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POTASSIUM RESERVES MOBILIZATION IN THE CALCAREOUS SOIL OF MOSUL CITY BY USING CONTINUES CUTTING OF ALFALFA CROP

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A B S T R A C T

A field experiment was conducted in the Al-Jawsaq area (Mosul city), using the local alfalfa crop (Medicago sativa L) as a plant indicator, to monitor the release of endogenic potassium, during 24 successive cuts biological indicators (green fodder, dry yield, and total potassium uptake) were described according to the kinetic approach by using the equations, (zero order, first order, second order, diffusion, Elovich, and power function). The results showed that the continuation of the processes of Successful mowing without potassium fertilization led to the depletion of the soluble and available forms, thus relying on the supply of potassium from the unprepared form. The results also indicated a significant variation in the values of green fodder yield, dry matter, and total potassium absorption, with a superiority for the power function equation, which obtained the highest coefficient determinant and a standard error compared to the rest equation. The equations are the biological absorption rate coefficient from the latent soil storage (0.9405), the rate coefficient of dry matter production (0.9377), and the rate coefficient of green fodder production (0.9081). The path of the biosorption process according to kinetic principles revealed the existence of two paths, the first with a high release rate (the phase available) and the second with a low release rate (non-available). The results also showed the superiority of the role of non-available potassium over both soluble and available potassium, which indicates the role of stored potassium in supplying the plant with potassium during the renewed growth stages after each mowing.

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Introduction

The alfalfa crop is one of the important fodder crops in animal nutrition, it is considered a stressful crop or depletes the basic nutritional elements, including potassium [1] [2]. It is characterized by its long stay in the field for many years, and many successive fills are taken from it [3]. Potassium contributes to the nutrition of this crop as it is depleted from it. large quantities are required within its management to adopt a fertilization program with potassium [4] after successive mowings to maintain optimal crop productivity, and the continuous cultivation of the crop and its continuous cutting weakens the plant's resistance to diseases and its ability to produce green fodder material and form root [5].Agricultural production has an essential role in financing economic development projects in various countries of the world [6] [7]. The countries of the world are considered naturally influential in their agricultural policies in the factors affecting agricultural production by increasing the availability of nutrients, including those that effectively depend on agricultural production in quantity and quality [8]. also requires readiness to conduct many studies of the chemical soil, especially in the soils of arid and semi-arid areas Given its importance, the daily examination to know the physiological-chemical behavior of potassium can be equipped with different methods to reveal its dynamics and availability [9] [10]. It is considered safe and accurate for the plant to enter moisture into food processing through monitoring only after testing it from the solid state until it reaches all the moisture, The process is specialized, whether available (easy to release) or non-available (slow to release), controlled by diffusion process that depends on their difference from biological diversity of activity in agriculture[11] [12] [13]. Because of this dynamic phenomenon, many are considered dependent on direct supply to plants, knowing that they are unreliable to exchange for potential capacity in the long term [14]. The period of the process of its release, as it occurs in the field [15], is closely related to the time factor, as it is a physical factor that determines the rate of chemical reactions during the period of crop formation[16], which helps provide a wonderful quantitative description of the release of nutrients from the soil according to mathematical equations.This method also expresses the extent of the release of nutrients by adopting the rate coefficient to be a new guide to express the ionic nutritional processing that characterizes each soil [17] [18]. Previous and current studies conducted at the local and global levels shed light on chemical extraction to determine the extent of the availability of non-exchangeable potassium and the extent of its contribution to Preparing the plant for its needs [19] [20] [21] and the amount biologically absorbed by the plant is the best, most expressive and realistic measure of the concept of its readiness for the plant [8] [22] Many studies have been conducted on the availability of potassium in Iraqi soil, as it was concluded that Iraqi soils are characterized by a large reserve of it. But the question related to the extent of the availability of Iraqi soils for potassium in conditions of intensive agriculture is still a matter of controversy, especially after many studies in the country have confirmed cases of response to potassium fertilization for several crops, especially in conditions of intensive agriculture or reclaimed soil [20] [24]. Therefore, the answer to this question is not only of scientific and applied importance, but it always has great economic importance, especially those related to agricultural planning for the availability of these fertilizers and their optimal use. In general, the possibility of predicting the condition or availability of the nutrient will lead to improving the accuracy of fertilizer recommendations and their optimal use to predict the strength of potassium preparation in the soil. Previous studies have relied on traditional chemical analysis and relating its value to growth indicators[25][26]. However, such a quantitative criterion often did not achieve the goal [27], which prompted researchers to adopt thermodynamic and kinetic criteria related to the release of potassium and its movement between different phases [28], [29] [30] pointed out that it is not necessary to calculate and the evaluation of the available quantity, but rather the rate of potassium release and its processing towards the roots of plants to reach a comprehensive and accurate assessment of the state of potassium in the soil [31] [32] [33].Here it must be noted that exploiting agricultural soils at a continuous production rate leads to the release of larger quantities of potassium compared to soils that are Left unexploited agriculturally, the amount of this element depends on the type of crop and the quantity and quality of the prevailing clay minerals [34] [35]. Any decrease in the soluble and exchangeable form as a result of biological depletion and leaching will lead to the release of more potassium from the non-exchangeable phase between the clay layers, especially from clay minerals such as illite or Although the mechanism of potassium release from non-exchangeable storage has been extensively studied [19] [36] [37] [38] [39] In the first attempt conducted by [23], biological potassium extraction was carried out using white corn for five successive agricultural cycles In 3 kg pots for 420 days as a biological extract instead of chemical extracts to study the kinetics of potassium release in fifteen soils dominated by the mineral smectite, the diffusion equation gave the best mathematical explanation for the movement of potassium storage by the plant, as the plant moved potassium from within. Interstitial clay layers, and indicated that the mica present in silt and clay separates are the main factor in the source of absorbed potassium

[40] showed that plant growth was closely related to the rate of nutrition processing of potassium in the soil of southern Iraq, as confirmed by [41]. The validity of the power function equation in describing the release of potassium and its effect on the alfalfa crop in two soils from central Iraq, in which the dry matter yield and biological absorption were significantly related to the release rate coefficient, as confirmed [42] in the same direction for five soils from northern Iraq for the alfalfa crop as evidence. Biologically, in light of the lack of extensive studies in Iraq on the use of plants as an extraction guide to study the release of potassium from calcareous soil, our current study aimed to identify the ability of the alfalfa crop to mobilize the potassium reserve that can be released from calcareous soil by using the mathematical description of the biosorption process and determining the best equations according to The kinetic approach, and based on this approach, the current study was conducted to link biological growth indicators With kinetic parameters.

MATERIALS AND METHODS

Al-Jawsaq field which has been famous for growing alfalfa for many years and is located in the city of Mosul on the right coast that has geographical coordinates N (36.325664) E (43.147481), was chosen were confirmed. Uncultivated soil samples were left as fields were taken. Soil and plant samples were taken on August 5, 2021, as the first planting, after which the plantings continued to be taken monthly for 24 months until July 5, 2023. The aforementioned soil samples were analyzed for their chemical and physical properties according to the methods provided by [43] and their properties are mentioned in Table (1). Water-soluble potassium was extracted at an extraction ratio of (1:1), and the available potassium was extracted using (1) molar neutral ammonium acetate, while the non-available potassium was It was extracted using (1) molar nitric acid. As for the plant samples, they were washed after each cutting with distilled water, then dried and digested using a mixture of hydrochloric, nitric, and perchloric acids, according to [43]. The amount of potassium extracted from the soil and plant samples was measured using a flame method using a flame. Photometer.

The green matter yield was calculated by taking an area of (1) m2 and several replicates of the field, and then the average green mass of the fodder material was calculated. As for the dry matter, it was dried in an electric oven at a temperature of 70 degrees Celsius for two days

Total Uptake= Dry Matter *Plant Potassium Concentration %------(1)

Plant-K Mobilization=Total Uptake-Exchangeable-(2)

Kinetics of biological Mobilization of potassium were calculated according to the following equations [42]

Zero order (Km-Kt= a-bt) -----------------(3)

First order (Km-Kt=a-blnt)-----------------(4)

Second order (1/Kt=a+b1/t)---------------(5)

Diffusion equation (Kt = a+bt1/2) --------(6)

Elovich (Kt = a-blnt)------------------------(7)

Power function (lnKt=lna + blnt) --------(8)

Whereas

Kt = accumulative potassium at time zero.

Km = maximum absorption or release process at given time.

a = transect secant of the linear relationship.

b = slope of the linear relationship, which expresses the rate of release.

t = time day.

In order to determine The best mathematical equation was chose according , the highest value of the determination coefficient R2 and the lowest standard error SE as the following equation.

$$\left[\sum(kt-kt^{*})^{2}/(n-2)\right]^{\frac{1}{2}} \;\ldots\ldots\ldots\ldots\ldots(9)$$

K= value of potassium actually measured and calculated against each equation

t = value of potassium actually absorbed n = number of times measured.

RESULTS AND DISCUSSION

Table (1) indicates that the study soil is classified as aridisol within the Great Soil Group (Calciorthids) due to its high content of carbonate minerals (187) g.kg^{-1} and the degree of neutral reaction tending to basically (7.1) with a low organic matter content (18.91) g.kg^{-1} The reason for the decrease in organic matter is that the agricultural environment is considered one of the arid and semi-arid regions, as well as the prevalence of chemical oxidation processes and the lack of vegetation cover, which causes a decrease in organic matter. The soil has A clay content is (264) gm kg^{-1} and has a coarse texture. As for fertility, it has a low potassium content for the soluble, available, and unavailable forms (0.33, 1.23, and 3.84), respectively.

Table1. Physical and chemical properties of the study soil before planting

Great group		Calciorthids
EC (dS.m$^{-1)}$		2.41
pH		7.1
OM (g.Kg^{-1})		18.91
CEC (C.mol. Kg $^{-1}$ soil)		23.05
carbonate g.Kg^{-1}		187.00
Texture		Silty Loam
Sand		221
Silt		515
Clay		264
POTASSIUM FORMS (C.mol. Kg $^{-1}$(		
	Before	after
Soluble	0.33	0.1
Available	1.23	0.41
Non-Available	3.84	1.66

Potassium transformations during biological depletion

The results shown in Figure (1) indicate that there is a significant effect of intensive growth of alfalfa crop on the state of soluble, available and non-available potassium due to continuous potassium withdrawals and its consumption by the plant throughout 24 months of growth, as soluble potassium decreased (0.33 - 0.1), with a decreasing percentage of (30.30%) and available potassium. (1.23-0.41), with a decrease of (33.33%), and potassium is non-available (3.84-1.66), with a decrease of (43.22%). This confirms the importance of the non-available phase in the nutritional processing process of the alfalfa plant throughout 24 months of continuous growth and cutting, and this is consistent with our results agree with as a significantly decline in K availabity range (654-412) and (198-99) mg Kg^{-1} in silty clay loam and sandy loam texture in Baghdad provies exhapted by alfalfa growth during 720 days [19] while [44] found a decline in K-available arrange (368-54) mg Kg^{-1} during growth.

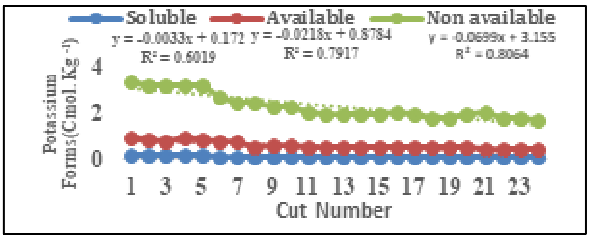

Figure 1. effect of continuous cutting onpotassium forms

Biological Indexes

The green crop production results shown in Figure (2) indicate that the fluctuation of green yield under continuous cutting conditions led to a significant decrease in green yield values, especially in the last stages of the crop's stay in the soil. The lowest amount of green yield, amounting to (2.96), was recorded at the twenty-first mowing, while the highest amount was recorded (6.66) at the twelfth cutting, at an average of (4.4) ($tons.ha^{-1}$). The reason for the high yield in the twelfth harvest is due to the high temperatures and increased irrigation of the crop in that month.

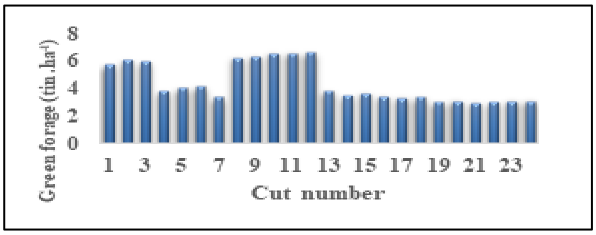

Figure 2. green matter production during successive harvest

As for the dry matter yield of fodder, it ranged from (0.78) at the twenty-first mowing, while the highest amount of dry matter yield was recorded (1.54) at the eleventh mowing, at an average of (1.12) ($ton.ha^{-1}$)as shown in figure (3).

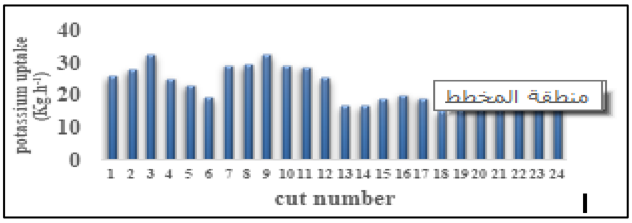

Figure 3. dry matter production during successive harvest

Total uptake results shown in figure (4) indicated that there were confirmed differences during growth periods, where the absorbed potassium decreased from (32.53) at the ninth cutting to (15.04) kg. h-1 at the nineteen, with (53.67%) decrease.

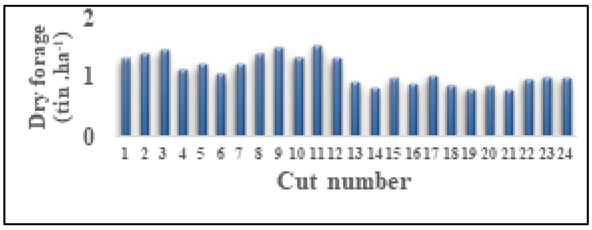

Figure 4. effect of continuous cutting on potassium uptake

The reason for the decrease in the total green, dry yield, and uptake Figures(2,3, and 4). This may be attributed to the continued mowing operations of the crop led to the depletion of the three forms of potassium (soluble, available, and non-available), and the crop remained dependent on the capacity of the non-available form, as it expresses the supply capacity of potassium for long growth periods, and this is confirmed by scientific research, as indicated by both: [7] [45] [46] [47] on the role of nonavailable potassium and considering it a potential store of potassium in the soil during long growth stages What we obtained is consistent with the findings of [48] [49] [50] and the difference in the amount of irrigated water (rain, irrigation, and temperature) differences during the seasons of the year, which affected the values of the green and dry fodder yields [51]. The results shown in Table (2) indicate, and this has confirmed to us statistically, that there is a significant effect of the three potassium formulas on growth parameters (green yield, dry yield, and total uptake), as the coefficient of determination for the nonavailable potassium with each of the green matter yield dry matter, and the K- uptake was (0.43 0.57 and 0.60** respectively) with clear superiority over both available and soluble potassium, which indicates the importance of the available phase during the first mowing stages into the soil solution While non-available potassium is relied upon supply the crop during the growth stages in the long term, and this is consistent with what was indicated by both [13] [37], as inferred From these results, the three growth indicators mentioned above decreased during the last plantings, which indicates the slow release of potassium released from the clay layers.

Table 2. Statistical relationships in terms of the coefficient of determination between potassium formulas contributing to plant supplies and growth indicators

	Potassium forms		
	Soluble	Available	Non available
Soluble	--	--	--
Available	0.89**	--	--
Non available	0.90**	0.95**	--
K-Uptake	0.41	0.52	0.60**
Dry matter	0.41	0.48	0.57*
Green matter	0.33	0.34	0.43

Kinetics Approach

The results shown in figures (5 and 6) indicate the adoption of the summation values of the green, dry matter yield and the total absorption to determine the pathway of the growth process and the extent of the contribution of the potassium phases to the processing. If it is possible to distinguish two stages of plant nutrition processing, the first started from the first to the ninth cut, which was characterized by a rapid decline, that is a rapid release rate coefficient. To keep pace with the growth of the plant and its actual need for potassium, the second stage is a slow stage that began from the tenth cut until the last cut, which was characterized by a slow release rate.

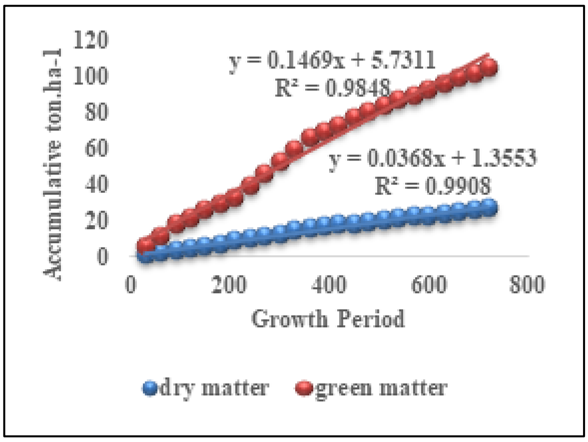

Figure 5. effect of period growth on accumulation of green and dry matter.

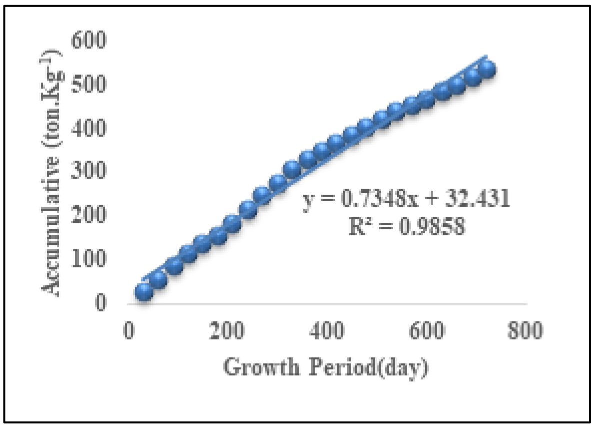

Figure 6. effect of period growth on accumulation of potassium uptake.

also, these results have been described biologically to reveal the validity of mathematical equations based on the foundations of chemical kinetics by adopting the green forage, dry forage and potassium uptake cumulatively as a function of time according to (zero order, first order, second order, diffusion, Elovich, and the power function). It appears from the results shown in Table (3) that the power function was the best one among this equation, the relationship between the accumulative biological absorption index with the crop growth period according to the above-mentioned equations that the occurrence of most points of the values of the absorbed and biologically release potassium on these lines gives conclusive evidence of the validity of these equations in describing the process of biological release mathematically, and this was confirmed by The results of the simple statistical analysis of the simple correlation coefficient (R2) and (SE) shown in the table (3) indicate that there is a statistically confirmed simple correlation, and this leads us to the conclusion that any of these equations can be used to reveal the best applied equations in describing the release process. Least square analysis was adopted by taking the highest coefficient Statistical correlation (R2) and less standard error SE according to [52].

Table 3. The biological parameters according to the applied kinetic equations

Equation	R^2	SE
Green Matter		
Order Zero	0.9848	3.9500
First Order	0.8348	0.3180
SCOND Order	0.9981	0.0385
Diffusion	0.9844	4.0100
Elovich	0.8974	64.7400
Power Function	0.9951	0.0544
dry Matter		
Equation	R^2	SE
Order Zero	0.9908	0.7700
First Order	0.8245	0.3350
SCOND Order	0.9991	0.1940
Diffusion	0.9883	0.8660
Elovich	0.901	2.5240
Power Function	0.997	0.0438
Uptake		
Equation	R^2	SE
Order Zero	0.9858	19.1400
First Order	0.8093	0.3500
SCOND Order	0.9982	0.0003
Diffusion	0.9908	15.3670
Elovich	0.9108	47.9450
Power Function	0.9947	0.0586

Rate Coefficient:

The mathematical description of the biological absorption process showed the superiority of the power function equation as shown in Figure (7). The course of the biological absorption process from the soil revealed that the diffusion process in heterogeneous media is symmetrical.

The results shown in Table (4) indicate that the rate coefficient of biological parameters by the Alfalfa crop according to power function was (0.9181, 0.9377 $ton.ha^{-1}$ $.day^{-1}$ and 0.9405 $Kg.ha^{-1}$ $.day^{-1}$) for green mater, dry matter and K- uptake respectively slow processing of the non-exchanged solid phase (long-term latent storage). What we have obtained confirms the findings of [30] [41] [42] [53] [54] [42] in their studies on the field yield of Alfalfa, and the findings that the biological extraction of potassium is carried out by moving the potassium state between the layers according to the bases of diffusion-controlled exchange processes, which depend mainly of the absorption processes on the difference between the concentration resulting from the continuous biological absorption processes of the element [18] [55]. Because of this dynamic phenomenon, the exchangeable phase is responsible for the direct supply of potassium in the short term, while the non-exchangeable phase is exchangeable for the potential supplying capacity of the soil in the long term potential [22] [37] [56] .

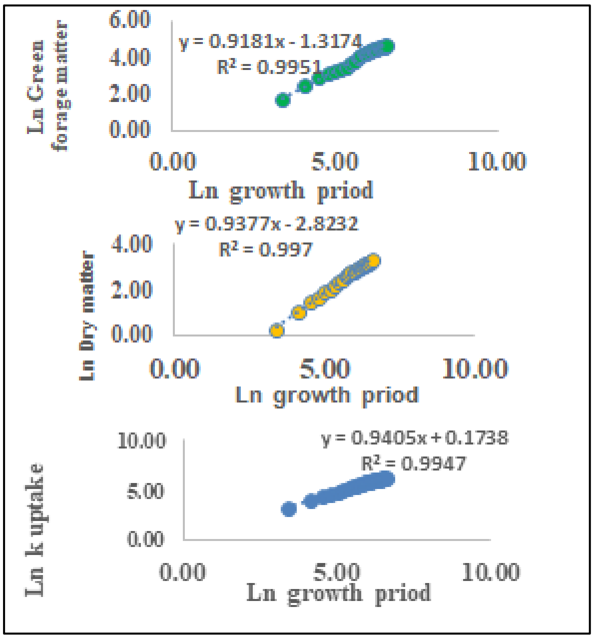

Figure 7. Statistical relationship between green , dry matter and K uptake and crop growth period according to the power function equation.

Table 4. The biological Coefficient of the applied Power Function equations

Green Matter	dry Matter	Uptake
0.9181	0.9377	0.9405

Conclusions

It is concluded from the study that the greed of the alfalfa crop leads to a significant depletion of potassium from its three forms, which requires periodic examination and the use of appropriate fertilization for a higher yield.

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