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THE ROLE OF PLANT EXTRACTS IN POTASSIUM AVAILABILITY IN CALCAREOUS SOILS

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Abstract
For the purpose of knowing the role of fermented aqueous plant extracts of yellow corn leaves, carpis, eucalyptus and palm fiber in different potassium forms and the growth of yellow corn plant in calcareous soil, a laboratory experiment was conducted by fermenting the plant parts aerobically for 28 days, then the organic acids in the fermented plant extracts were diagnosed by HPLC device, then the aqueous extract of the above plant parts was prepared at a ratio of (1:25) ml g^{-1} soil.. The soil was incubated at 30°C for periods of 14, 42 and 70 days while maintaining 60% of the field capacity moisture throughout the incubation period by weight method. The amount of dissolved, exchanged, non-exchanged and metallic potassium was estimated after each incubation period. The study concluded that the addition of aquatic plant extracts of maize, carpis, eucalyptus and palm fiber led to an increase in the average amount of soluble, exchanged, non-exchanged, mineral and total potassium in the soil, Its quantity increased significantly with an increase in the level of plant extract added to all forms of potassium in the soil, and the results indicated that the increase in the incubation period led to a decrease in the amount of soluble, exchanged and non-exchanged potassium, an increase in mineral potassium and the stability of total potassium in the soil. The types of plant extracts can be arranged according to their efficiency in increasing the availability of potassium as follows: Yellow Corn Extract > Carpis Extract > Eucalyptus Extract > Palm Leaf Extract > Comparison.

Keywords: plant extracts, potassium, calcareous soils

1- Introduction:

Agricultural production has an important and basic role in the plans and financing of economic development in different countries of the world, as it was an important reason for the development of developed countries. Also, the priority of agriculture is not an option for most developing countries, but rather is considered a direct necessity, and due to the impossibility of a fundamental launch in industry without a previous development in agriculture, this fact forces the developing countries to make the natural direction of their agricultural policy oriented towards addressing the main factors that affect the increase in agricultural production by increasing the availability of nutrients for plants, including potassium, which plays an important role in agricultural production in quality and quantity.

The method of using intensive agriculture also requires carrying out some studies that include preparing specific programs and plans for chemical management of this element and studying them, especially in areas of dry and semi-arid soils (Al- Zubaidi and Pagel 1979; Badraoui et al. 1992, Agbani et al. 1993). For the purpose of knowing the state of potassium in Iraqi soils, several studies were conducted, in which it was confirmed that most of these soils contain relatively large amount of potassium (Al-Zubaidi and Pagel 1979).

The research is extracted from a master's thesis of the first researcher

Many studies have been conducted about potassium, its condition and quantity in Iraqi soils, and it has been shown that it possesses relatively large amount of it, as is the case in the soils of arid and semi-arid areas. However, the speed of potassium liberation is relatively low, as its release into the soil solution is affected by the degree of weathering on the one hand and the availability of minerals carrying it on the other hand, and therefore it is not sufficient to meet the needs of many crops and intensive agriculture (Al-Shammari, 2013), so there is a need to conduct many studies About potassium in order to increase its readiness for plants.

The use of potassium fertilizers is of great importance, as it is considered one of the necessary elements for plant growth and contributes to increasing the plant's ability to tolerate salinity through its physiological role in regulating the osmotic effort of cells, preventing wilting and reducing water loss, as well as increasing the protein content in the plant (Rezaeian et al., 2014).

Al-Zubaidi (2000) pointed to the interest in potassium fertilization because of its important functions and its high concentration inside the plant, and that the soils of the central and southern regions of Iraq were characterized as calcareous soils, due to the high lime and clay in them, and due to the presence of a hot and dry climate, this affects the readiness of nutrients, especially potassium. Therefore, it requires specialists to study all these problems and reach successful solutions to them and how to manage the soil without affecting agricultural production by addressing the factors that affect its readiness, such as the use of plant extracts, which is a recent trend in treating the readiness of nutrients in calcareous soil, including potassium, because it contains organic acids with low molecular weights such as citric, oxalic, malic and lactic acids, in addition to humic and fulvic acids whose carboxylic groups compete with negative nutrient ions and prevent their sedimentation (Jones, 1998 and Sposito, 1998).

In the absence of primary or local studies showing the role of plant extracts, especially fermented ones, in potassium availability, this study aimed to determine the primary properties of fermented plant extracts (Compost) and to identify their content of low molecular weight organic acids LMWOAS, and the role of fermented plant extracts in potassium forms (dissolved, exchanged, non-exchanged, mineral and total potassium).

2 - Materials and Methods:

2-1 - Selection and preparation of soil samples:

A soil with a silty clay loam texture was taken from the surface layer (0-30) cm from the field of the College of Agriculture / Wasit University and dried aerobically, then the gravel and impurities were removed, the sample was crushed and passed through a sieve with holes 2 mm in diameter, the analyzes shown in Table (1) were carried out on the soil sample and according to the methods indicated.

Table (1) Chemical and physical properties of the study soil.

Characteristic	Measurement unit	The calculated value
pH	-	7.80
Electrical conductivity (EC)	dsm^{-1}	3.25
total solid carbonate	gm kg^{-1}	415.00
The exchange capacity of cations	centimol kg	15.18
Organic Matter	gm kg^{-1}	2.25
Dissolved potassium	mmol $liter^{-1}$	2.26
Exchanged potassium	mmol $liter^{-1}$	14.03
Non-exchanged potassium	mmol $liter^{-1}$	19.30
Mineralized potassium	mmol $liter^{-1}$	30.29
Total potassium	mmol $liter^{-1}$	360
Sodium (Na)	mmol $liter^{-1}$	14.43
Calcium (Ca)	mmol $liter^{-1}$	4.81
Magnesium (Mg)	mmol $liter^{-1}$	3.02
Dissolved Carbonates (CO_3)	mmol $liter^{-1}$	---
Dissolved Bicarbonates (HCO_3)	mmol $liter^{-1}$	4.00
Chloride (Cl)	mmol $liter^{-1}$	14.65
Sulfates (SO_4)	mmol $liter^{-1}$	6.92
Silt	Gm kgm^{-1}	560.00
Clay		390.00
Sand		50.00
Soil texture		Silty Clay Loam (SiCL)

2-2- Aerobic fermentation of plant parts:

100 gm of dry material was taken from each crushed plant part, then placed in plastic cans with a capacity of 250 cm^3 and moistened with a limit of 60% on the basis of dry weight. Allowing air access through placing a small tube in the plastic cans lid while maintaining the mentioned humidity through the daily weight of those containers, the lost amount of moisture was replaced with distilled water for four weeks, after which the crushed plants were dried to be ready for extraction (Pavinato et al., 2008).

2-3- Preparation of plant extracts

The different plants were extracted aqueous at a ratio of (25:1) (plant: water) according to the method described by Pavinato et al. (2008) with some modifications. 10 g of the ground and aerobically fermented plant material was placed in a flask with a capacity of 500 cm3 and 250 cm3 of distilled water was added to it and the mixture was shaken in a mechanical shaker for six hours at a speed of 160 rpm^{-1}.

After completion of the shaking well and the end of the shaking period, the mixture was passed on a cloth to separate the large obstructions, then the filtrate was taken and passed on the (Whatman No.1) filter paper for the purpose of obtaining a clear solution. The entire clear solution was collected and kept in the freezer until practical tests were performed on it. It is the original solution of the studied plant parts whose properties are shown in Table (2).

Table (2) Some chemical properties of plant extracts used in the study.

Characteristic / Extract	pH	EC ds m^{-1}	Total Nitrogen %	Total phosphorous %	Total potassium%	Organic matter gm $liter^{-1}$	Calcium mg $liter^{-1}$	Magnesium mg $liter^{-1}$
Yellow corn	6.34	1.80	4.03	0.50	0.38	18.2	16.00	3.97
Carpis	5.28	2.54	3.72	0.36	0.25	9.17	19.3	9.00
Eucalyptus	5.33	2.23	2.56	0.26	0.30	14.39	14.2	4.00
Palm's fiber	6.53	1.00	1.93	0.20	0.45	0.55	10.00	7.56

2-4 - The role of aqueous extracts in potassium forms in the soil:

75 gm of air-dry soil was placed in plastic containers with a capacity of 100 cm^3. Plant extracts of maize leaves, carpis, eucalyptus and palm leaf were added at levels of 0, 0.025, 0.05 and 0.1 ml g^{-1} of soil. Soil moisture completed with distilled water to the limits of soil field capacity. The samples were incubated at 30°C for 70 days. Soil moisture was maintained at field capacity during the incubation period, by weighing it periodically.

Samples were drawn from the treatments for three periods of time, 14, 42 and 70 days. At each time period, dissolved potassium (1:1), exchanged potassium and non-exchanged potassium were estimated according to the method of (Pratt; 1982) and mineral potassium according to (Martin and Sparks, 1983) and total potassium according to (Page et al., 1982).

3- Results and Discussion

3-1: The role of plant aqueous extracts and incubation periods in the amount of dissolved potassium in the soil:

Table 3 shows the effect of adding plant extracts on the amount of dissolved potassium in the soil during different incubation periods. The results indicated that the addition of plant aqueous extracts led to a significant increase in the amount of dissolved potassium, which amounted to (10.71, 9.06, 7.56 and 6.28) mg K kg^{-1} in soil for the extracts of yellow corn, carpis, eucalyptus and palm fibers, respectively.

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It appears from the results that the highest amount of soluble potassium was achieved when the yellow corn extract was significantly superior to all extracts, while the treatment of palm leaf extract gave the lowest value and this is due to the difference of these plant extracts in their content of organic acids, as the yellow corn extract contains the highest quantity of tricarboxylic citric acid compared to other plant extracts, which was positively reflected in the amount of potassium dissolved in the soil compared to the treatment of palm fiber, which gave the lowest value in the amount of dissolved potassium because it contained the highest amount of acetic and lactic acid, and this was confirmed by Pavinato and others, 2008.

The plant content of nutrients varies according to the type of plant, and these plants have the ability to return these high quantities of nutrients to the soil when they are extracted, and thus the ready quantities of them rise. The types of plant extracts used in the study can be arranged according to their ability to prepare potassium, regardless of concentration and incubation duration as follows: Yellow Corn Extract > Carpis Extract > Eucalyptus Extract > Palm Leaf Extract.

The results of table 3 also showed a significant decrease in the amount of dissolved potassium in the soil by increasing the incubation period, as it decreased from 9.41 mg K kg^{-1} soil after 14 days of incubation to 7.21 mg K kg^{-1} soil at 70 days of incubation. The amount of dissolved potassium was 08.6 mg K kg^{-1} soil for incubation periods of 42 days for the plant extracts, which indicates that the plant extracts may work to encapsulate the fixation sites, which reduces the chances of potassium binding with the soil components of calcium carbonate and clays and thus reduces its readiness. As well as the role of organic acids in plant extracts in dissolving potassium metal compounds that are less soluble with time.

The results in Table 3 indicate that increasing the level of plant extracts added to the soil led to a significant increase in the average amount of dissolved potassium, as it reached 9.39, 10.53 and 11.07 mg K kg^{-1} soil for levels 0.025, 0.05 and 0.1 ml g^{-1} soil respectively compared to the level 0 (without addition), which amounted to 2.63 mg K kg^{-1} soil. This may be due to the fact that increasing the level of the extract in the soil leads to the dissolution and destruction of part of the minerals carrying potassium and thus increasing its release in the soil, This was confirmed by Marschner (1995) that the presence of organic compounds in the root zone dissolves minerals carrying nutrients and thus increases its readiness for plants.

As for the effect of the interaction between the incubation period and the level of plant extract on the amount of soluble potassium in the soil, it is noted from Table 3 that there is a significant difference in the decrease in the amount of soluble potassium in the soil for all incubation periods and for all levels of plant extract treatments, with a significant decrease in the amount of soluble potassium at The comparison treatment increased the incubation period in which the amount of dissolved potassium decreased from 2.86 mg K kg^{-1} soil at the incubation period of 14 days to 2.30 mg K kg^{-1} soil at the incubation period of 70 days. The highest level of dissolved potassium was at the 14-day incubation period for the levels (0.025, 0.05 and 0.1) ml g^{-1} soil, and it reached 10.03, 11.61 and 13.13 mg K kg^{-1} soil, respectively, while the lowest level of soluble potassium was at the duration of Incubation for 70 days for levels (0.025, 0.05, and 0.1) ml g^{-1} in soil and reached 8.38, 8.99 and 9.16 mg K kg^{-1} soil, respectively, and this decrease may be attributed to the rapid

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dissolution of part of the mineral potassium, the provision of soluble potassium and an increase in the activity of microbiology.

Table (3) Effect of the type and level of plant extract (mg^{-1} soil) on the amount of potassium dissolved in soil (mg K kg^{-1} soil) during different incubation periods.

Incubation Period (Day)	Extract Level	Type of Plant Extract				Incubation Period *Extract Level
		Yellow Corn	Carpis	Eucalyptus	Palm Leaf	
14	0	2.86	2.86	2.86	2.86	2.86
	0.025	12.37	11.22	8.82	7.69	10.03
	0.05	14.29	13.11	10.46	8.59	11.61
	0.1	17.28	14.32	11.46	9.44	13.13
42	0	2.73	2.73	2.73	2.73	2.73
	0.025	12.11	11.17	8.28	7.54	9.78
	0.05	14.28	11.35	9.58	8.69	10.98
	0.1	16.28	10.42	9.57	7.40	10.92
70	0	2.30	2.30	2.30	2.30	2.30
	0.025	11.21	9.27	8.13	4.91	8.38
	0.05	11.40	9.67	8.65	6.26	8.99
	0.1	11.43	10.34	7.86	7.00	9.16
Extract Type *Extract Level *Incubation Time L.S.D 0.05		1.11				0.55
Effect Rate Of Extract Type		10.71	9.06	7.56	6.28	Incubation Period Effect Rate
LSD 0.05		0.32				
Incubation Period * Type of Extract	14	11.70	10.38	8.40	7.15	9.41
	42	11.35	8.92	7.54	6.59	8.60
	70	9.09	7.90	6.74	5.12	7.21
LSD 0.05		0.55				0.27
						Effect Rate of the Extract Level
	0	2.63	2.63	2.63	2.63	2.63

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Extract Level * Extract Type	**0.025**	11.90	10.55	8.41	6.71	**9.39**
	0.05	13.32	11.38	9.56	7.85	**10.53**
	0.1	15.00	11.69	9.63	7.94	**11.07**
L.S.D 0.05	**0.64**					**0.32**

The results in Table 3 showed that there was a significant interaction between the incubation period and the type of plant extract in the amount of potassium dissolved in the soil. The results of the treatments showed that the highest amount of soluble potassium reached when treating yellow corn extract during periods of 14, 42 and 70 days of incubation, with values of 11.70, 11.35 and 9.09 mg K kg^{-1}, respectively, compared to treatments of other extracts at the same periods, while the lowest rate of the amount of dissolved potassium when treating palm fiber in the last period of incubation (70 days) was 5.12 mg K kg^{-1} soil, and the reason for the superiority of the yellow corn extract treatment over other treatments may be due to its containing a high amount of tricarboxylic group's citric acid, which was positively reflected in the release of the amount of soluble potassium in the soil, while the palm fiber content was relatively high of acetic and lactic acids (monocarboxylic group), which is believed to be the reason for the decrease in the amount of soluble potassium in the soil.

To show the effect of the interaction between the level of the plant extract and the type of plant extract on the amount of soluble potassium in the soil, it is noted from table 3 that the average amount of soluble potassium in the soil differed significantly depending on the level of the extract and the type of extract.

The addition of plant extracts led to an increase in the amount of soluble potassium in the soil for the treatments compared to no addition. The results showed in table 3 that the yellow corn extract treatment achieved the highest rate in soluble potassium compared to all extracts for levels (0.025, 0.05 and 0.1) ml g^{-1} soil especially at the level of addition of 0.1 ml g^{-1} soil, as it reached 15.00 mg K kg^{-1} soil, while the lowest value of soluble potassium was achieved for palm fiber extract at a level of 0.025 ml gm^{-1} soil which amounted to 6.71 mg K kg^{-1} soil, and this is due to the reasons mentioned earlier.

The results of the triple interaction between incubation periods, the level of plant extract and the type of plant extract in table (3) indicate that there is a significant effect of the interaction between the above factors,

The highest value of soluble potassium for yellow corn extract was achieved at the incubation period of 14 days at the level of 0.1 ml g^{-1} soil, which was 17.28 mg K kg^{-1} soil, while the concentration of 0.025 ml g^{-1} soil for palm fiber extract at the incubation period of 70 days gave the lowest value of potassium dissolved in soil, it amounted to 4.91 mg K kg^{-1} soil.

3-2: The role of plant aqueous extracts and incubation periods in the amount of potassium exchanged in the soil.

The results of table 4 indicate that there are significant differences in the amount of exchanged potassium as a result of the effect of adding plant extracts on the amount of potassium exchanged in the soil during different incubation periods. The results indicate that the addition of aqueous plant extracts of yellow corn, carpis, eucalyptus and palm fiber led to a significant increase in the amount of potassium exchanged in the soil compared to the control treatment, and the results gave an average of 26.62, 25.26, 24.13 and 22.77 mg K kg^{-1} soil, respectively.

The results show that the highest amount of exchanged potassium was achieved with yellow corn extract, and it was significantly superior to all the extracts, while the palm leaf extract treatment gave the lowest value, the reason for this may be due to the different content of these extracts of organic acids, as the yellow corn extract contains the highest amount of citric acid compared to other plant extracts, which was positively reflected in the amount of potassium exchanged in the soil, this is consistent with the results of Al-Fartousi (2003), which showed that the aqueous extracts contain non-humic organic acids, humic organic acids, sugars and amino acids, and the type of acids, sugars and amino acids differ according to the extracted organic matter.

Table (4) Effect of the type and level of plant extract (ml g^{-1} soil) on the amount of potassium exchanged in soil (mg K kg^{-1} soil) during different incubation periods.

Incubation Period (Day)	Extract Level	Type Of Plant Extract: Yellow Corn	Carpis	Eucalyptus	Palm Fiber	Incubation Period *Extract Level
	0	18.00	18.00	18.00	18.00	**18.00**
	0.025	30.72	28.98	27.85	26.56	**28.53**
	0.05	32.81	30.88	29.91	27.77	**30.34**
14	**0.1**	35.23	33.32	32.14	29.41	**32.53**
	0	17.30	17.30	17.30	17.30	**17.30**
	0.025	27.48	25.55	23.96	22.51	**24.88**
	0.05	29.00	27.81	25.86	24.91	**26.90**
42	**0.1**	32.22	29.16	27.55	26.64	**28.89**
	0	15.00	15.00	15.00	15.00	**15.00**
	0.025	25.26	24.45	22.86	20.18	**23.19**
	0.05	27.17	25.41	23.86	21.44	**24.47**
70	**0.1**	29.30	27.28	25.21	23.52	**26.33**
Extract Type *Extract Level *Incubation Period L.S.D 0.05		**N.S**				**0.53**
Effect rate of the extract type		**26.62**	**25.26**	**24.13**	**22.77**	**The Effect Rate of Incubation Period**
LSD 0.05		**0.31**				

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Incubation Period * Type of Extract	**14**	29.19	27.80	26.98	25.44	**27.35**
	42	26.50	24.96	23.67	22.84	**24.49**
	70	24.18	23.04	21.73	20.04	**22.25**
LSD 0.05		**N.S**				**0.27**
						The Effect Rate of The Extract Level
Extract Level * Extract Type	**0**	16.77	16.77	16.77	16.77	**16.77**
	0.025	27.82	26.33	24.89	23.08	**25.53**
	0.05	29.66	28.03	26.54	24.71	**27.24**
	0.1	32.25	29.92	28.30	26.52	**29.25**
L.S.D 0.05		**0.61**				**0.31**

The types of plant extracts can be arranged according to their ability to release exchanged potassium as follows:

Yellow Corn Extract > Carpis Extract > Eucalyptus Extract > Palm Leaf Extract.

The results of Table 4 also show a significant decrease in the amount of potassium exchanged in the soil with an increase in the incubation period. Its value decreased from 27.35 mg K kg^{-1} soil after 14 days of incubation to 22.25 mg K kg^{-1} soil at 70 days of incubation. The amount of exchange potassium was 24.49 mg K kg^{-1} soil for 42 days of incubation and this is due to the same reasons mentioned above. The results also showed that the increase in the level of added plant extracts led to a significant increase in the average amount of potassium exchanged, as it reached 25.53, 27.24 and 29.25 mg K kg^{-1} soil for levels 0.025, 0.05 and 0.1 ml g^{-1} soil, respectively, compared to level 0. (without addition), which amounted to 16.77 mg K kg^{-1} soil.

The effect of the interaction between the incubation period and the level of plant extract on the amount of exchanged potassium in the soil, it is noted from the above table that there is a significant difference in the decrease in the amount of exchanged potassium in the soil and for all incubation periods and for all levels of plant extracts treatments, with a significant decrease in the amount of exchanged potassium when treating Compared with increasing the incubation period, in which the exchanged potassium decreased from 18.00 mg K kg^{-1} soil at the incubation period of 14 days to 15.00 mg K kg^{-1} soil at the incubation period 70 days.

The highest level of exchanged potassium was at the incubation period of 14 days for the levels of addition (0.025, 0.05 and 0.1) ml g^{-1} soil, which amounted to 28.53, 30.34 and 32.53 mg K kg^{-1} soil, respectively, while the lowest level of potassium Reciprocal at incubation period of 70 days for levels (0.025, 0.05 and 0.1) ml g^{-1} soil and reached 23.19, 24.47 and 26.33 mg K kg^{-1} soil, respectively. The results in Table 4 showed that there was no significant effect of the interaction between the incubation period and the type of plant extract on the amount of potassium exchanged in the soil.

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To show the effect of the interaction between the level of the plant extract and the type of plant extract on the amount of potassium exchanged in the soil, it is noted from Table 4 that the average amount of potassium exchanged in the soil differed significantly depending on the level of the extract and the type of extract. The addition of plant extracts led to an increase in the amount of potassium exchanged in the soil for the treatments compared to no addition.

The results in Table 4 showed that the treatment of yellow corn extract achieved the highest rate in the amount of exchanged potassium compared to all extracts and for the addition levels of (0.025, 0.05 and 0.1) ml g^{-1} soil, especially at the level of addition 0.05 ml g^{-1} soil, which was 29.66 mg K kg^{-1} soil

It achieved a significant superiority in the potassium exchange rate compared to all other extracts at the addition level of 0.1 ml g^{-1} soil, as it reached 32.25 mg K kg^{-1} soil, except for the treatment of carpis, which was significantly superior to it in the amount of exchanged potassium. The results of the triple interaction between incubation times, the level of plant extract and the type of plant extract in Table 4 show that there is no significant effect of the interaction between the above factors.

3-3: The role of plant aqueous extracts and incubation times in the amount of non-exchanged potassium in the soil:

The results of Table 5 show the presence of significant differences in the amount of non-exchanged potassium in the soil treated with aqueous plant extracts. The addition of plant extracts of yellow corn, carpis, eucalyptus and palm fiber led to a significant increase in the amount of non-exchanged potassium, and the results gave an average of 51.65, 50.08, 48.48 and 46 .69 mg K kg^{-1} soil respectively.

It is clear from the above results that the treatment of yellow corn extract significantly increased the amount of non-exchanged potassium in the soil over all aqueous plant extracts, while the treatment of palm leaf extract gave the lowest values. The reason for the increase in the amount of non-exchanged potassium is the ability of the organic acids present in the plant extracts to dissolve part of the potassium-bearing minerals and release it to the soil. The types of plant extracts can be arranged according to their ability to release non-exchanged potassium as follows:

Yellow Corn Extract > Carpis Extract > Eucalyptus Extract > Palm Leaf Extract.

The results also show in Table 5 that there was a significant decrease in the amount of non-exchanged potassium in the soil with the increase in the incubation period, as its value decreased from 56.65 mg K kg^{-1} soil after 14 days of incubation period to 40.76 mg K kg^{-1} soil at the incubation period 70 days .

The decrease in the amount of non-exchanged potassium in the soil over time may be attributed to the reasons mentioned in paragraph 4-1.

The results in the previous table also show that the increase in the level of addition of aquatic plant extracts led to a significant increase in the average amount of non-exchanged potassium, which reached 2.83, 56.31 and 60.15 mg K kg^{-1} soil to the levels of addition (0.025, 0.05 and 0.1) ml g^{-1} soil, respectively, compared to the level of addition (0), which was 27.62 mg K kg^{-1} soil, with significant differences between the levels of plant extract.

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As for the effect of the interaction between the incubation period and the level of the plant extract on the amount of non-exchanged potassium in the soil, the results of Table 5 showed that there was a significant increase in the amount of non-exchanged potassium with the increase in the addition level of the plant extract, and for each incubation period, the 14-day incubation period achieved the highest amount of non-exchanged potassium at the addition level of 0.1 ml g^{-1} soil and an average of 68.24 mg K kg^{-1} soil, while the lowest amount of non-exchanged potassium was at the level of 0.025 ml g^{-1} soil, at an average of 41.98 mg K kg^{-1} soil.

The results in Table 5 also indicate that there was no significant effect of the interaction between the incubation period and the type of plant extract on the amount of non-exchanged potassium in the soil. To show the effect of the interaction between the levels of plant extracts and the type of plant extracts on the amount of non-exchanged potassium in the soil.

The results in Table 5 indicated that the amount of non-exchanged potassium differed according to the level of the extract and the type of extract. The addition of plant extracts at the levels of addition (0.025, 0.05 and 0.1) ml g^{-1} soil increased the amount of non-exchanged potassium. The two levels of addition (0.05 and 0.1) ml g^{-1} soil from yellow corn extract achieved the highest amount of non-exchanged potassium with a significant difference compared to all other interaction treatments except for carpis treatment at the addition level of 0.1 ml g^{-1} soil where its amount were 59.24.63 57 mg K kg^{-1} soil respectively, and this proves that yellow corn extract is more efficient even when added at half the level to which other extracts are added.

To show the effect of the triple interaction between the duration of incubation, the type of plant extract and the level of the plant extract. The results in Table 5 show that there is no significant effect of the interaction between the above factors on the amount of non-exchanged potassium in the soil.

Table (5) Effect of the type and level of the plant extract (ml g^{-1} soil) on the amount of non-exchanged potassium in the soil (mg K kg^{-1} soil) during different incubation periods .

Incubation Period (Day)	Extract Level	Type of Plant Extract				Incubation Period *Extract Level
		Yellow Corn	Carpis	Eucalyptus	Palm Fiber	
	0	30.25	30.25	30.25	30.25	**30.25**
	0.025	65.25	63.21	61.26	59.20	**62.23**
	0.05	68.23	66.91	65.24	63.18	**65.89**
14	**0.1**	71.23	69.24	67.29	65.21	**68.24**
	0	27.60	27.60	27.60	27.60	**27.60**
	0.025	57.21	55.41	53.24	51.25	**54.28**
	0.05	60.28	58.21	56.24	53.91	**57.16**
42	**0.1**	65.24	63.21	61.29	58.35	**62.02**
	0	25.00	25.00	25.00	25.00	**25.00**
70	**0.025**	46.10	43.34	40.27	38.21	**41.98**

	0.05	49.21	47.27	44.84	42.21	**45.88**
	0.1	54.24	51.35	49.21	45.91	**50.18**
Extract Type *Extract Level *Incubation Period L.S.D 0.05		**N.S**				**0.64**
Effect Rate of Extract Type		**51.65**	**50.08**	**48.48**	**46.69**	**Effect Rate of Incubation Period**
LS.D. 0.05		**0.37**				
Incubation Period * Type of Extract	**14**	58.74	57.40	56.01	54.46	**56.65**
	42	52.58	51.11	49.59	47.78	**50.27**
	70	43.64	41.74	39.83	37.83	**40.76**
L.S.D 0.05		**N.S**				**0.32**
						Effect Rate Of Extract Level
Extract Level * Extract Type	**0**	27.62	27.62	27.62	27.62	**27.62**
	0.025	56.19	53.99	51.59	49.55	**52.83**
	0.05	59.24	57.46	55.44	53.10	**56.31**
	0.1	63.57	61.27	59.26	56.49	**60.15**
L.S.D 0.05		**0.74**				**0.37**

3-4: The role of plant aqueous extracts and incubation times in the amount of mineral potassium in the soil:

The results of Table 6 show that there are significant differences in the amount of mineral potassium in the soil treated with aqueous plant extracts, where the addition of aqueous plant extracts of yellow corn, carpis, eucalyptus and palm fiber led to an increase in the amount of mineral potassium in the soil compared to the control treatment.

The values of mineral potassium were 156.55, 153.56, 150.35 and 139.22 mg K kg^{-1} soil, respectively, the reason for the superiority of yellow corn extract treatment over all treatments is due to its containing the highest amount of organic acids such as citric (tricarboxylic group) acid, which has the ability to dissolve the mineral potassium in the soil.

The presence of the high amount of (dicarboxylic group) malic acid in the extract of carpis compared to other treatments was the reason for achieving the level of the high amount of mineral potassium in the soil after adding yellow corn extract,

Regarding the decrease in the amount of mineral potassium in the soil of the palm fiber extract compared to the rest of the extracts, it is due to the dominance of acetic and lactic (monocarboxylic

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group) acids, while the plant extracts took the same order in their ability to release mineral potassium as previously in the forms of soluble, exchanged and non-exchanged potassium.

The results of Table 6 also indicate a significant decrease in the amount of mineral potassium in the soil with an increase in the incubation period, as its value decreased from 175.02 mg K kg^{-1} soil after 14 days of incubation period to 106.81 mg K kg^{-1} soil at a period of 70 days of incubation .

The results in Table 6 showed that adding aquatic plant extracts at different levels to the soil led to a significant increase in the average amount of mineral potassium, as its quantity increased from 45.58 mg K kg^{-1} to soil when compared to 165.10, 185.92 and 203.08 mg K kg^{-1} Soil to the levels of addition of (0.025, 0.05, and 0.1) ml gm^{-1} soil, respectively, due to the same reasons mentioned above.

The results of Table (6) show that there is a significant effect between the incubation period and the level of the plant extract in the amount of mineral potassium in the soil. There was an increase in the amount of mineral potassium in the soil with an increase in the level of the plant extract and for all incubation periods and for all levels, as the level of mineral potassium increased at the incubation period of 14 days at a rate of 203.82, 216.33 and 229.25 mg K kg^{-1} of soil to treat the level of addition of the extract (0.025 and 0 .05 and 0.1) ml g^{-1} soil, respectively. Then it gradually decreased until the end of the incubation period of 70 days with values of 100.43, 130.59 and 155.94 mg K kg^{-1} soil for the above addition levels, respectively.

The results in Table 6 indicate that there is a significant interaction between the incubation period and the type of plant extract in the average amount of mineral potassium in the soil.

The results of the treatments showed that the highest amount of mineral potassium reached when treating yellow corn extract during periods of 14, 42 and 70 days of incubation, with values of 178.37, 172.42 and 118.85 mg K kg^{-1} soil, respectively, compared to treatments of other extracts at the same incubation period, while the lowest rate of the amount of mineral potassium was when treating palm fiber in the last period of incubation (70 days) with a value of 82.66 mg K kg^{-1} soil.

To show the effect of the interaction between the level of the plant extract and the type of plant extract on the amount of mineral potassium in the soil, it is noted from Table 6 that the average amount of mineral potassium in the soil differed significantly depending on the level of the extract and the type of plant extract. The addition of plant extracts at their three levels (0.025, 0.05 and 0.1) ml g^{-1} soil increased the amount of mineral potassium for all treatments, and the yellow corn extract treatment gave an increase in the amount of mineral potassium with a significant difference from all extracts. The values of mineral potassium were 173.59, 195.54 and 211.48 mg K kg^{-1} soil for the above levels, respectively, compared to the comparison level (0) which was 45.58 mg K kg^{-1} soil, while the palm fiber extract treatment gave the lowest values and were 153.39, 169.73 and 188.20 mg K kg^{-1} soil for the same levels above, respectively.

As for the effect of the triple interaction between the incubation period, the type of plant extract and the level of the plant extract, the results in Table 6 indicate a significant effect of the interaction between the above factors on the amount of mineral potassium in the soil.

The yellow corn extract achieved the highest amount in mineral potassium at a period of 14 days, especially at the level of 0.1 ml g^{-1} soil, where its quantity reached 233.21 mg K kg^{-1} soil compared to palm fiber extract, which achieved the lowest value in mineral potassium at the incubation period of 70 days for the addition level of 0.025 ml g^{-1} soil which was 77.07 mg K kg^{-1} soil.

Table (6) Effect of the type and level of plant extract (ml g^{-1} soil) on the amount of mineral potassium in soil (mg K kg^{-1} soil) during different incubation periods.

Incubation period (day)	**extract level**	**Type of plant extract**				**Incubation period *Extract level**
		yellow corn	**carpis**	**eucalyptus**	**palm fiber**	
14	**0**	50.66	50.66	50.66	50.66	**50.66**
	0.025	208.38	205.32	202.24	199.33	**203.82**
	0.05	221.24	218.36	214.33	211.39	**216.33**
	0.1	233.21	231.25	228.24	224.29	**229.25**
42	**0**	45.78	45.78	45.78	45.78	**45.78**
	0.025	198.37	194.26	187.87	183.77	**191.07**
	0.05	216.36	212.33	209.17	205.47	**101.83**
	0.1	229.17	225.36	222.32	219.38	**224.06**
70	**0**	40.30	40.30	40.30	40.30	**40.30**
	0.025	114.03	108.28	102.32	77.07	**100.43**
	0.05	149.02	143.21	137.79	92.32	**130.59**
	0.1	172.06	167.61	163.14	120.93	**155.94**
Extract type *Extract level *Incubation period L.S.D 0.05		**1.89**				**0.94**
Effect rate of the extract type		156.55	153.56	150.35	139.22	**effect rate of the Incubation period**
LSD 0.05		**0.5**				
Incubation period * type of extract	**14**	178.37	176.40	173.87	171.42	**175.02**
	42	172.42	169.43	166.29	163.60	**167.94**
	70	118.85	114.85	110.89	82.66	**106.81**
L.S.D 0.05		**0.94**				**0.54**

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						Effect Rate of the Extract Level
Extract Level * Extract Type	0	45.58	45.58	45.58	45.58	**45.58**
	0.025	173.59	169.29	164.14	153.39	**165.10**
	0.05	195.54	191.30	187.09	169.73	**185.92**
	0.1	211.48	208.07	204.57	188.20	**203.08**
L.S.D 0.05		**1.08**				**0.54**

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