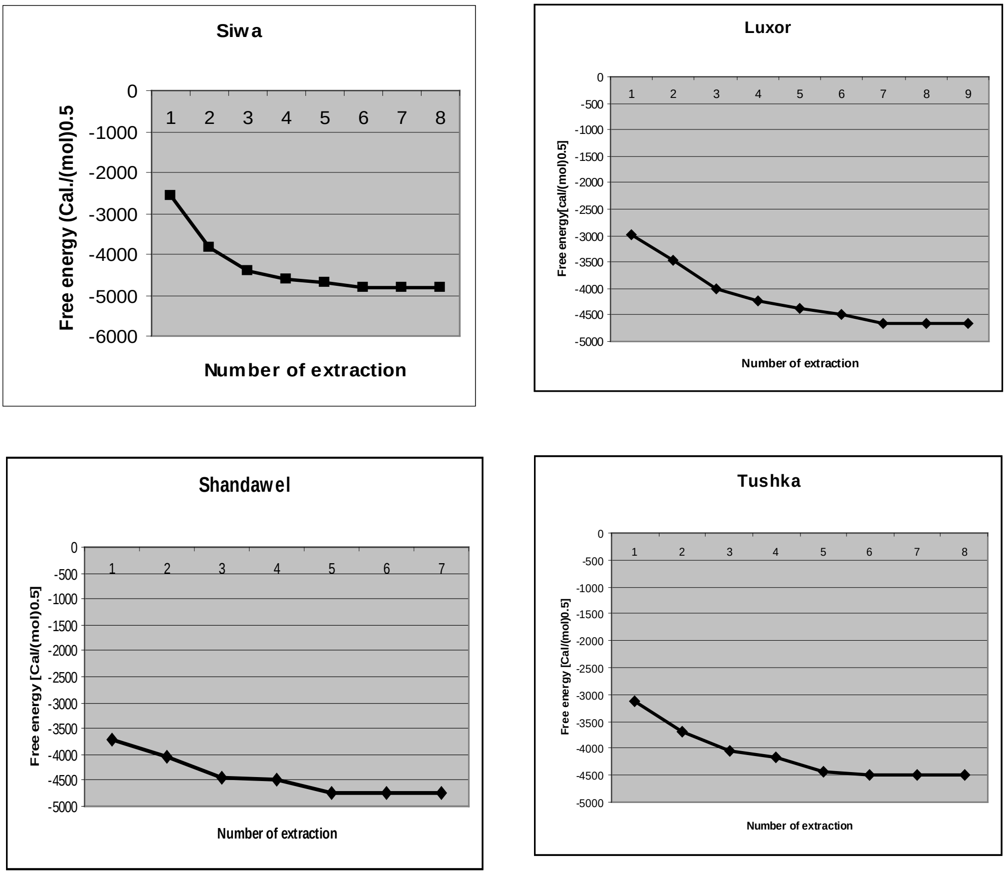

Fig. (2): Relation between number of extraction and free energy of K-exchange (∆ F) in the investigated soil samples.

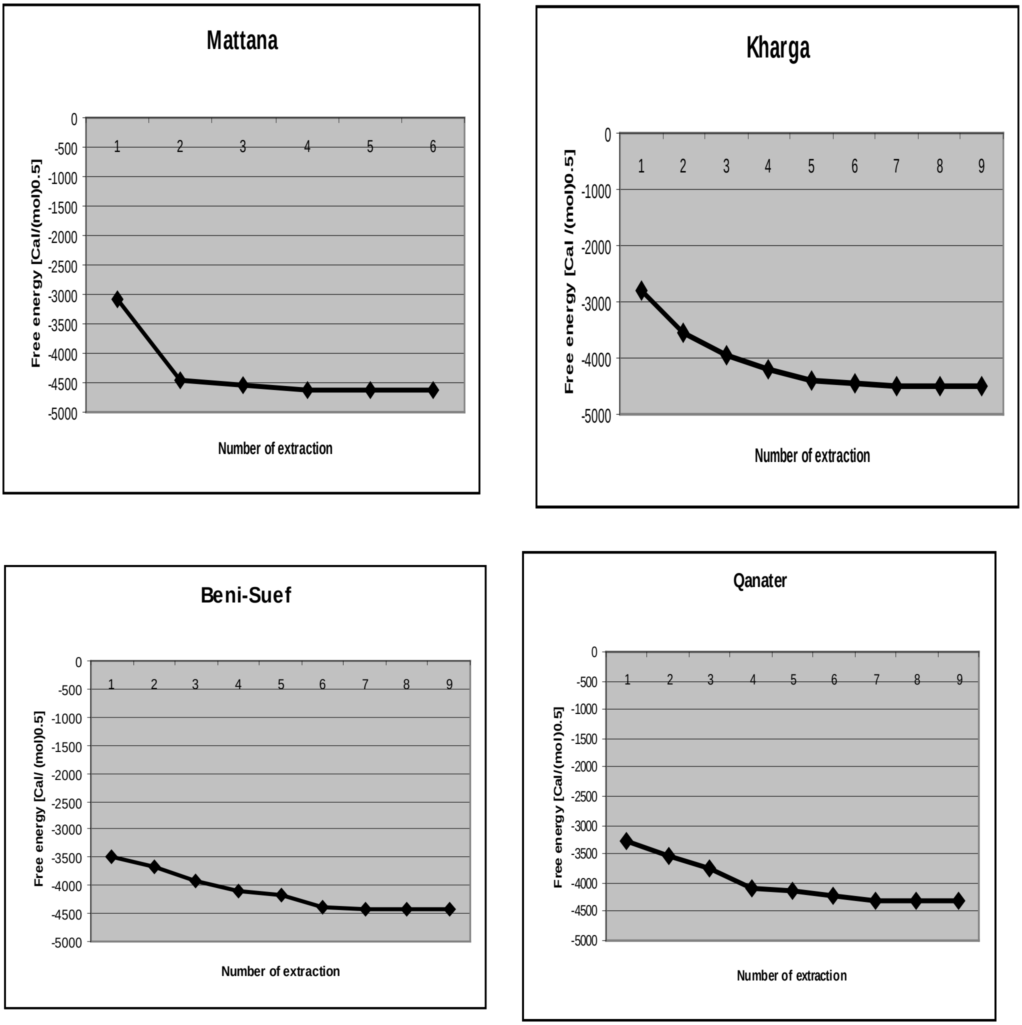
Mattana
Free energy [Cal/(mol)0.5]
0
-500
-1000
-1500
-2000
-2500
-3000
-3500
-4000
-4500
-5000
1 2 3 4 5 6
Number of extraction
Kharga
Free energy [Cal /(mol)0.5]
0
-1000
-2000
-3000
-4000
-5000
1 2 3 4 5 6 7 8 9
Number of extraction
Beni-Suef
Free energy [Cal/ (mol)0.5]
0
-500
-1000
-1500
-2000
-2500
-3000
-3500
-4000
-4500
-5000
1 2 3 4 5 6 7 8 9
Number of extraction
Qanater
Free energy [Cal/(mol)0.5]
0
-500
-1000
-1500
-2000
-2500
-3000
-3500
-4000
-4500
-5000
1 2 3 4 5 6 7 8 9
Number of extraction

Fig. (2): Con.

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تقدير الطاقة الحرة لأستخلاص البوتاسيوم

فى بعض الأراضى فى مصر

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الملخص العربى

تم أختيار ثمانية عينات تربة سطحية (صفر–٣٠) من مواقع مختلفة فى مصر لتقدير الطاقة الحرة لكميات البوتاسيوم المستخلصة من التربة. وأشارت النتائج أن كميات البوتاسيوم الذائب تراوحت بين ٠.٠٤– ٦.٣٨ مليمكافئ / لتر وقد تناسبت تلك الكميات طرديا مع ملوحة التربة. وأوضحت النتائج أن كميات البوتاسيوم المستخلصة من العينات المدروسة بمحلول كلوريد الكالسيوم تراوحت بين ٠.١٥–١.٦ مليمكافئ / ١٠٠ جم تربة ودلت النتائج على وجود انخفاض كبير فى الكميات المستنفذة من البوتاسيوم فى الأراضى عالية الملوحة. وتم حساب الطاقة الحرة لأستخلاص البوتاسيوم حيث أظهرت النتائج أن الكميات المنفردة من البوتاسيوم فى الأراضى المدروسة غير كافية لتغطية احتياجات النباتات النامية من عنصر البوتاسيوم وبذلك تعتبر تلك الأراضى فى حاجة للتسميد البوتاسى.