Potassium Forms Status in Some Iraqi Sedimentary Soils and Effect of Cultivation on It

To cite this article: Mohammed Malik Hamid and Aws Jawad Kadhim 2022 *IOP Conf. Ser.: Earth Environ. Sci.* **1060** 012018

Potassium Forms Status in Some Iraqi Sedimentary Soils and Effect of Cultivation on It

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Abstract. A field experiment was carried out in Al-Hussainiya area / Al-Mussaib district within Babil Governorate to study the extraction and estimation of potassium in cultivated soil, and bush soil, and uncultivated soil, to identify the state of the soil in terms of its ability to supply potassium (poor potassium - moderate potassium - rich in potassium). Soil samples were collected from the study area in the period (1-4-2022) for each soil from the surface depth (0-30) cm and sub-surface (30-60) cm. Potassium was extracted from the study soil and the amount of potassium Soluble in water, and the exchangable, reserve-K, primary step-K and total step-K, and total K. The value of reserve-K was 0.40 and 0.46 cmol in the cultivated soil, 0.99 and 1.07 cmol in the uncultivated soil, 0.66 and 0.87 cmol in the bush soil and the surface and subsurface layers, respectively, and the initial step-K values were 0.213 and 0.487 cmol in the cultivated soil and 0.845 and 0.929 cmol in uncultivated soil and 0.48 and 0.511 bush soil, and value of total step-K was 0.982 and 0.944 cmol in the cultivated soil, 3.073 and 3.136 cmol in the uncultivated soil, 2.795 and 2.109 cmol in the bush soil and the surface and subsurface layers, respectively. Based on the results obtained and under the conditions of this study, the concentration of potassium Soluble in water and exchangable within the content of the dry and semi-arid areas, and that the exploitation of the soil by intensive cultivation constantly led to a decrease in the values of step-K and reserve-K, and that the concentration of step-K and reserve-K is lower in the subsurface layers (30- 60) cm in the cultivated soil and the soil in which the bush grows. As for the uncultivated soils, the potassium values are higher and almost close in the subsurface layer compared to the surface. As a result of the conditions of use, the sequence of the step-K and reserve-K in the study soils are as follows: Cultivated soil > bush soil > uncultivated soil**.** In addition to the need to use potassium fertilizers under conditions of intensive cultivation.

Keywords. Potassium, Extractable-K, Reserve-K, Primary step-K, Step-K.

1. Introduction

Potassium is one of the main important elements, as the plant needs it in large quantities that exceed the amount of other nutrients except for nitrogen, and the plant's need for it may exceed its need for nitrogen in some stages of its growth. It is necessary for the plant and cannot be dispensed with and replace it with another element entirely and determine the importance of potassium through the large cycle in the process of photosynthesis, the formation of proteins and the transfer of water and nutrients, so its abundance in the soil is ready for absorption by the plant contributes to increasing the productivity of agricultural crops [1].

Potassium is found in the soil in the form of three forms: potassium that is not available to plants and is present in the composition of earth minerals such as potassium feldspar and mica, and it constitutes about 90-98%, which contribute in the long run to increasing the potassium available in the soil. The second form is the facilitated potassium and it is called potassium exchangable on the surfaces Colloids and Soluble in the soil solution, and the amount of facilitated potassium represents from 1-2% of the total amount of potassium, and it includes the Soluble potassium, which represents 10% of this form, and the potassium exchangable on the surfaces of the colloids in the soil, which represents 90%. The exchangable potassium is in equilibrium with the Soluble potassium, and they represent the main source of potassium absorbed by the growing plants. As a result of the fact that both the Soluble and exchangable potassium are constantly in a state of dynamic equilibrium, this is important from a practical point of view, because by absorbing the Soluble potassium by the plant, an reserve-k occurs in this equilibrium as a result of a decrease in the concentration in the ground solution, and thus the exchangable of potassium ions occurs on the surfaces of the colloids in the soil into the solution The ground solution, and the exact opposite occurs by increasing the concentration in the ground solution as a result of adding potassium fertilizers. The third picture is slow-release potassium and it is called non-exchangable potassium, and it constitutes 1-10%. It includes potassium that is fixed between the layers of clay minerals, such as: illite, vermiculite, and bidelite, and some of the trapped can be released. Between layers of minerals to compensate for what the plant absorbed during the growing seasons, so it can be adopted as a criterion for assessing the state of potassium in the soil as it determines its ability to supply potassium during the growing season [2].
Therefore, the objectives of the study can be summarized as follows:

- Determination of potassium in cultivated and uncultivated soils and bush soil in a specific area.
- Identifying the ability of the soil to supply potassium and giving the necessary recommend.

2. Materials and Methods

2.1. Study Area

a field experiment was carried out in Al-Hussainiya area located in Babil Governorate / Al-Mussaib District, which is 70 km south of Baghdad. Soil samples were collected for depths (0-30,30-60 cm) representing each of the study areas: cultivated soil, uncultivated soil (barren), and soil in which the bush grows. The soil samples were taken by an Auger, and the samples were placed in plastic bags with a card. Data and then transferred to the laboratory for air drying and dismantling using a ceramic hammer to avoid contamination. Then the samples were passed through a sieve with holes diameter of 2 mm and collected in plastic containers for the purpose of preparing them for conducting the required analyzes. The physical and chemical properties were estimated according to the methods mentioned in [7] and as in Table (1).

2.2. Laboratory Work

Potassium Soluble in water : the amount of soil extract: water (1:1) according to the method proposed by Knudsen et al., mentioned in [3].
Exchangable potassium: measure the exchangable potassium extracted with ammonium acetate 1 at a concentration of 1N according to the method mentioned in [3].

Table 1. Some chemical and physical properties of the study soil.

Region	sample	EC_e ds.m^{-1}	pH	CEC Cmol+ kg^{-1}	SOM	Carbonate Menirals	soil particles			Tex.
							Clay	Silt	Sand	
cultivated soil	C	3.20	7.87	25.53	11.80	264.7	348	451	201	Clay loam
	N	3.58	7.89	26.90	11.40	298.4	353	447	200	Clay loam
uncultivated soil	C	7.36	7.63	20.10	3.00	225.1	180	420	400	loamy
	N	6.68	7.53	18.40	3.60	244.2	130	576	294	Silt loam
bush soil	C	6.20	7.86	21.05	5.80	260.9	252	483	265	loamy
	N	5.34	7.73	20.56	4.10	258.1	212	484	304	loamy

* C: superficial sample (0-30 cm) N:Non superficial sample (30-60 cm).

Total potassium: Soil samples were digested with a mixture of 48% hydrofluoric acid and 97% sulfuric acid Perchloric acid using a platinum eyelid capacity of 30 ml with heating, and then measure the total potassium (Flame photometer) according to the method proposed by [4].
Non-exchangable potassium
Reserve-K: It was estimated by boiling 10 g of soil with 100 mm of hydrochloric acid for 5 minutes according to the Stahlberg method as mentioned in [5].
Primary step-K, Total step-K and Constant rate-K were estimated according to the Haylock and Wakaley (1956): 50 mL of nitric acid, 0.1 M, were added to 5 g soil, left to settle overnight (over night) and filtered to to obtain primary step-K. 50 ml of nitric acid 1 N was added to the previous soil sample with the filter paper and placed on a water bath for 10 minutes after the start of boiling and then filtered, and the process was repeated five times in a row, and each of the first four extracts was called step-K, and the fifth extract was called the fixed rate of potassium. (CRK) and the sum of the values of the four extracts after subtracting the CRK value from each of them is called the total step-K. Potassium was estimated in all extracts using a flame photometer and used spss program to calculate the correlation between potassium forms with each other.

3. Results and Discussion

3.1. Some Chemical and Physical Properties

The results in Table 1 indicate that the pH ranged between 7.53 to 7.89 in the study areas, while the electrical conductivity values ranged between 3.2 to 7.36 decismens.m^{-1}, and through the obtained results, the soil content of carbonate minerals ranged between 225.1 to 289.4 g Kg^{-1} soil, and we find that the cation exchangable capacity ranged between 18.40 to 26.90 cmol + kg^{-1} , which plays an important role in the availability of potassium in the soil. Table 1 shows that the soils of the study areas tend to have moderate textures, ranging from Clay loam to Silt loam The clay content of the soil plays an important role in the potassium fixation process.

3.2. Soluble Potassium

It is noted from Table 2 that the values of Soluble potassium in the agriculturally exploited study soils were between 0.036 and 0.040 cmol kg^{-1} soil in the surface and sub-surface layer, respectively, and in the agriculturally unexploited soils between 0.069 and 0.052 cmol kg^{-1}soil for the surface and sub-surface layer, respectively. And in unexploited soils between 0.50 and 0.047 cmol kg^{-1} soil for the surface and subsurface layer, respectively, this value represents 0.199% and 0.08% in cultivated soils, 0.148 % and 0.110 % for uncultivated soils, and 0.114 and 0.114% for bush soils. Of the total potassium, which reached a value of 30.326% , 45.540 %, and 46.680 % for these soils, respectively. This amount of Soluble potassium is sufficient to meet the needs of many agricultural crops, except for plants that absorb high potassium, such as maize [6].

Table 2. Soluble and exchangable potassium in the study soils.

soil	depth	Soluble-K	Exchangable - K
cultivated soil	C	0.0360	0.1300
	N	0.0400	0.2900
uncultivated soil	C	0.0690	0.5600
	N	0.0520	0.4980
bush soil	C	0.0500	0.3800
	N	0.0470	0.4161

The difference in the values of dissolved potassium in soils in general can be due to the difference in their content of exchangable potassium due to the dynamic relationship between them, and what supports this is the presence of a positive correlation. Irrigation due to the speed of potassium movement in the soil, and the dissolved potassium was associated with a significant relationship with the fixed rate of potassium and total and a high significant relationship with all other forms of potassium included in the study, and the existence of a highly significant correlation between dissolved and mutual potassium is due to the state of continuous equilibrium between these two forms (Table 4).

3.3. Exchangeable Potassium

The content of the study soil of exchangable potassium in the cultivated soil was between 0.130 and 0.290 cmol kg^{-1} soil in the surface and sub-surface layer respectively, and in the non-cultivated soils between 0.560 and 0.560 cmol kg^{-1} soil for the surface and sub-surface layer respectively, and in the bush soil Between 0.380 and 0.416 cmol kg^{-1} soil kg^{-1} soil for the surface and sub-surface layer, respectively, and this value represents 0.429% and 0.637% in the cultivated soil and 1.200% and 1.058% for the uncultivated soil and 0.791% and 1.036% for the bush soil of the total potassium whose value reached 30.326%, 45.540% and 46.680% for these soils, respectively.

Also, the soil content of exchangable potassium is above the critical limit of 36.0 cmol kg^{-1} which was determined by [7] in and outside the rhizosphere, so these soils will not suffer from potassium deficiency if they are grown with crops that are not highly absorbent of potassium.

The uncultivated soils have a high content of exchangable potassium, and agriculture led to a decrease in the values of exchangable potassium, as a result of its absorption from the roots of the plant during the growing season, and to increase the washing of dissolved potassium with irrigation water, which is in a state of dynamic equilibrium with this picture, and potassium was associated with The interaction has a highly significant relationship with all other potassium forms (Table 4).

3.4. Regulatory Capacity of Soils to Replace Potassium

The results of the study showed the difference in the values of reserve-k in the different study soils (table 3), and that the concentration of reserve-k in the surface soil is less than its concentration in the subsurface soil (table 3), and the reason for this can be attributed to the washing process as a result of irrigation and rainfall.

The results confirmed that the agriculturally exploited soils are poor in potassium, where the reserve-k concentration was 0.460-0.400 cmol kg^{-1}.

And based on the limits set by [8]. in determining the need for potassium fertilizing, which is when the values of the reserve-k are less than 0.512 cmol kg^{-1} that is considered poor in its content of reserve-k and when it ranges between 1.023 -0.512 cmol kg^{-1} is considered to have moderate content and does not need fertilizing, and when the values of potassium reserve are more than 1.023 cmol kg^{-1} of potassium reserve is considered rich in its content of stored potassium. Potassium reserve was associated with a highly significant relationship with progress, constant rate and total progress.

As for the soil in which the bush grows, the values of reserve-k in the subsurface soil were higher than the values of potassium in the surface soil, as shown in the table (3). The phase and reserve-k is higher than the cultivated soils, as the potassium concentration reserve-k was 18.4-34.1 cmol kg^{-1}, we will finance potassium cmol kg^{-1}, and this indicates that the soil condition is moderate in content and does not need fertilizing according to the limits set by [8].

Table 3. Primary-K, Step-K ,CRK ,Total step-K and Reserve-K(cmolkg^{-1}).

soils	Depth	Step-K					CRK	Total step-K	Reserve-K
		Primary step	1	2	3	4			
cultivated soil	C	0.213	0.418	0.374	0.348	0.33	0.122	0.982	0.40
	N	0.487	0.678	0.525	0.48	0.361	0.175	0.944	0.46
uncultivated soil	C	0.845	2.248	1.023	0.452	0.234	0.253	3.073	0.99
	N	0.929	2.101	0.992	0.455	0.228	0.298	3.136	1.07
bush soil	C	0.48	1.595	0.917	0.504	0.391	0.221	2.795	0.66
	N	0.511	1.432	0.902	0.305	0.262	0.262	2.109	0.87

This rise in the values of potassium reserve-k in these soils can be explained by the lack of exploitation of these soils in the cultivation of a specific crop, where the bush grows in which its spread is not dense and thus the lack of spread and penetration of the roots in a homogeneous manner, meaning that there is no significant depletion as in the densely planted soils.

As for the uncultivated soils, it is noted from Table 3 the values of potassium in the surface soils are similar to the values of potassium in the subsurface soils, where the value of reserve-k is 39.5-42.0 cmol kg^{-1}, meaning that the condition of the soil is rich in potassium and this increase is due to the absence of plants that consume potassium as in Cultivated soils, in which a decrease in potassium level is observed, while continuing to cultivate for the plant's consumption of potassium, as non-exchangable potassium contributes significantly to feeding the plant. These results confirm that the non-exchangable potassium formula can make a significant contribution to the plant's potassium supply.

3.5. Primary Step Potassium and Total Step Potassium

The primary step potassium represents the easy-to-extract phase, and is estimated for calculating the constant rate of potassium and total step potassium. Soils differed in the initial step potassium values, as they were in the agriculturally exploited soil between 0.296 and 0.384 cmol kg^{-1} soil in the surface and sub-surface layer respectively, and in the non-cultivated soils between 0.892 and 0.930 cmol kg^{-1} soil for the surface and sub-surface layer respectively, In bush soil between 0.450 and 0.560 cmol kg^{-1} for the surface and subsurface layer, respectively, this form was associated with a significant and highly significant relationship with other potassium forms in a table 4.

As for the response to potassium fertilization and according to the limits set by [7], which is that soils containing from step-k less than 0.307 cmol kg^{-1} are poor and between 0.409-0.307 cmol kg^{-1} respond to potassium fertilization. As for soils containing more than 0.409 cmol kg^{-1}, a soil that does not respond to potassium fertilization, so it is expected that the cultivated soil responds to potassium fertilization as the interim potassium concentration is 0.384 - 0.269 cmol kg^{-1} of potassium.

There is a general decrease in the amount of potassium temporarily with the increase in the number of extracts and this is normal and represents the depletion of potassium by the crop in repeated plantings in the case of cultivated soil.

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Table 4. Correlation coefficient between potassium forms of the study soil.

K	Extractable	Reserve	Step-K	CRK	Total step–K	Total-K
Soluble	0.896	0.784	0.823	0.674	0.922	0.610
Extractable		0.928	0.904	0.918	0.919	0.762
Reserve			0.948	0.954	0.832	0.538
Step-K				0.856	0.852	0.560
CRK					0.790	0.560
Total step-K						0.764

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