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Effect of Soil Properties on forms of potassium in Some Soils of Homs Governorate

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Abstract— The study was conductedto determine the forms of potassium in soils (water soluble K, exchangeable K, available K, non-exchangeable K, lattice K, total K) in some of Homs soils using standard laboratory procedures. The soils were ASHRAFIA, MARANA, MOUKHTARIA, ROUGHAMA, SANKARY, MASTORAH, SADAD, ARQAYA, GDAIDA, SAYED. The samples were analyzed for mechanical composition of soil viz., sand, silt, clay and chemical composition viz., pH, EC, O.M., and analyzed the different forms of potassium. The amount of water soluble, exchangeable, available, non-exchangeable, lattice and total-K in soils; ranged from 1.49 – 145.92, 244.46 – 787.71, 245.95 – 954.83, 11.10 – 836.57, 3678.08 – 18041.08 and 4583.00 – 19643 mg/Kg. The study showed that lattice K is the largest part of total K in the soils, while the water soluble K is the lowest part of total K.The total K and lattice K showed significant and positive correlation with pH. Water-soluble K concentrations positively correlated with organic matter and sand. The available K showed significant and positive correlation with sand.

Keywords— Soil, Potassium, Forms, Non-exchangeable K, Lattice, Organic matter, Homs.

1. Introduction

Potassium enters into the synthesis of all living cells and is needed in large quantities by plants, animals and humans [13]. Potassium is an essential element for the growth of all plants[6], because plays an important role in plant nutrition and physiology.Many plants absorb more potassium than nitrogen and phosphorus. K is depleted in great amount in intensive agriculture[32]. potassium increases resistance of plants to stress factors, such as pathogens, pests, and draught [20]. K enhance photosynthesis, controls stomata opening, improves N employment. It Also affects the microbial activity in the rhizosphere [23; 36]. Therefore, the lack of this elementlead toprevent of plant growth and thus reductionin field yield [42]. Potassium is found in large quantities in the soil, where the concentrations ranging between 0.4 - 30 g k g− 1 with an average of 14 g kg− 1 [5; 15].feldspar and mica are the most commonminerals containing K.

In general, plants mainly uptake available K (water soluble, exchangeable) which isbound to the clay minerals and organic matters by electrostatic forces. available K formabout 1- 2% of the total K in soil.[17] The plants can also absorb K, which is more strongly associated with the soil minerals than the Kex [28, 29], which is fixed within clay minerals (illite, vermiculite and chlorite), which are consist of sheets of silica and alumina [40], and held between adjacenttetrahedral layers of dioctahedral and trioctahedral micas, vermiculites [19, 24]. This form of K, is slowly available for crops, is called as nonexchangeable K (Kne), [9, 25, 29, 30] have found that plants acquire a large proportion of their requirement of potassium from this form (Kne) .Potassium is formed in soil from the degradation of rocks containing K bearing minerals. These minerals are completely resistant to weathering factors and therefore release K very slowly[11],According to [17], they account for 90-98% of total K in soil, where they are not available fractions .However, availablepotassium are slowly depress after long periods of agricultural production. After that cropss can only depend on the release of nonexchangable K,but [26] found that the amount of the nonexchangable potassium is insufficient to meet the requirements of plants, especially in high-yielding agriculture systems. [27] reported that the water soluble, exchangeable, available soil K had positive correlation with organic carbon content, EC and CEC, whereas, lattice and total soil K were negatively correlated to clay content and EC. [41] reported that the electrical conductivity (EC) was significantly and positively correlated with water-soluble, available and exchangeable K. Like EC, organic carbon was also positively correlated with water soluble, available and exchangeable K. [38] found that the water soluble K show negative relationship with sand, Sand positive relationship with clay, organic carbon, pH, CaCO3 and CEC. Das et al noticed that the pH of the soils, positive significant correlation with all the forms other than water soluble –K [10]. Chand et al observed that the content of clay, cation exchange capacity and pH showed significant positive correlation with all fractions of K, except water soluble K [7]. Arora et al found that available K content was positively and significantly correlated with silt, clay and CEC while negatively and significantly correlated with sand content [2]. Therefore, there was a need to study the distribution of potassium forms in the soil, in order to determine the extent of soil need for it.The study aimed at determining the distribution of K forms in some soil types in Homs governorate and studying the relationships between the K forms and the physical chemical properties of the soil.

2. Materials and methods

Soils surface composite samples (0-20 cm) of 10 soils were collected from homs governorate. The soils are the (ASHRAFIA, MARANA, MOUKHTARIA, ROUGHAMA, SANKARY, MASTORAH, SADAD, ARQAYA, GDAIDA, SAYED).The soils were air dried, crushed and sieved (2 mm) and stored until analysis.

3. Laboratory analyses

The particle-size distribution of the soils was carried out by the hydrometer method [1]. Soil pH in water was determined by the glass electrode pH (1: 2.5, soil: water). Soil organic carbon concentration were analyzed according to procedures described by [43], while electrical conductivity (1: 2.5, soil: water) were analyzed according to procedures described by [35], CEC were analyzed according to procedures described by [8], carbonat was determined by the calcimeter [4], active lime was analyzed according to procedures described by [12].

4. Determination of forms of potassium

Total K (Kt) was extracted with HNO3 - HClO4mixture [16]. Watersoluble K (Ks)was extracted with water (1:5 , soil:water) as described by [18]. Exchangeable K (Ke) was extracted with 1M NH4OAc (pH= 7). Non-exchangeable K (Kne) was extractedwith 1 N boiling HNO3 (1:10 , soil: HNO3)[14]. Mineral Potassium (Km) was calculated from the difference between total K and the sum of available K and non-exchangeable K. All forms of Potassium was measured by flame photometry.[31]

5. Statistical analyses

A correlation analysis was carried out among different forms of potassium (Ks, Ke, Kav, Kne, Km and Kt) and soil properties. Statistical analyses were achieved with the SPSS 16.0.

6. Results and Discussions

6.1 *Physico-chemical properties of the soils*

Table.1 shows physico-chemical properties determined in the soil. content of the soil from sand, silt and clay was ranged from 19.44 to 58.47, 15.34 to 55.97 and 21.98 to 50.4%, respectively. and pH measured in the study ranged from 7.63 to 8. Table.1. The CEC values werebetween16and 49.38 meq/100g. organic matter in the soils ranged between0.88- 6.55%.

Table 1: physicochemical characteristics of the soils.

Soil Series	pH	EC **µS/cm**	Carbonat %	Active lime %	OM (%)	CEC Meq/100g	Sand %	Silt %	Clay %	Texture
ASHRAFIA	8.3	148	4.98	4.41	1.21	49.38	23.14	26.47	50.4	clay
MARANA	7.87	72	5.11	3.92	0.88	32.88	27.31	36.82	35.87	clay loam
MOUKHTARIA	8.34	146.4	23.71	15.19	0.95	32.5	29.46	33.42	37.12	clay loam
ROUGHAMA	8.35	127.2	15.51	7.84	1.6	27	26.45	40.8	32.74	clay loam
SANKARY	8.6	300	36.9	14.95	1.91	20.88	22.04	55.97	21.98	silt loam
MASTORAH	7.97	146.6	2	1.47	1.09	37.38	19.44	41.53	39.04	clay loam
SADAD	8.36	709	51.34	12.01	1.81	17.75	35.51	38.02	26.46	loam
ARQAYA	7.63	278	8.25	2.94	6.55	25.13	44.77	31.5	23.73	loam

GDAIDA	8.39	260	9.28	5.15	4.31	25.38	58.47	15.34	26.18	sandy clay loam
SAYED	8.5	136	47.06	12.25	3.17	16	29.02	40.5	30.48	clay loam

7. Forms of potassium in the soils

Table. 2 shows the concentrations of the different forms of K (mg/ kg) in the soils. the results indicated a significant difference in the distribution of K forms in the soils,This may be due to the difference in the physical and chemical characteristic of the studied soil. in the study, total K values ranged from 2153 to 18848 mg/ kg. MARANA soil, which contained the lowest soil pH and high clay content, showed the lowest total content of the K ($P<0.05$). This corresponds to Suddhiprakarn et al, who observed that the high clay content in the soil with low soil pH is often related to low concentration of total potassium [39] .Water soluble K and exchangeable K measured in the soils ranged from 1.49 to 145.92 mg/ kg and 244.46 to 808.91 mg/ kg, respectively. the water soluble and exchangeable K concentrations, which are available K according to [33],were the highest in the GDAIDA soil, while the lowest available K concentration was measured in the MARANA soil ($P<0.05$), This may be due to the low pH of this soil. The non-exchangeable K ranged from 11.10 to 836.57 mg/ kg. The results showed that the soil content ofwater soluble K ranged from 0.09 to 2.58% of total K concentrations, exchangeable K concentrations ranged from 2.69 to 12.15% , while non-exchangeable K, lattice K accounted for 0.25 to 4.50% , 80.97 to 96.05% of the total K concentrationsrespectively, indicative that the lattice K concentrations constituted the highest part of the total K in the soils, while the water soluble K considered the lowest proportion of the total K.

Table 2: different forms of potassium in the studied soils mg/ kg.

Soil Series	Kt	Ks	% of Total K	Ke	% of Total K	Kav	% of Total K	Kne	% of Total K	Km	% of Total K
ASHRAFIA	11693.00 c	10.77 g	0.09	314.69 e	2.69	325.45 f	2.78	428.47 b	3.66	10939.08 c	93.55
MARANA	2153.00 e	21.37 e	0.99	244.46 f	11.35	265.83 g	12.35	11.10 d	0.52	1876.08 e	87.14
MOUKHTARIA	14078.00 b	33.29 e	0.24	762.54 a	5.42	795.83 b	5.65	360.90 b	2.56	12921.28 b	91.78
ROUGHAMA	18583.00 a	41.24 d	0.22	787.71 a	4.24	828.95 b	4.46	836.57 a	4.50	16917.48 a	91.04
SANKARY	18848.00 a	45.22 d	0.24	538.61 c	2.86	583.83 d	3.10	223.10 c	1.19	18041.08 a	95.71
MASTORAH	4538.00 d	1.49 g	0.04	244.46 f	5.58	245.95 g	5.62	62.77 d	1.36	4229.28 d	93.02
SADAD	11163.00 c	27.99 f	0.25	648.59 b	5.82	676.58 c	6.07	77.35 d	0.70	10409.08 c	93.24
ARQAYA	4538.00 d	116.77 b	2.58	546.56 c	12.15	663.33 c	14.74	196.60 c	4.29	3678.08 d	80.97
GDAIDA	19643.00 a	145.92 a	0.74	808.91 a	4.12	954.83 a	4.86	806.10 a	4.10	17882.08 a	91.04
SAYED	14078.00 b	70.39 c	0.50	447.19 d	3.19	517.58 e	3.69	34.94 d	0.25	13525.48 b	96.05

Values followed by different letters are Statistically different ($P < 0.05$). Means with similar letters are not Statistically significant at ($P < 0.05$).

8. Influence of some selected soil properties on different forms of potassium

Table.3.shows the correlation between different forms of K and the physicochemical characteristics of thesoils. Soluble K forms correlated with positive correlation with organic matter ($r= 0.879$) ,Similar results were obtained by [3; 21, 27; 41],This observation may be attributed to negative charges of organic matter which have affinity for K^+ ions, or this is probably due to the fact with increase in organic matter in soils, the clay-humus complex become more active thereby providing more exchange sites and access to K.Soluble K forms significantly correlated positively with sand content, ($r = 0.897$), The present finding disagreed with the finding of [38]. The concentrations of total K, and mineral K, significantly correlated positively with soil pH,with correlation coefficients ($r = 0.846, 0.887 : P < 0.01$) respectively,**Table.3**.[7; 10],also had similar observations in their studies. The correlation observed between soil pH and Kt disagreed with [37].

Additionally, the study demonstrated that available K significantly correlated positively with sand content ($r = 0.664^*$), The present finding disagreed with the finding of [2; 22].

Ks form andKavsignificantly correlated negatively with fine particle content (clay + silt) ($r = -0.879$; $p< 0.01$, $r.= -0.664$; $p< 0.05$) respectively, this is due to the binding of these forms in lattice structure of the clay minerals, they are then slowly released with time [34].

Table 3: correlation between different forms of potassium and some selected soil properties.

	pH	EC	Carbonat	Active lime	OM	CEC	Sand %	Silt %	Clay %	clay+silt
Kt	.864(**)	0.105	0.393	0.583	-0.008	-0.322	0.19	0	-0.264	-0.191
Ks	-0.051	0.095	-0.022	-0.088	.879(**)	-0.459	.897(**)	-0.502	-0.621	-.897(**)
Kex	0.415	0.319	0.297	0.467	0.274	-0.456	0.556	-0.235	-0.48	-0.556
Kav	0.359	0.301	0.259	0.398	0.41	-0.492	.664(*)	-0.304	-0.544	-.664(*)
Knex	0.309	-0.163	-0.3	-0.06	0.116	0.138	0.395	-0.462	0.025	-0.395
Km	.887(**)	0.108	0.421	0.606	-0.031	-0.329	0.155	0.036	-0.26	-0.155

* Significant at P<0.05 ** significant at P<0.01

9. Conclusions

The study showed the soils contain a large lattice K fraction (91%) of total K, and a smaller fraction of available forms of K.(%6) The study displayed that the percentage of exchangeable and non-exchangeable K is about 7% of the total K. However, K (ne) can serve as K reserves, where crops can rely on this form to satisfy their requirements. It is released slowly when the available K becomes depleted.

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العلاقة بين أشكال البوتاسيوم والخصائص الفيزيائية والكيميائية لترب مأخوذة من محافظة حمص

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الخلاصة – أجريت هذه الدراسة لتحديد توزع أشكال البوتاسيوم (الذائب في الماء، المتبادل، المتاح، غير المتبادل، البللوري، الكلي) في ترب مأخوذة من محافظة حمص. الترب هي الأشرفية، المرانة، المختارية، الرغاما، السنكري، المستورة، صدد، عرقايا، الجديدة، الصايد. تم إجراء التحليل الميكانيكي للتربة، وتحديد نسب الرمل والطين والسلت، كما تم إجراء التحاليل الكيميائية للتربة كدرجة الحموضة، والملوحة، والمادة العضوية، وتم تقدير الأشكال المختلفة للبوتاسيوم. تراوح تركيز كل من الشكل الذائب، والمتبادل، والمتاح، وغير المتبادل، والبللوري، والكلي بين 1.49 -145.92، 244.46-787.71، 245.95 -954.83، 11.10-836.57، 3678.08 -18041.08، 4583.00-19643.00 مغ/ كغ على التوالي. أظهرت الدراسة بأن نسبة الشكل البلوري للبوتاسيوم من الشكل الكلي هي الأعلى، بينما كانت نسبة الشكل الذائب للبوتاسيوم في الماء بالنسبة للشكل الكلي هي الأخفض. ارتبط الشكل الكلي والبللوري للبوتاسيوم بعلاقة ارتباط ايجابية معنوية مع pH التربة، بينما ارتبط الشكل الذائب في الماء للبوتاسيوم بعلاقة ارتباط ايجابية معنوية مع كل من محتوى التربة من المادة العضوية والرمل، كما ارتبط البوتاسيوم المتاح بعلاقة ايجابية معنوية مع الرمل.

الكلمات الرئيسية – التربة، البوتاسيوم، أشكال، البوتاسيوم غير المتبادل، البللوري، المادة العضوية، حمص.