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(Original Article)

Mapping of Available Potassium of Upper Egypt Soils Using GIS

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Abstract

The main activity in Upper Egypt is agriculture, also potassium is one of the essential nutrients for plant. In the past years, scientists expected that the construction of Nasser High Dam in Aswan, Egypt, would prevent the yearly clay sediments reach in potassium that comes with the Nile River flooding water and may negatively affect the future of agriculture on the river banks of the Nile. Therefore, this study was conducted to monitor the levels of available potassium in the soils of the Upper Egypt governorates. 110 samples were taken from the surface and sub-surface layers from 55 sites in the governorates of Aswan, Luxor, Qena, Sohag, Assiut and Minya. The results showed that, the expectation was not totally wrong, since about 2% of soil samples has low (<135 mg/kg) available potassium. However, 30% of them were medium (135-335) and 68% of soil samples were high (>335 mg/kg). The data was drowned in GIS maps to be helpful for the grower and as a record of the lands of Upper Egypt, it monitors the situation in history.

Keywords: *Available potassium, Upper Egypt soils, GIS*

Introduction

Potassium (K) is the most abundant inorganic cation in plant tissues. In adequately supplied plants it may make up about 6% of the dry matter or concentrations of about 200 mM (Leigh and Wyn, 984). K is unique as a plant nutrient as it occurs exclusively in the form of the free ion. Under K deficiency cytosolic K activity is maintained at the expense of vacuolar K activity (Leigh 2001). Highest concentrations of K are found in young developing tissues and reproductive organs indicative of its high activity in cell metabolism and growth. K activates numerous enzymes including those involving energy metabolism, protein synthesis, and solute transport (Mengel and Kirkby 2001; Amtmann *et al.* 2008).

The relationship between clay mineralogy composition and potassium forms and physico-chemical properties has been demonstrated by several studies (Sharpley, 1989; Bhonsle *et al.*, 1992; Ghosh and Singh, 2001; Surapaneni *et al.*, 2002; Srinivasarao *et al*, 2006). Relationships between clay mineralogy and potassium forms can be used in evaluating potential soil K fertility, prediction of K cycling and plant uptake (Sharply, 1989). Information on the NH4OAc-K form

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of potassium (i.e. soluble and exchangeable K) along with knowledge of mineralogical clay composition can provide insights into the equilibrium and release of non-exchangeable K to plants and the need for K fertilizers (Bhonsle *et al*., 1992). The release of K from clay minerals is influenced by particle size distribution and chemical composition (Huang 2005). Different articles have reported that plants can take up both exchangeable and non-exchangeable forms of potassium (Ghosh and Singh, 2001). Readily available potassium is a dissolved form of K (water-soluble) or K held on the outer surface of clay particles (exchangeable K). Plants can take up both exchangeable and non-exchangeable forms of potassium. (Bhonsle *et al*. 1992) suggested that fixed or non-exchangeable forms of K can even be the main source of potassium for plants. Minerals' K release to soluble and exchangeable forms and its adsorption by exchange sites depends on the equilibrium between different phases of soil K, which may be affected by such factors as root uptake, applied fertilizer K, soil moisture, soil pH and soil temperature (Zhang *et al*, 2011; Britzke *et al*., 2012).

Geographic information system (GIS) allows overlaying of maps with different thematic data (e.g. soil and land use, watershed, district, village maps) and thereby facilitates map integration and analysis. GIS distance modeling makes it possible to assess the interaction of (potential) land uses, and the physical infrastructure and market. It also permits the combination of maps with data generated by models (Bronsveld *et al*., 1994).

The Egyptian agricultural scientific authorities have a big concern about availability of potassium in the soil after construction of the Nasser High Dam which prevent the yearly supply to the agriculture land by clays which are reach in potassium. There for the aim of this study in to study and map potassium in upper Egypt from Aswan to Minya after fifty years from the construction of Aswan Nasser High Dam and utilize the produced maps in the agriculture extension services.

Materials and Methods

To achieve the goal of the study the agriculture land of six governorate bordering the Nile River from Aswan, Luxor, Qena, Sohag, Assiut and Minya were sampled and represented by ten samples from each governorate.

1-Soil sampling Location

Samples were collected from the study area which extends from Aswan governorate to Minya governorate. Fifty-five soil profiles were selected to cover the study area. Locations of the soil samples were recorded in the field using the global positioning system (GPS). The samples collected in October of 2020 and field date were collected in site. Total of 110 soil samples were collected from two soil depth including (0 – 30 and 30 – 60) (Table 1).

Table 1. Soil sampling locations in Upper Egypt (Aswan - El Minya)

No.	Governorate	Sector	Location	
			N	E
1	Aswan	Kom Ombo	24.463507	32.951503
2		W. Edfu	25.128645	32.661605
3		E. Edfu	24.976289	32.868151
4	Luxor	Qurna	25.250746	32.580561
5		Zinnia	25.761918	32.684895
6		Luxor	25.677605	32.637779
7		E. Armant	25.559027	32.435518
8		W. Armant	25.599835	32.547495
9		Todd	25.580388	32.527894
10		W. Esna	25.479384	32.514873
11		E. Esna	25.446289	32.500478
12	Qena	Neghda	25.901092	32.719001
13		Qus	25.926713	32.763891
14		Qift	25.998976	32.805935
15		Qena	26.153689	32.709874
16		Wakf	26.093001	32.431555
17		Deshna	26.128567	32.470082
18		Nag Hammadi	26.043503	32.237812
19		Frshout	26.051235	32.173784
20		Abu Tesht	26.11708	32.086857
21	Sohag	Plena	26.275699	31.954728
22		Dar El Slam	26.237261	32.098905
23		Gerga	26.343283	31.890266
24		Osirat	26.388465	31.821933
25		Minshaa	26.481049	31.788859
26		Sohag	26.546821	31.684639
27		Shandawil	26.648975	31.673257
28		Akhmim	26.554214	31.731316
29		Saqalta	26.665221	31.670597
30		Maragha	26.704842	31.599266
31		Juhayna	26.689503	31.488829
32		Tahta	26.75555	31.504629
33		Tema	26.895401	31.436398
34	Assiut	El Fateh	27.240091	31.235015
35		El Sahel	27.057452	31.336213
36		Ghanaim	26.885599	31.338665
37		Badary	26.986497	31.414018
38		Sedfa	26.960147	31.383193
39		Abu Teg	27.037531	31.315196
40		Assiut	27.206945	31.169636
41		Abanob	27.278227	31.14854
42		W. Manfalout	27.310724	30.979553
43		E. Manfalout	27.279373	30.992311
44		Qusia	27.430133	30.824606
45		Dayrout	27.558841	30.797971

Table 1. Continue

46	Minya	Der Mawas	27.642449	30.840587
47		Mallawy	27.724649	30.855387
48		Abu korkas	27.933249	30.842663
49		Minya	28.07184	30.757277
50		Samalut	28.31495	30.721355
51		Mattai	28.425305	30.781627
52		W. Bany Mazar	28.47821	30.809228
53		E. Bany Mazar	28.479859	30.844035
54		Maghagha	28.645559	30.827459
55		El edwa	28.691566	30.771135

2- Soil analysis

Physical analysis

-Particle size distribution: Particle size distribution was estimated using the international hydrometer method, as described by (Jackson, 1969).

The saturation percentage (SP): was estimated as described by (Hesse, 1998)

Chemical analysis

-Soil pH: was measured in a 1:2 (soil: water) suspension using A glass electrode (pH meter) according to (Jackson, 1973).

-Electrical conductivity: was determined in the soil- water 1:2 extracts of the soil samples according to (Jackson, 1973). EC_e was calculated based on the following equation:

$EC_e = EC_{1:2} * (100/SP)$.

-Organic matter content (OM) of the soil samples was determined using the dichromate oxidation method as described by Wakley and Black (Jackson, 1973).

-Calcium and magnesium were determined using the titration with a standard versenate (EDTA) solution (Jackson, 1973).

-Available potassium and sodium were extracted by (1 N) NH_4OAC at pH 7.0 as described by (Jackson, 1973). Then K and Na were measured using flame photometer.

Map preparation

The data were saved in excel database format and contained the X and Y coordinate system. Data input include locations of samples and have been classified into number of classes. The results of soil properties have been drawn by the GIS (Arcview, 10.2.2).

Table 2. Some physical properties of the soils of Upper Egypt (Aswan - El-Minya)

No.	Gov.	Sector	Particle size distribution%0 – 30			Texture	Particle size distribution%30 - 60			Texture	S.P%	
			Clay%	Silt%	Sand%		Clay%	Silt%	Sand%		0 - 30	30 - 60
1		*Kom Ombo*	25	16	59	sandy clay loam	13	8	79	Sandy loam	36.25	30.85
2	*Aswan*	*W. Edfu*	13	8	79	sandy loam	5	2	93	Sand	30.85	27.15
3		*E. Edfu*	33	18	49	sandy clay loam	25	26	49	sandy clay loam	39.35	37.75
4		*Qurna*	39	4	57	sandy clay	15	16	69	sandy lome	39.35	32.75
5		*Zinnia*	43	20	37	Clay	53	14	33	Clay	43.15	45.75
6		*Luxor*	53	16	31	Clay	47	4	49	sandy clay	46.05	42.15
7	*Luxor*	*E. Armant*	25	12	63	sandy clay loam	31	12	57	sandy clay loam	35.65	37.75
8		*W. Armant*	45	12	43	Clay	35	16	49	sandy clay	42.65	39.75
9		*Todd*	31	10	59	sandy clay loam	31	18	51	sandy clay loam	37.45	38.65
10		*W. Esna*	25	16	59	sandy clay loam	23	26	51	sandy clay loam	36.25	37.05
11		*E. Esna*	21	12	67	sandy clay loam	49	22	29	Clay	34.25	45.55
12		*Neghda*	41	8	51	Sandy clay	37	12	51	Sandy clay	40.65	39.85
13		*Qus*	35	8	57	Sandy clay	43	18	39	Clay	38.55	42.85
14		*Qift*	37	20	43	clay loam	27	24	49	sandy clay loam	41.05	38.15
15		*Qena*	41	18	41	Clay	41	20	39	Clay	42.15	42.45
16	*Qena*	*Wakf*	23	40	37	Loam	17	14	69	sandy loam	39.15	33.15
17		*Deshna*	27	14	59	sandy clay loam	25	14	61	sandy clay loam	36.65	35.95
18		*Nag Hammadi*	41	12	47	sandy clay	33	14	53	sandy clay loam	41.25	38.75
19		*Frshout*	31	12	57	sandy clay loam	47	22	31	Clay	37.75	44.85
20		*Abu Tesht*	25	24	51	sandy clay loam	15	10	75	Sandy clay	37.45	31.85
21		*Plena*	39	12	49	sandy clay	39	10	51	sandy clay	40.55	40.25
22		*Dar El Slam*	21	24	55	sandy clay loam	27	14	59	sandy clay loam	36.05	36.65
23		*Gerga*	43	18	39	Clay	53	18	29	Clay	42.85	46.35
24		*Osirat*	41	16	43	Clay	17	18	65	sandy loam	41.85	33.75
25	*Sohag*	*Minshaa*	33	28	39	clay loam	35	16	49	sandy clay	40.85	39.75
26		*Sohag*	41	22	37	Clay	39	22	39	clay loam	42.75	42.05
27		*Shandawil*	25	26	49	sandy clay loam	17	8	75	sandy loam	37.75	32.25
28		*Akhmim*	33	8	59	sandy clay loam	41	20	39	Clay	37.85	42.45
29		*Saqalta*	45	22	33	Clay	49	16	35	Clay	44.15	44.65

Table 2. (Continued) Some physical properties of the soils of Upper Egypt (Aswan - El-Minya)

No.	Gov.	Sector	Particle size distribution%0 - 30			Texture	Particle size distribution%30 – 60			Texture	S.P%	
			Clay%	Silt%	Sand%		Clay%	Silt%	Sand%		0 - 30	30 - 60
30	*Sohag*	*Maragha*	41	22	37	Clay	43	18	39	clay	42.75	42.85
31		*Juhayna*	49	12	39	Clay	51	14	35	clay	44.05	45.05
32		*Tahta*	41	14	45	Clay	51	14	35	clay	41.55	45.05
33		*Tema*	21	14	65	sandy clay loam	41	8	51	sandy clay	34.55	40.65
34	*Assiut*	*El Fateh*	39	8	53	Sandy clay	35	18	47	sandy clay	39.95	40.05
35		*El Sahel*	39	22	39	Clay loam	49	16	35	Clay	42.05	44.65
36		*Ghanaim*	33	14	53	sandy clay loam	35	16	49	sandy clay	38.75	39.75
37		*Badary*	39	18	43	Clay loam	27	24	49	sandy clay loam	41.45	38.15
38		*Sedfa*	41	18	41	Clay	41	20	39	Clay	42.15	42.45
39		*Abu Teg*	45	18	37	Clay	39	12	49	sandy clay	43.55	40.55
40		*Assiut*	39	20	41	clay loam	19	16	65	sandy loam	41.75	34.15
41		*Abanob*	25	38	37	Loam	15	16	69	sandy loam	39.55	32.75
42		*W. Manfalout*	47	16	37	Clay	47	16	37	clay	43.95	43.95
43		*E. Manfalout*	19	4	77	sandy loam	17	10	73	sandy loam	32.35	32.55
44		*Qusia*	49	12	39	Clay	49	14	37	clay	44.05	44.35
45		*Dayrout*	23	20	57	sandy clay loam	31	22	47	sandy clay loam	36.15	39.25
46	*Minya*	*Der Mawas*	25	16	59	sandy clay loam	23	26	51	sandy clay loam	36.25	37.05
47		*Mallawy*	39	2	59	sandy clay	37	10	53	sandy clay	39.05	39.55
48		*Abu korkas*	21	12	67	sandy clay loam	51	20	29	Clay	34.25	45.95
49		*Minya*	21	12	67	sandy clay loam	13	8	79	sandy loam	34.25	30.85
50		*Samalut*	29	16	55	sandy clay loam	41	20	39	clay	37.65	42.45
51		*Mattai*	33	14	53	sandy clay loam	41	24	35	clay	38.75	43.05
52		*W. Bany Mazar*	41	8	51	sandy clay	45	6	49	sandy clay	40.65	41.75
53		*E. Bany Mazar*	25	18	57	sandy clay loam	35	28	37	clay loam	36.55	41.55
54		*Maghagha*	25	12	63	sandy clay loam	31	10	59	sandy clay loam	35.65	37.45
55		*El edwa*	39	20	41	Clay loam	19	18	63	Sandy loam	41.75	34.45

Results and Discussion

1-Particle-size distribution

Particle size distribution was presented in Table (2). The results indicated that the most of the overall studied soil samples were sandy clay loam with a percentage of 30.9 %, as it is spread in most of the lands of the studied governorates, followed by the percentage 0f clay with about 30.00 % of the samples, most of which were concentrated in Sohag governorate. The proportion of sandy clay texture was about 17.27%, while the proportion of sandy loam was about 10.00 %. The percentage of clay loam was about 5.45%, while sand and loam constituted a small percentage of the samples.

In the surface soil (0-30 cm), the highest sand content (78.72%) was pronounced for the soil samples collected from Aswan governorate followed by Assiut governorate (76.72%). The highest clay content (53%) was observed in soil samples collected from Luxor governorate followed by Assiut governorate (49%). Additionally, the highest silt content (41%) in the soil samples at Qena followed by Assiut governorate (38%).

In the subsurface soil (30-60 cm), the highest sand content (92.72%) was pronounced for the soil samples collected from Aswan governorate followed by Minya governorate (78.72%). The highest clay content (53,28%) was observed in soil samples collected from Luxor and Sohag governorate followed by Assiut governorate (49.28%). Additionally, the highest silt content (28%) in the soil samples at Minya followed by Aswan and Luxor governorate (26%). The fine texture of the surface and sub-surface layers can be due to the naturally alluvial deposits. These results are in an agreement with those obtained by Awad (1996).

2-Saturation percentage (S.P %)

The saturation percentage of these samples varied between 27.1 and 46.3 (Table 2) with average of 39.3%. The highest SP values were in sub surface layer in Gerga city while the lowest once were recorded in sub-surface layer in West Edfu.

3-Soil reaction (pH)

The data in Table (3) and Table (4) shows the data of overall soil pH ranged from 7.56-8.73 with average of 7.58. In the surface soil (0-30 cm), the highest pH content (8.73) was recorded in Assiut governorate followed by Luxor governorate (8.29). Meanwhile, the lowest pH value of 7.56 was found in soil samples collected from Luxor and Minya. In the subsurface soil (30-60 cm), the highest pH content (8.55) was pronounced for the soil samples collected from Luxor governorate followed by Assiut governorate (8.50). Meanwhile, the lowest pH value of 7.45 was found in soil samples collected from Qena. According to Soil Survey Division Staff, (1993), about 51.8 % of soil samples have slightly alkaline pH (7.4-7.8), 30.9 % of these samples have been strongly moderately alkaline pH (7.9-8.4), and a few samples (4.54 %) have alkaline pH (8.5-9).

Table 3. Some chemical properties of the soils of Upper Egypt (Aswan - El-Minya)

No.	Gov.	Sector	pH (1:2)		EC 1:1		O.M %		Available cations mg/kg 0-30 cm				Available cations mg/kg 30-60 cm			
			0 - 30 cm	30 - 60 cm	0 - 30 cm	30-60 cm	0-30 cm	30-60 cm	Na	Ca	Mg	K	Na	Ca	Mg	K
1	*Aswan*	*Kom Ombo*	7.79	7.73	2.68	2.79	1.95	0.87	416.48	6960	1728	467.61	357.55	7280	1776	488.35
2		*W. Edfu*	7.81	8.22	1.97	1.08	1.48	0.07	361.76	4360	912	363.88	262.86	5040	576	85.90
3		*E. Edfu*	7.77	7.83	1.46	1.91	2.42	1.01	401.74	5880	2160	612.82	376.49	14080	1632	222.82
4	*Luxor*	*Qurna*	7.84	8.35	6.81	5.94	2.49	0.54	1203.51	7280	2352	421.97	1094.08	7760	1104	21.59
5		*Zinnia*	7.83	7.79	1.36	1.60	1.82	1.48	347.03	4680	720	374.25	422.79	11920	1632	359.73
6		*Luxor*	8.20	8.23	2.51	3.58	2.49	1.08	833.14	2680	6144	644.00	1317.15	10960	3168	442.71
7		*E. Armant*	7.56	7.66	2.40	1.93	2.08	1.48	452.25	3440	2304	415.74	418.58	7840	1776	251.86
8		*W. Armant*	7.83	7.74	1.72	1.85	2.42	1.28	521.69	5920	2256	513.00	397.54	9920	1920	510.00
9		*Todd*	8.29	8.31	3.76	2.91	2.15	0.61	934.15	4480	1824	529.84	824.72	8720	1104	297.50
10		*W. Esna*	8.14	8.55	14.24	9.02	0.81	0.13	1561.26	3760	1248	282.98	1426.58	7680	1776	278.83
11		*E. Esna*	7.82	7.78	2.18	1.76	1.01	0.67	399.64	4680	1968	295.42	586.93	11280	1248	330.69
12	*Qena*	*Neghda*	7.65	7.45	3.32	1.93	4.17	2.62	349.14	4120	1488	463.46	311.26	9920	192	486.28
13		*Qus*	7.70	7.66	3.01	3.08	1.68	2.82	443.83	4160	912	505.00	536.42	9600	1536	453.00
14		*Qift*	7.66	7.67	2.10	1.86	2.42	1.28	387.01	4080	2016	403.30	502.75	10080	1056	316.17
15		*Qena*	7.87	8.07	2.41	4.29	0.74	1.01	622.70	4880	2448	374.25	1146.69	8000	1488	664.68
16		*Wakf*	7.86	7.79	2.21	1.32	1.68	1.48	365.97	3320	2016	433.00	180.78	4080	624	511.00
17		*Deshna*	8.19	8.34	4.67	3.73	1.68	0.94	1104.61	4320	2640	347.29	1197.20	8400	2736	177.18
18		*Nag Hammadi*	7.81	7.75	1.80	2.09	2.29	0.47	445.94	5240	1296	546.00	593.24	9840	2064	202.07
19		*Frshout*	7.65	7.65	1.75	1.44	1.95	1.82	574.30	7320	1584	471.75	443.83	10560	1872	347.29
20		*Abu Tesht*	7.75	8.30	2.39	2.84	2.29	1.14	456.46	3240	2640	619.04	1041.48	10560	624	206.22
21	*Sohag*	*Plena*	7.65	7.48	3.32	1.92	4.17	2.42	351.24	4040	1632	461.38	323.88	9680	192	488.35
22		*Dar El Slam*	7.97	7.95	2.67	1.99	1.61	1.48	450.15	3440	2016	330.69	418.58	9600	1584	233.19
23		*Gerga*	7.80	7.75	1.36	1.56	1.82	1.41	336.51	4680	864	374.25	416.48	11600	1920	357.66
24		*Osirat*	8.41	8.35	2.15	2.22	1.68	0.67	435.41	3400	2448	527.76	408.06	7360	2016	280.90
25		*Minshaa*	7.78	7.91	1.42	1.81	2.15	1.68	323.88	4440	864	471.75	399.64	9600	2784	488.35
26		*Sohag*	7.70	7.69	2.56	1.85	2.69	1.14	342.82	4760	1584	231.12	372.28	9360	2016	264.31
27		*Shandawil*	7.87	8.40	2.37	2.80	2.22	1.08	479.61	3320	2544	619.04	1066.73	10400	576	206.22
28		*Akhmim*	7.73	7.65	3.09	2.83	1.61	2.62	464.88	4080	960	605.00	561.68	9920	1488	553.00
29		*Saqalta*	7.67	7.67	1.88	1.76	2.42	1.41	582.72	6360	2256	582.00	441.73	12240	2256	492.50

Table 3. (Continued) Some chemical properties of the soils of Upper Egypt (Aswan - El-Minya)

No.	Gov.	Sector	pH (1:2)		EC_e 1:1		O.M %		Available cations mg/kg 0-30 cm				Available cations mg/kg 30-60 cm			
			0 - 30 cm	30 - 60 cm	0 - 30 cm	30-60 cm	0-30 cm	30-60 cm	Na	Ca	Mg	K	Na	Ca	Mg	K
30		*Maragha*	8.10	8.20	2.53	3.36	1.21	1.75	822.62	2680	7872	370.10	1304.52	10400	3360	353.51
31		*Juhayna*	8.35	8.46	4.11	3.48	2.69	2.42	1689.62	7080	3744	518.00	1609.66	9200	2064	320.32
32		*Tahta*	8.01	7.99	2.84	1.58	2.49	2.22	509.07	5960	1968	563.00	557.47	9920	1248	662.00
33		*Tema*	7.58	7.70	8.97	8.17	1.34	1.75	1531.80	3680	1344	533.99	1386.59	7200	1968	289.20
34	*Assiut*	*El Fateh*	7.58	7.59	4.28	4.74	0.34	1.01	679.52	4600	2352	591.00	700.57	9600	1680	595.00
35		*El Sahel*	7.78	7.90	1.40	1.64	2.15	1.68	321.78	4400	912	471.75	395.43	11600	1488	486.28
36		*Ghanaim*	7.58	7.60	4.42	4.53	0.47	1.08	700.57	4680	2304	493.00	763.70	9600	1824	616.00
37		*Badary*	7.66	7.67	2.07	1.83	2.08	1.21	384.91	4000	2112	401.22	492.23	10000	1152	318.24
38		*Sedfa*	7.87	8.50	2.43	4.30	0.87	0.81	620.60	4920	2352	370.10	1171.95	8080	1488	664.68
39		*Abu Teg*	7.83	7.85	1.68	1.87	1.55	0.74	607.97	5200	2160	287.13	559.57	8720	1824	318.24
40		*Assiut*	7.72	7.79	1.86	2.38	1.55	0.87	361.76	4040	1152	401.22	262.86	8400	1728	256.01
41		*Abanob*	7.86	7.78	2.17	1.31	1.68	1.55	338.61	3320	1968	431.00	174.47	4240	768	492.00
42		*W. Manfalout*	8.16	7.97	13.47	15.93	1.95	1.75	1609.66	5080	2448	541.68	2186.64	14400	2592	668.83
43		*E. Manfalout*	8.73	8.03	12.98	1.59	1.48	0.74	481.71	2000	624	530.00	222.87	7120	480	378.40
44		*Qusia*	8.00	8.10	2.52	2.93	2.15	1.75	828.93	5560	4848	303.72	1167.74	10800	5520	312.02
45		*Dayrout*	7.84	8.11	1.94	2.26	1.48	0.67	462.77	6760	816	455.16	347.03	9840	1200	480.05
46	*Minya*	*Der Mawas*	8.14	8.55	14.07	8.64	0.87	0.27	1554.94	3760	1248	280.90	1418.16	7520	1824	276.75
47		*Mallawy*	7.75	7.73	2.33	2.18	2.15	1.34	473.29	4480	1584	330.69	557.47	10080	1392	376.33
48		*Abu korkas*	7.81	7.78	2.18	1.78	1.08	0.67	395.43	4680	1968	297.50	584.83	11200	1488	330.69
49		*Minya*	7.72	7.89	1.29	1.31	1.08	0.47	279.69	3400	768	164.73	218.66	6880	1344	347.29
50		*Samalut*	7.89	7.99	2.51	1.93	1.68	0.74	528.01	4840	1488	494.00	631.12	10080	1104	428.00
51		*Mattai*	7.79	7.57	2.12	2.39	1.01	3.77	368.07	4800	768	430.26	389.12	9600	1104	247.71
52		*W. Bany Mazar*	7.71	7.81	2.40	2.27	2.55	1.14	650.06	7040	2448	593.00	618.50	9040	2784	392.92
53		*E. Bany Mazar*	7.58	7.69	5.42	3.39	1.28	1.01	410.16	4960	672	459.31	849.98	13280	2352	440.64
54		*Maghagha*	7.56	7.65	2.40	1.92	1.88	1.55	448.04	3400	2352	413.67	408.06	7760	1872	251.86
55		*El edwa*	7.70	7.75	1.86	2.32	1.61	0.87	307.05	4080	1104	403.30	317.57	8480	1728	256.01

4-The electrical conductivity (EC_e)

The overall average of soil EC_e ranged from 1.29– 14.24 with average of 3.49 (Tables 3 and 4). In the surface soil (0-30 cm), the highest EC_e (14.24) was pronounced for the soil samples collected from Luxor governorate followed by Minya governorate (14.07). Meanwhile, the lowest EC_e value of 1.29 was found in soil samples collected from Minya (Tables 3 and 4). While, in the subsurface soil (30-60 cm), the highest ECe content (15.93) was found in Assiut governorate followed by Luxor governorate (9.02). Meanwhile, the lowest ECe value of 1.08 was found in soil samples collected from Aswan. According to Soil Survey Division Staff (1993), about 33.6% of soil samples are non-saline (ECe<2 dS m^{-1}), 45.45% of them are very slightly saline (ECe=2-4 Ds m^{-1}), 10% of the studied soils are slightly saline (EC_e=4-8 dSm^{-1}) and 8.18% are moderately saline (EC_e=8-16 dSm^{-1}).

Table 4. Statistics of soil chemical properties of the Upper Egypt Soils (Aswan- El-Minya) (pH, EC_e and OM)

Governorate		pH		EC_e		O.M	
		0-30 cm	30-60 cm	0-30 cm	30-60 cm	0-30 cm	30-60 cm
Aswan	Min	7.77	7.73	1.46	1.08	1.48	0.07
	Max	7.81	8.22	2.68	2.79	2.42	1.01
	Av	7.79	7.93	2.04	1.93	1.95	0.65
	SD	0.02	0.21	0.50	0.70	0.38	0.42
Luxor	Min	7.56	7.66	1.36	1.60	0.81	0.13
	Max	8.29	8.55	14.24	9.02	2.49	1.48
	Av	7.94	8.05	4.37	3.57	1.91	0.91
	SD	0.23	0.32	4.06	2.46	0.62	0.46
Qena	Min	7.65	7.45	1.75	1.32	0.74	0.47
	Max	8.19	8.34	4.67	4.29	4.17	2.82
	Av	7.79	7.85	2.63	2.45	2.10	1.51
	SD	0.16	0.29	0.87	0.98	0.87	0.74
Sohag	Min	7.58	7.48	1.36	1.56	1.21	0.67
	Max	8.41	8.40	8.97	8.17	4.17	2.62
	Av	7.89	7.94	3.02	2.72	2.16	1.70
	SD	0.25	0.31	1.86	1.69	0.75	0.56
Assiut	Min	7.58	7.59	1.40	1.31	0.34	0.67
	Max	8.73	8.50	13.47	15.93	2.15	1.75
	Av	7.88	7.91	4.27	3.78	1.48	1.15
	SD	0.30	0.25	4.11	3.84	0.59	0.40
Minya	Min	7.56	7.57	1.29	1.31	0.87	0.27
	Max	8.14	8.55	14.07	8.64	2.55	3.77
	AV	7.77	7.84	3.66	2.81	1.52	1.18
	SD	0.16	0.26	3.62	2.01	0.53	0.94
Overall	Min	7.56	7.45	1.29	1.08	0.34	0.07
	Max	8.73	8.55	14.24	15.93	4.17	3.77
	AV	7.85	7.92	3.49	3.01	1.84	1.28
	SD	0.23	0.29	3.16	2.45	0.73	0.70

5-Organic matter

The soil OM ranged from 0.3 – 4.2 % with average of 1.80% (Table 3 and Table 4). In the surface soil (0-30 cm). However, the highest OM content (4.17%)

was found in Qena and Sohag governorate followed by Minya governorate (2.55%). Meanwhile, the lowest OM value (0.34%) was found in soil samples collected from Assiut.

In the subsurface soil (30-60 cm), the highest OM content (3.77) was pronounced for the soil samples collected from Minya governorate followed by Qena governorate (2.82). Meanwhile, the lowest OM value of 0.13 was found in soil samples collected from Luxor. According to Kumar *et al*. (2014) in the classification of organic matter content, it was 40% of soil samples were medium (0.86-1.29), and 60% of them were high (> 1.29%).

6-Available cations

Available Sodium (Na^+)

Available Sodium as overall ranged from 279.7 – 1689.6 mg/kg with average of 605.75 mg/kg in the surface soil (0-30 cm) (Table 3 and Table 5). The highest Na^+ content (1689.6) was pronounced for the soil samples collected from surface soil samples at Sohag governorate followed by Luxor governorate (1561.25). Meanwhile, the lowest Na^+ value of 279.69 was found in soil samples collected from Minya.

In the subsurface soil (30-60 cm), the highest Na^+ content (2186.64) was pronounced for the soil samples collected from Assiut governorate followed by Sohag governorate (1609.66). Meanwhile, the lowest Na^+ value of 174.47 was found in soil samples collected from Assiut.

Available calcium (Ca^{2+})

The overall soil available Ca^{2+} ranged from 2000 – 7320 mg/kg with average of 4594.91 (Table 3 and Table 5). In the surface soil (0-30 cm), the highest Ca^{2+} content (7320) was pronounced for the soil samples collected from Qena governorate followed by Luxor governorate (7280). Meanwhile, the lowest Ca^{2+} value of 10 was found in soil samples collected from Assiut (Tables 3 and 5).

In the subsurface soil (30-60 cm), the highest Ca^{2+} content (14400) was pronounced for the soil samples collected from Assiut governorate followed by Aswan governorate (14080). Meanwhile, the lowest Ca^{2+}value of 4080 was found in soil samples collected from Qena.

Available magnesium (Mg^{2+})

The soil available Mg^{2+} ranged from 624 – 7872 mg/kg with average of 1980 in the surface soil (0-30 cm) (Table 3 and Table 5). The highest Mg^{2+} content (7872) was pronounced for the surface soil samples collected from Sohag governorate followed by Luxor governorate (6192). Meanwhile, the lowest Mg^{2+} value of 624 was found in soil samples collected from Assiut (Tables 3 and 5).

In the subsurface soil (30-60 cm), the highest Mg^{2+} content (5520) was pronounced for the soil samples collected from Assiut governorate followed by Sohag governorate (3360). Meanwhile, the lowest Mg^{2+} value of 192 was found in soil samples collected from Qena and Sohag.

Table 5. Statistics of available cations in the soils of the Upper Egypt (Aswan- El-Minya) (Na, K, Ca, Mg)

		Na^{+}		Ca^{++}		Mg^{++}		K^{+}	
		0-30	30-60	0-30	30-60	0-30	30-60	0-30	30-60
Aswan	Min	361.76	262.86	4360.00	5040.00	912.00	576.00	363.88	85.90
	Max	416.48	376.49	6960.00	14080.00	2160.00	1776.00	612.82	488.35
	Av	393.33	332.30	5733.33	8800.00	1600.00	1328.00	481.43	265.69
	SD	23.12	49.71	1066.50	3843.89	517.47	534.98	102.10	167.07
Luxor	Min	347.03	397.54	2680.00	7680.00	720.00	1104.00	282.98	21.59
	Max	1561.26	1426.58	7280.00	11920.00	6144.00	3168.00	644.00	510.00
	Av	781.58	811.05	4615.00	9510.00	2352.00	1716.00	434.65	311.61
	SD	406.60	393.91	1354.98	1621.57	1528.86	625.73	114.88	136.10
Qena	Min	349.14	180.78	3240.00	4080.00	912.00	192.00	347.29	177.18
	Max	1104.61	1197.20	7320.00	10560.00	2640.00	2736.00	619.04	664.68
	Av	527.77	661.52	4520.00	9004.44	1893.33	1354.67	462.57	373.76
	SD	221.27	351.73	1159.00	1929.65	580.48	762.91	80.83	157.27
Sohag	Min	323.88	323.88	2680.00	7200.00	864.00	192.00	231.12	206.22
	Max	1689.62	1609.66	7080.00	12240.00	7872.00	3360.00	619.04	662.00
	Av	640.02	712.87	4455.38	9729.23	2315.08	1805.54	476.01	383.81
	SD	434.02	437.36	1253.43	1337.01	1780.15	801.32	113.20	133.98
Assiut	Min	321.78	174.47	2000.00	4240.00	624.00	480.00	287.13	256.01
	max	1609.66	2186.64	6760.00	14400.00	4848.00	5520.00	591.00	668.83
	Av	616.57	703.75	4546.67	9366.67	2004.00	1812.00	439.75	465.48
	SD	337.52	550.05	1131.53	2370.81	1075.84	1233.78	89.07	141.47
Minya	Min	279.69	218.66	3400.00	6880.00	672.00	1104.00	164.73	247.71
	Max	1554.94	1418.16	7040.00	13280.00	2448.00	2784.00	593.00	440.64
	AV	541.48	599.35	4544.00	9392.00	1440.00	1699.20	386.74	334.82
	SD	352.79	322.76	1001.31	1811.32	615.82	512.14	115.67	70.15
Overall	Min	279.69	174.47	2000.00	4080.00	624.00	192.00	164.73	21.59
	Max	1689.62	2186.64	7320.00	14400.00	7872.00	5520.00	644.00	668.83
	AV	605.75	675.36	4594.91	9387.64	1985.45	1674.76	443.95	374.13
	SD	11.37	428.72	1207.95	2028.75	1260.60	855.11	108.34	145.27

7-Available potassium

The overall available soil K in the surface soil (0-30 cm) ranged from 164.7-644 mg/kg with average of (443.95) (Table 3 and Table 5). In the surface soil samples, the highest soluble K (644) was pronounced for the soil samples collected from Luxor governorate followed by Sohag governorate (619.04). Meanwhile, the lowest available soil K value of 164.7 was found in soil samples collected from Minya governorate. In the subsurface soil (30-60 cm), the highest available soil K content (668.83) was pronounced for the soil samples collected from Assiut governorate followed by Qena governorate (664.68). Meanwhile, the lowest available soil K value of 21.6 was found in soil samples collected from Luxor**.** Available K was low (<135 mg/kg) in about 2% of soil samples, 30% of them were medium (135-335) and 68% of soil samples were high (>335 mg/kg), according to the classification of Kumar *et al*. (2009), Table (3) and (5), Figure (1-6).

In Aswan governorate, Mostafa, (2023) said that available potassium for West Edfu ranged from 99.27 to 814 mg/kg. Also, the area of East Edfu, available potassium varied from 80.60 to 210.22 mg/kg. While, in Com Ombo, available potassium was range from 24.61 to 646.76 mg/kg.

According to Shaker (2001), available potassium in Assiut governorate ranged from 159.9 to 624 mg/kg in surface layer of the sub group Torrerts (Vtt), and it ranged from 31.2 to 678.6 mg/kg in surface layer of the sub group Torrifluvents (Eftt). Also, in sub-surface layer available potassium ranged from 140.4 to 608.4 mg/kg in the sub group Torrerts (Vtt) and ranged from 101.4 to 549.9 mg/kg in sub-surface layer of the sub group Torrifluvents (Eftt). According to Abdel-Aal (1988), available potassium in Minya governorate ranged from 58.5 to 1599 with average of 382.02 mg/kg.

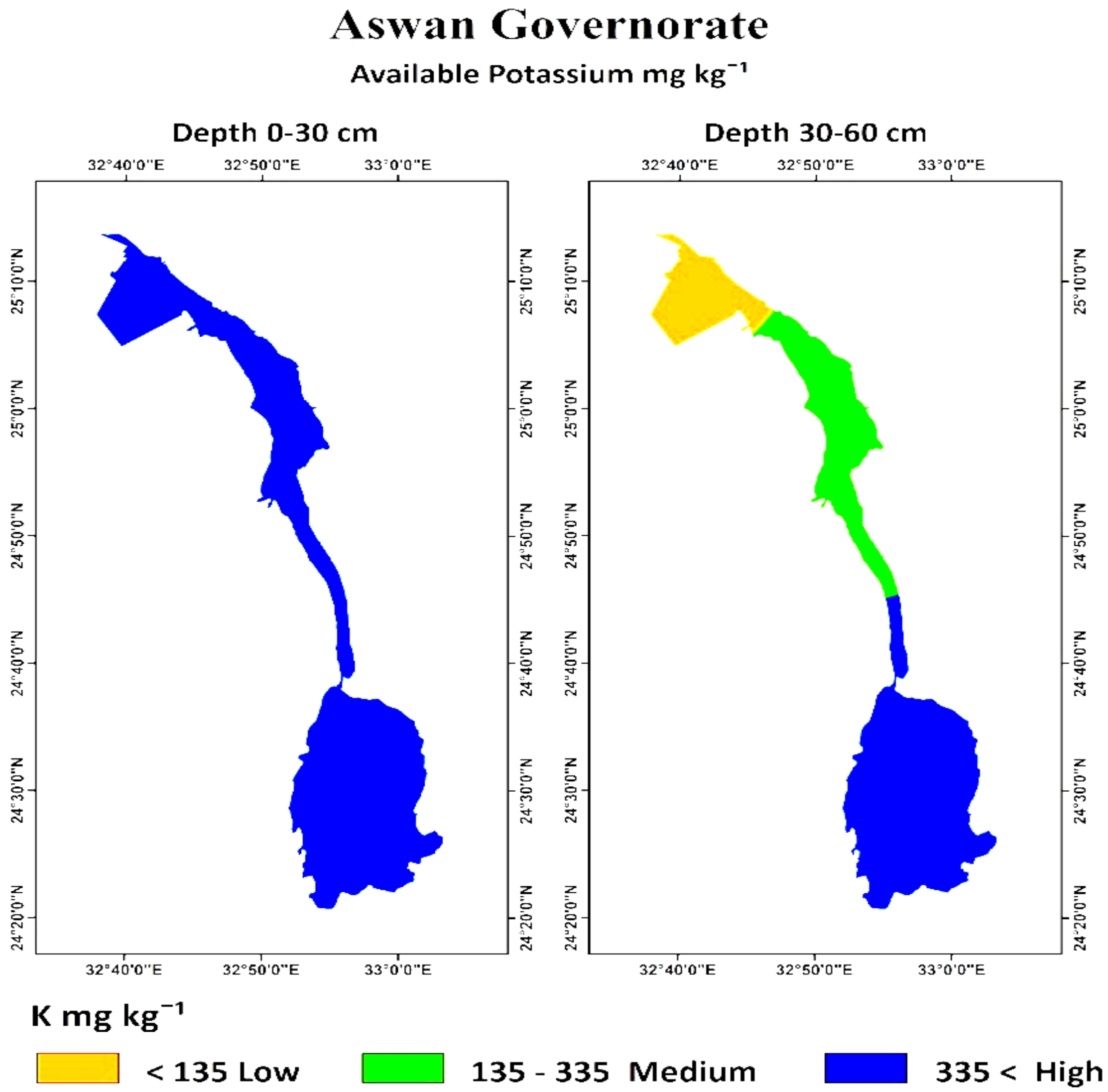

Figure 1. Available K in the soils of Aswan governorate.

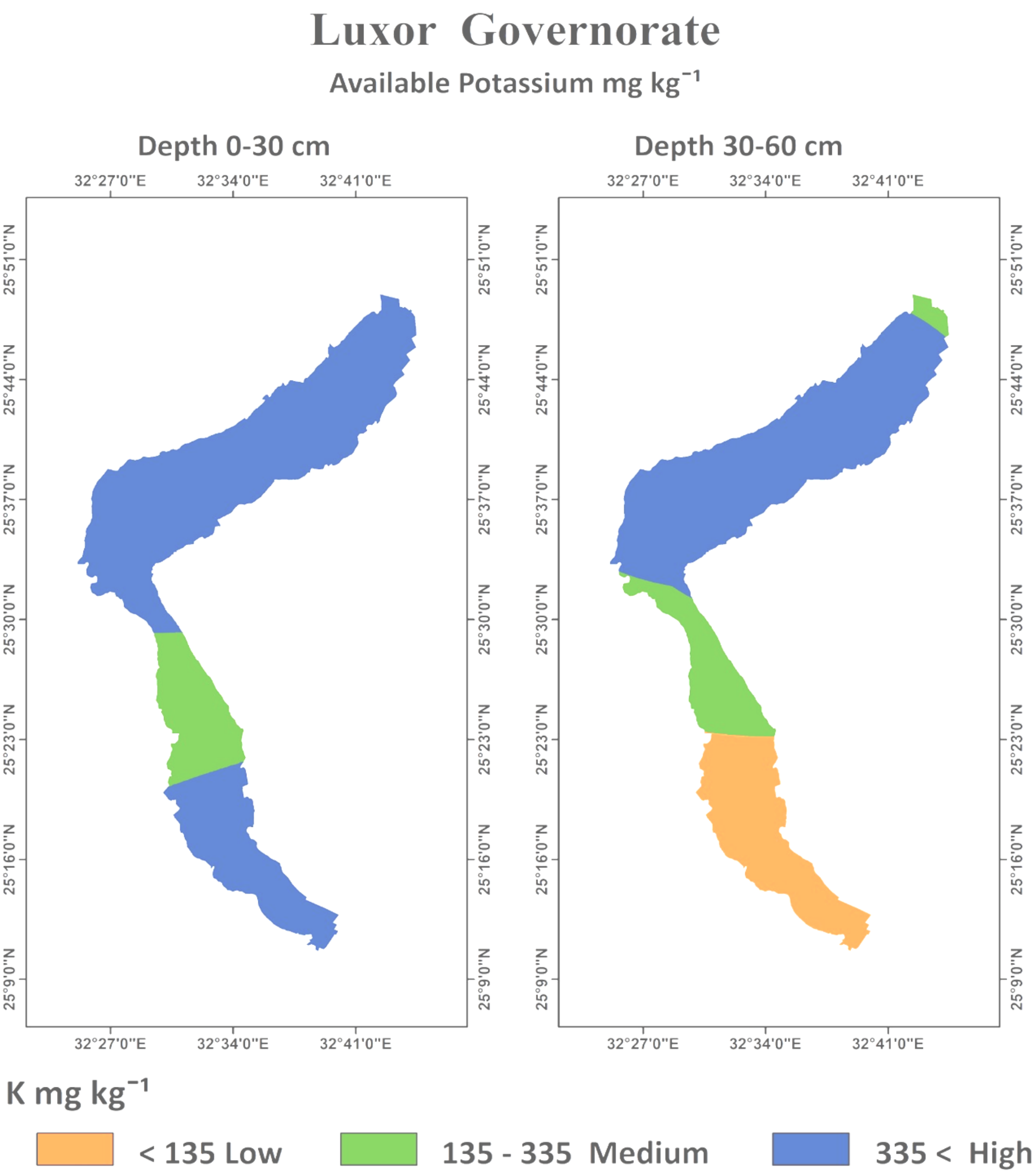

Figure 2. Available K in the soils of Luxor governorate.

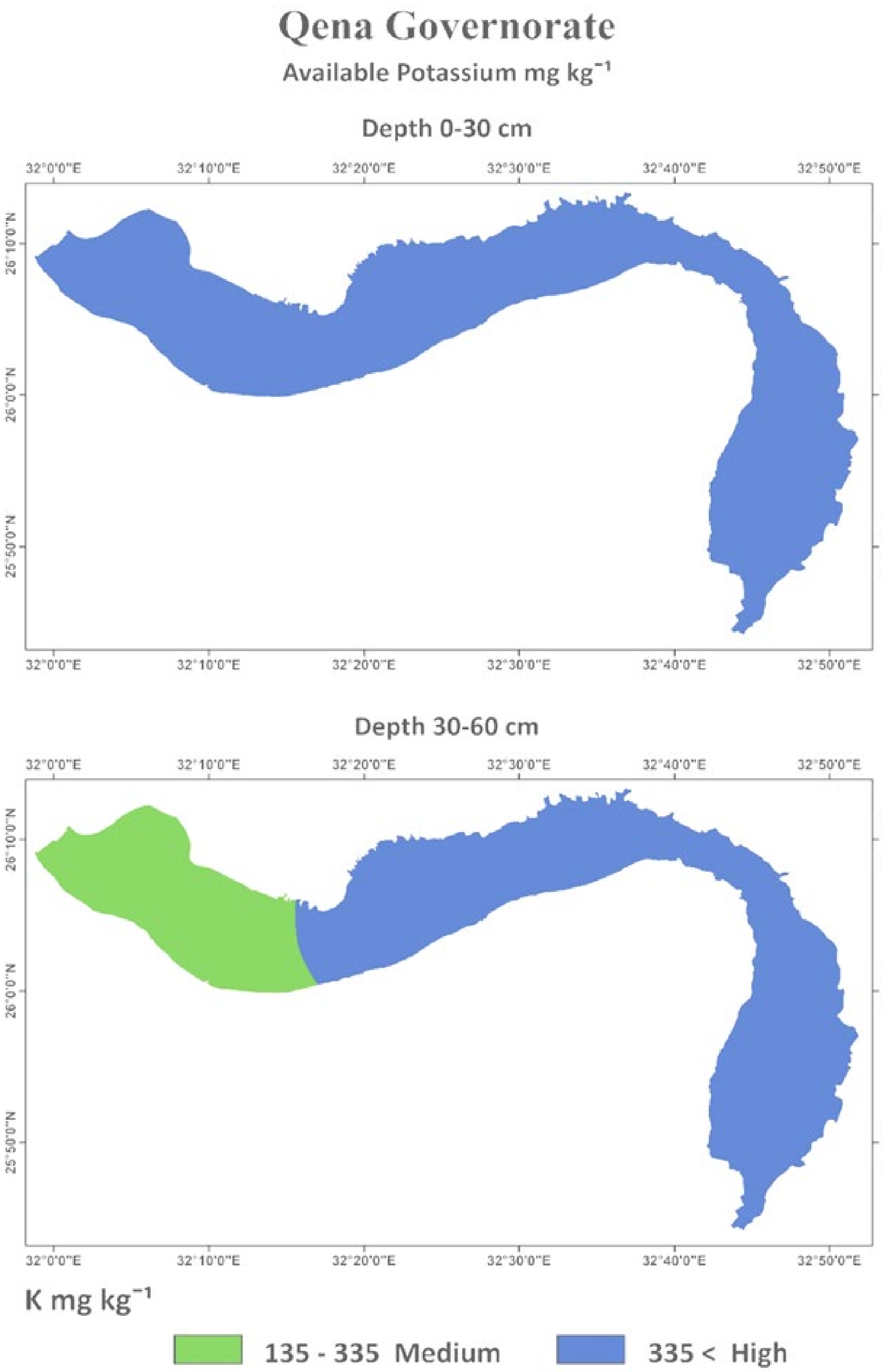

Figure 3. Available K in the soils of Qena governorate.

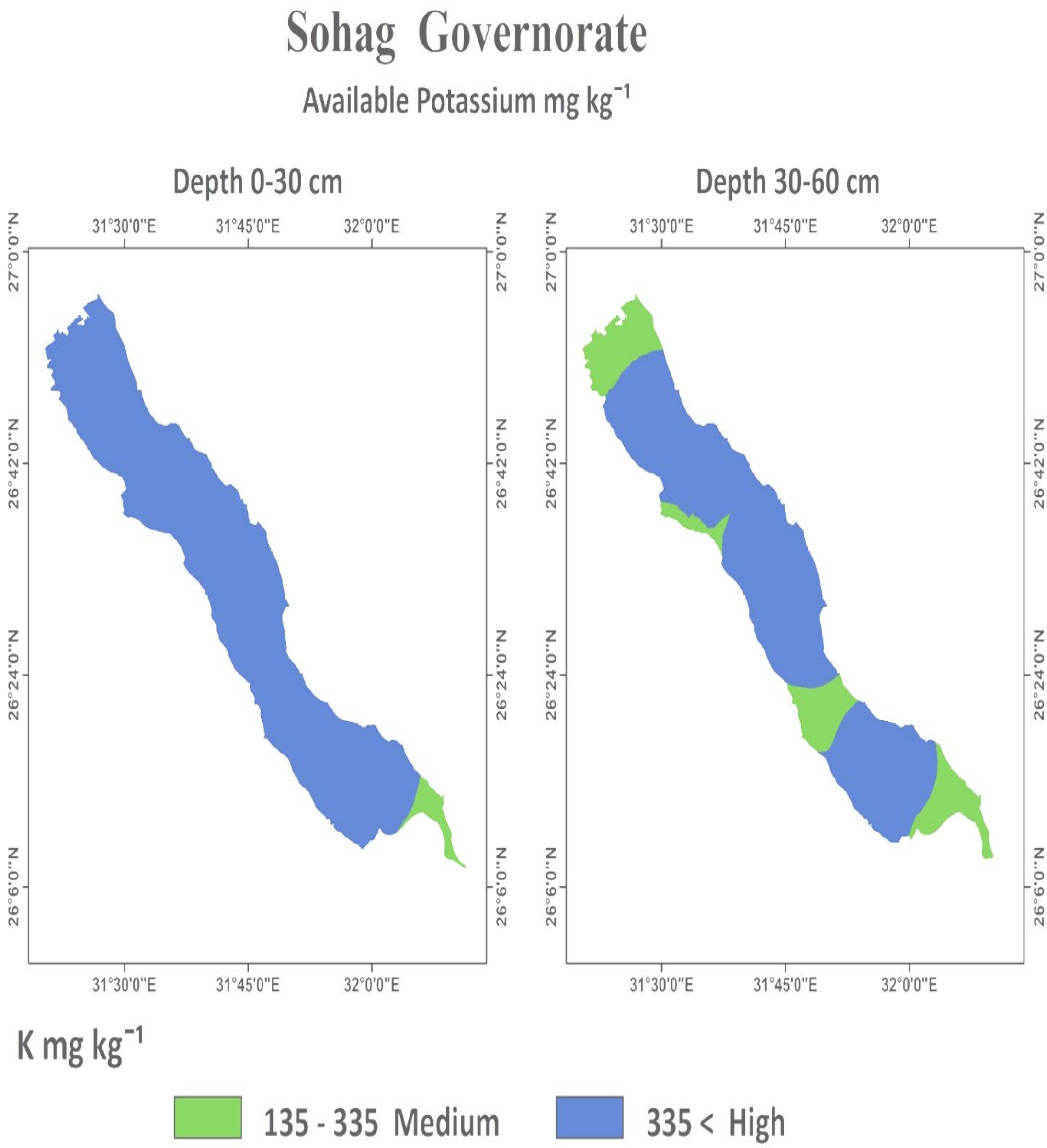

Figure 4. Available K in the soils of Sohag governorate.

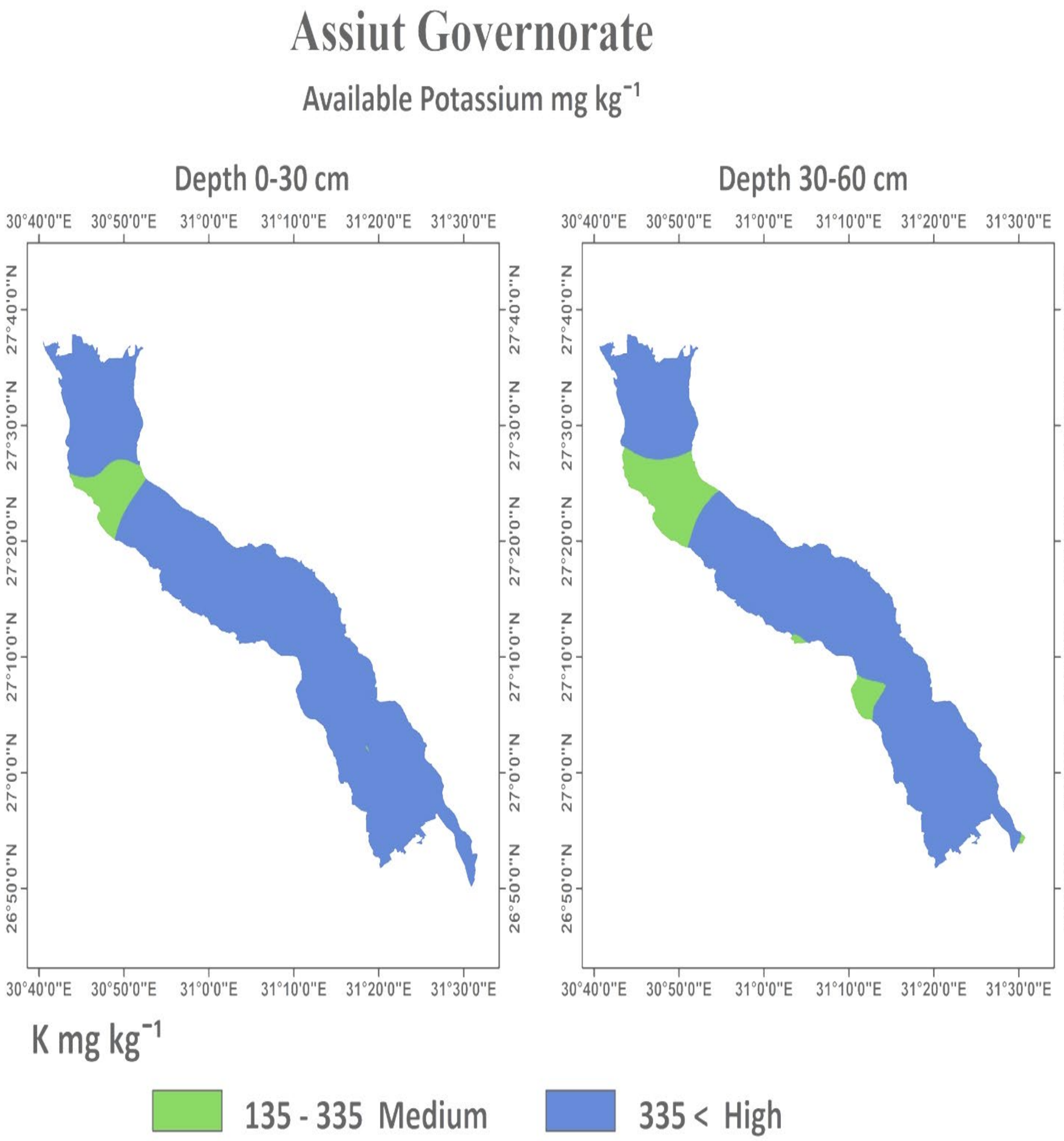

Figure 5. Available K in the soils of Assiut governorate.

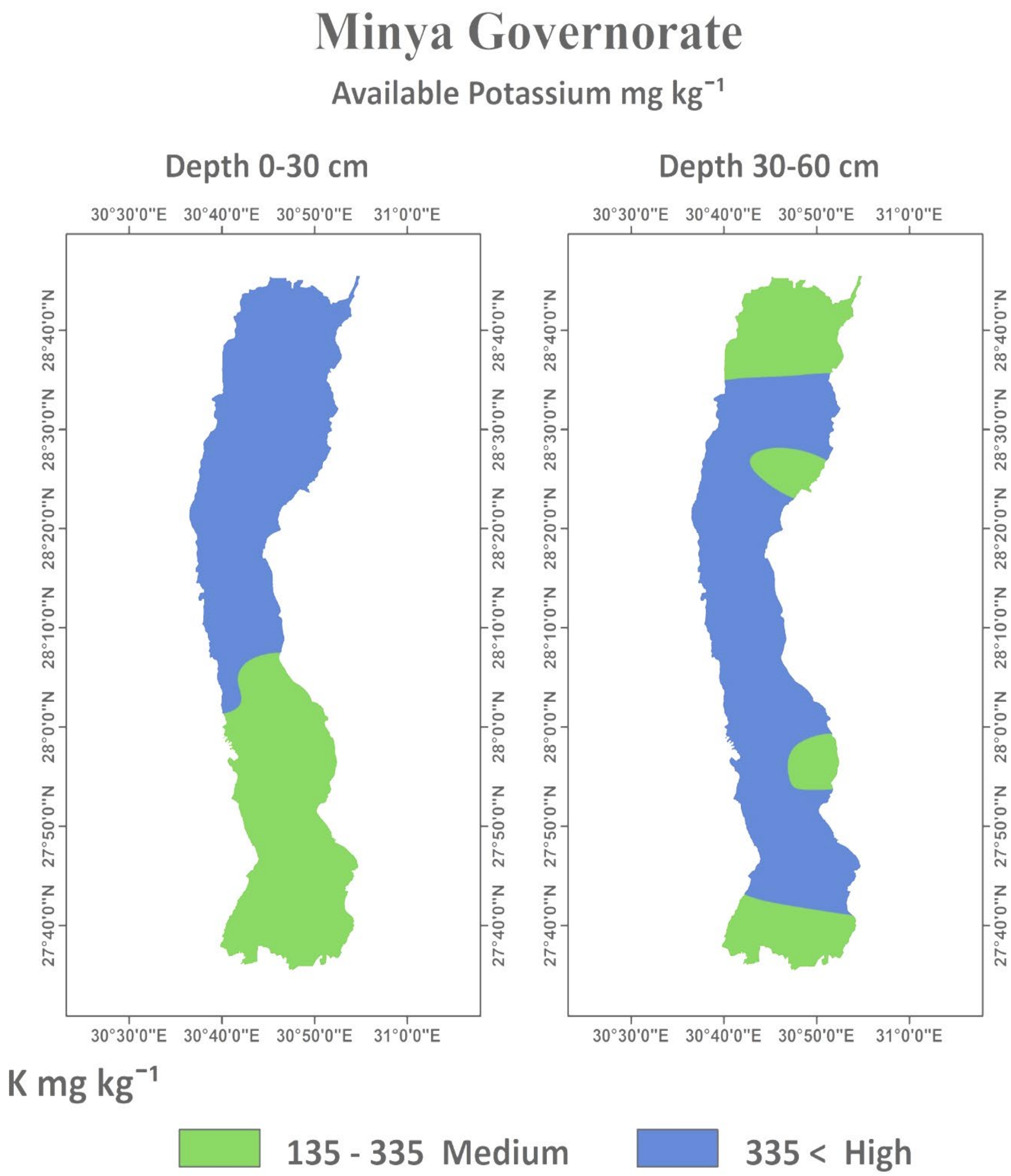

Figure 6. Available K in the soils of Minya governorate.

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رصد ورسم خرائط البوتاسيوم المتاح في اراضي مصر العليا باستخدام نظم المعلومات الجغرافية

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الملخص

يعتبر النشاط الرئيسي في صعيد مصر هو الزراعة، كما أن البوتاسيوم هو أحد العناصر الغذائية الأساسية للنبات. في السنوات الماضية، توقع العلماء أن بناء سد ناصر العالي في أسوان بمصر، من شأنه أن يمنع وصول الرواسب الطينية السنوية الغنية في البوتاسيوم التي تأتي مع مياه فيضان نهر النيل قد يؤثر سلبا على مستقبل الزراعة على ضفاف نهر النيل. لذلك تم إجراء هذه الدراسة لرصد مستويات البوتاسيوم المتاحة في تربة محافظات الصعيد. تم أخذ 110 عينة من الطبقات السطحية وتحت السطحية من 55 موقعا في محافظات أسوان والأقصر وقنا، وسوهاج، وأسيوط، والمنيا. أظهرت النتائج أن التوقع كان خاطئا تماما، حيث إن 2٪ فقط من عينات التربة كانت منخفضة في البوتاسيوم الميسر للنبات (اقل من 135ملجم/كجم) وأن 30% من العينات كانت متوسطة (335-135مجم / كجم) وان 68%من العينات كانت عالية (أكبر من 335 ملجم/كجم) وتم رسم النتائج في خرائط نظم المعلومات الجغرافية لتكون مفيدة للمزارع وكسجل لأراضي صعيد مصر ترصد الحالة بالتاريخ.