Nat. Volatiles & Essent. Oils, 2021; 8(6): 2510-2520

Effect Of Potassium Fertilizers And Organic Matter Additions On Soil Available Potassium

Abdulkareem Hasan Odhafa[1] and Hashim H. Kareem [2]

[1]Dept. of Soil Sciences and Water Resources, College of Agriculture, University of Wasit, Iraq

[2]Dept. of Geography, College of Basic Education, University of Misan, Iraq

Abstract

This experiment carried out at the soil and water sciences department , college of agriculture , university of Wasit during the season of 2019 to investigate the effect of addition different levels of organic matter , potassium fertilizers associated with two incubation periods on potassium availability in two different textures calcareous soils located in two different locations in Wasit governorate , Iraq .The two selected soils are clay loam brought from Al-Swera ,and sandy loam brought from a farm in Al-Nomanya district , four potassium levels (in form K_2SO4) were added at the levels (0,100,200,300 kg/h) which estimated on the basis of sample weight 100 gm, on the other hand , organic matter levels (sheep manure) were added in three levels (0% , 3% ,6%),these levels were estimated on 100 gm on the basis of soil weight too , all treatments were replicates 3 times , the results showed that there is significant difference in the values of available potassium in relation to soil type , were Al-Swera samples showed 14% available potassium higher than Alnumanya due to high clay content in former sample , also results pointed out the difference between applied potassium levels which significantly reflected on available potassium in soil , were the increase reached 108% for K3 as compared with control treatment K0, as it turned out the addition of organic matter also gave significant differences in available potassium values with the increase of addition levels , wherever higher available potassium level was achieved 754.4 ppm , The binary interaction treatment between soil type and organic matter levels achieved significant differences where the combination T1M2 surpassed (804ppm) nuances with control treatment (441.9 ppm) for Alnumanya soil, the binary interaction between soil type(T) and applied potassium levels (K) achieved significant differences where the combination K1K3 was surpassed (827.8 ppm) as compared with lowest value which achieved 323.2 ppm for the combination T2K0 also the results of second incubation period appears that Al-Swera soil surpass (T1) which achieved increase amounts to 15% in available potassium as compared with Al-Numanya soil (T2) which return to the difference of its clay content , the level K3 also surpass as compared with control treatment by achieving 105% increment percentage, there is significant increase of available potassium levels with the increase of organic matter addition as compared with no addition treatment where higher value was(836.3 ppm) at the level (M3) while the lowest value 548.8

ppm for control treatment (M0), whereas interaction of organic matter level (M2) with fertilizer addition for the combination M2K3 which was (1003 ppm) as compared with control treatment, extending of incubation period have a role in available potassium increase in soil **,** there is clearly rising trend in available potassium which stood at (678.7 ppm) at the incubation period D2 which significantly differs from incubation period D1 which amounted (612.9 ppm) , this due to that the second incubation period provided enough opportunity to achieve equilibrium with colloids surfaces which has been clearly reflected on available potassium concentrations no matter what is the soil type.

Key words : potassium availability , soil texture , organic manures , fertilizers , incubation periods.

Introduction

Potassium is one from the most essential common elements in the earth crust , (Idris et al. 2017), this element differ in its range of availability in soil according to the binding sites on which potassium phases are determined , chemically , (Sparks & Carski, 1985)pointed that potassium is divided to four phases which are soluble-K exist in ionic state in soil solution and not adsorbed on colloids surfaces and its concentration increase as a result of adsorbed – K hydrolysis or by its replacement with other ions , this phase more easily to loss by leaching (Raheb and Heidari 2012) so its amounts is minimal , secondly , exchangeable potassium , this part occupy exchangeable sites of the soil and it's may release to the liquid phase by cationic exchange process with other ions , this depend on the affinity between exchangeable sites and K which also affected by potassium concentration and its relationship with other ions in soil solution , this phase represents the base to unstable reservoir and correlate in fast equilibrium state with soluble phase which make it difficult to separate between these two phases through quantitative analysis ,thirdly , non-exchangeable potassium phase which include all fixed and mineral potassium also classify as slow and moderate release phase, however , non-exchangeable potassium in equilibrium with exchangeable phase and the uptake quantity of this phase increase with time , in this way this phases contributes to represent the available potassium reservoir for plant , fourthly , structural –K , this phase accounts maximum percent from total potassium in most soils and its quantity depends on parent rocks and soil development stage , this phase named as mineral , un-weathered and texture or inert potassium.

In the other hand available potassium phase means the quantity of potassium existed in way easily uptake by plant (Dastbandan Nejad, Saki Nejad, and Lack 2010), all potassium phases take part in plant nutrition in different degrees. It's found that the available potassium in some calcareous soils ranged between (213-531 ppm) (Abolfazl Azadia and Sirous Shakeri 2021) which accounts for (0.1-2%) from total potassium .

There is many factors that effect on available potassium which include : cation exchange capacity (CEC) were fine textured soil have greater ability to hold potassium compared with course textured soils due to the low CEC for the latter , this indicate the more CEC, the greater potassium storage in soil .

Soil moisture is the other factor that’s have important role in controlling potassium movement from soil to plant roots , soil temperature also effect on potassium availability and its transformations also this factor have role in microbial activity and roots, therefore effect on potassium uptake by roots.

Soil aeration , soil pH , soil texture & mineral composition and organic matter are key factors by effecting on potassium availability and its behavior in soil solution were soil colloids have widely variation in its ability to control potassium availability in soil according to its percentage , also soil with high 1:1 kaolinite content have high potassium availability as compared with 2:1 montmorillonite (Tran , 2012) (Barré et al. 2008).

(Havlin and Heiniger 2020) refers to high CEC fine soils have high exchangeable potassium but high density grown crops in highly montmorillonitic content have low available potassium which require potassium fertilization to obtain better yield .

Organic matter possess direct effect on soil reaction (pH) which produces organic acids during microbial and chemical decomposition , this organic acids contributes in reducing soil pH as add to its role in improvement of physical , chemical and biological properties , also its consider good source for many nutrients and tend to formation of chelating compounds with cations, this chelating compounds hold the ion and covered it preventing this ion to act alone in solution and that's indicate the contribution of organic matter in increase of potassium availability (Abu-Zahra and Tahboub 2008)

This study aims to show the effect of addition different levels of (potassium fertilizer and organic matter) on potassium availability in two textures soils under different incubation periods.

Materials and methods :

The experiment carried out in soil and water sciences department , college of agriculture , university of Wasit during the season of 2019 to investigate the effect of addition 3 levels of organic matter (, 4 levels of potassium fertilizers and two incubation periods on potassium availability in two different textures calcareous soils brought from two different locations in Wasit governorate .used treatments :

1-soil texture : two different textures was used (clay loam) from Alsoayra research station symbolized by T1 , (sandy loam) brought from a farm in Al-Nomanya symbolized by T2.

2-potassium levels (in form K_2SO_4) as (0,100,200,300 kg/h) it was estimated on the sample weight basis 100 gm , were the levels of potassium became (0 , 0.12 , 0.24 , 0.36 gm K_2SO_4/100gm soil) symbolized by (K0 ,K1 ,K2 ,K3).

3-Organic matter levels (sheep manure) were added in three levels (0% , 3% ,6%),these levels were estimated on100 gm weight soil basis too, symbolized by (M0 , M1 , M2) respectively .

4-inucubation periods were (15 , 30) days symbolized by (D1 , D2).

5-Replications was 3 symbolized by (R1 , R1 , R3).

Total experimental units was (2*2*4*3*3) = 144

Studied soil samples were brought from different zones differentiated by their textures class from the surface layer (0-30 cm) , some physical and chemical properties were determined as shown in table (1) according to standard procedures , in which pH , Ec , soluble ions (Ca , Mg , Cl , CO_3, HCO_3) in 1:1 soil : water extract as mentioned in Richards (1954) , soil texture classify according to (Black et al., 1965) other properties were determined according to (Page , 1982).

Table 1. chemical and physical properties of studied soils.

Property	T1	T2
pH	7.28	7.44
Ec ($Ds.m^{-1}$)	2.84	2.11
Cation exchange capacity (CEC) (Cmol.kg-1)	16.97	11.50
CaCo3 (gm.kg)	286.70	234.90
Organic matter (gm.kg)	9.62	7.64
Soluble Ions (Cmol.kg-1):		
Na^{+1}	1.84	1.43
Ca^{+2}	0.82	0.68
Mg^{+2}	0.61	0.47
K^{+1}	0.08	0.06
$SO4^{-2}$	1.74	1.41
Cl^{-1}	1.39	1.12
$HCO3^{-1}$	0.19	0.16
$CO3^{-2}$	-	-
Soil separates ($gm.kg^{-1}$):		
Sand	251.2	480.3
Silt	382.6	365.2
Clay	366.2	154.5
Texture class	Clay Loam	Sandy Loam
Moisture content (%) at 33 kp	33	26
Moisture content (%) at 1500 kp	16	12
Bulk density (Mega $gm.m^{-3}$)	1.28	1.21

Soil samples were subjected to air dry , grinding and passed from 2mm openings sieving then 100 gm precisely weigh from each sample and put in plastic tightly closed cups then all required treatments are applied as mentioned previously , in which 144 experimental unit were done. Also include addition of organic matter which mixed in appropriate way to take sample for analysis table (20). Potassium levels were applied for both soils (textures) and wet to field capacity level, samples incubated after addition of experiments materials according to incubation period (D1,D2) , at the end of incubation period the samples were dried , grinding and sieving from 2 mm openings sieve , to extract available potassium by using ammonium acetate according to (Page, Miller, and Keeney 1982), after that potassium were determined in aliquot by flame photometer type (GANWAY) in Wasit agriculture directorate.

Table 2. chemical analysis of organic manure used in the experiment

Property	Value	Unit
pH	7.46	
Ec	6.32	**$Ds.m^{-1}$**
Total nitrogen	1.44	**%**
Total phosphorous	1. 02	**%**
Total potassium	1.21	**%**
Total organic carbon	27.83	**%**
Organic matter	40.61	**%**
C / N Ratio	19.32	

Results and discussion

1-Available potassium in first incubation period (D1):

Table (3) show the effect of soil type (T_1,T_2) and organic matter addition levels (M_0,M_1,M_2) and the levels of potassium fertilizer (K_0,K_1,K_2,K_3) and their interactions on the values of soil available potassium during incubation period 15 day (D_1) , in which there was significant differences between soil types were increased by 14% this is due to soil texture difference in Al-Swera station (T_1) which have 364 $gm.kg^{-1}$ clay percent as compared with Al-Nomanya soil (T_2) which achieved 77.8 $gm.kg^{-1}$ percent clay , hence is evident the impact of soil fractions in the increase of available potassium concentration in soil which is correlated with high CEC for the first soil consequently increase its ability to provide available potassium in soil solution , this results agreed with (Wani and Datta 2007) regarding the increment of available potassium significantly with the increment of fine particles and CEC.

Also results refers to the difference between applied potassium levels significantly reflected on available potassium in soil , were the increase reached 108% for K3 as compared with control treatment K0 , this clearly indicate the appropriate this conditions to give this significant differences for mineral fertilizers levels which had an impact on available potassium values in this stage were (Sh. Jarallah and Abbas Mohammed 2018) show the effect of potassium fertilizer on soluble potassium values. As it turned out the addition of organic matter also gave significant differences in available potassium values with the increase of addition levels , wherever higher available potassium level was achieved 754.4 ppm , hence , achieved increase percentage amount to 60% which due to the role of organic matter in exchange hydrogen produced by the hydrolyzed organic acids by potassium on exchange sites, therefore, it turned out the role of addition of organic matter in appropriate levels to maintain the availability of this phase of potassium (Bader et al. 2021). The binary interaction treatment between soil type and organic matter levels achieved significant differences where the combination T1M2 surpassed (804ppm) nuances with control treatment (441.9 ppm) for Numanya soil , this suggests the role of organic matter addition (M2) and its interaction with soil texture(Clay loam) which reflected on available potassium in soil (Tian et al. 2017), Meanwhile the binary interaction between soil type(T) and applied potassium levels (K) achieved significant differences where the combination K1K3 was surpassed (827.8 ppm) as compared with lowest value which achieved 323.2 ppm for the combination T2K0 ,whilst , the binary interaction M2K3 (883.1ppm surpassed compared with binary interaction for the combination M0K0(218ppm) , hence , its clearly showed the role of these factors (soil type , applied organic matter levels) for the level K3 for potassium fertilizer addition compared with other combinations.

As regards to triple interaction for these factors its showed surpassed the combination T1M2K3 (907.8ppm) as compared with the value of (167.1ppm) for the combination T2M0K0 , which points to the role of organic matter addition at the level K3 in Al-Swera station soil (T1) by giving surpassed value for available potassium in this soil.

Table 3. Available potassium concentration in soil at different levels of organic matter additions for first incubation period.

Treatment		Potassium level				T*M
		K0	K1	K2	K3	
T1	M0	268.8	420.6	590.2	722.2	500.5
	M1	442.2	577.1	746.7	853.5	654.9
	M2	622.2	818.1	867.8	907.8	804
T2	M0	167.1	405	533.7	661.9	441.9
	M1	299.6	506.7	686.2	794.7	571.8
	M2	502.9	705.5	752.2	858.4	704.7
LSDT*M*K		40.9				20.4
K means		383.8	572.2	696.1	799.7	
LSDK		16.7				
T * K						T means
T1		444.4	605.3	734.9	827.8	653.1
T2		323.2	539	657.4	771.7	572.8
LSDK*T		23.6				11.8
M * K						M means
M0		218	412.8	561.9	692.1	471.2
M1		370.9	541.9	716.5	824.1	613.3
M2		562.5	761.8	810	883.1	754.4
LSDK*M		28.9				14.5

2-Available potassium for the second incubation period:

Table (4) shows the effect of potassium levels and organic matter and soil type and their interaction on available potassium concentration at the end of second incubation period (30days) , however ,it appears Al-Swera soil surpass (T1) which achieved increase amounts to 15% in available potassium as compared with Al-Numanya soil (T2) which return to the difference of its clay content , also the figure refers to significant differences between applied potassium levels where its effect appear on available potassium in the soil in this period, the level K3 also surpass as compared with control treatment by achieving 105% increment percentage , this agree with results reached by (Sparks et al., 1985)) showing surpass of fertilizer treatment 150 $kgK.h^{-1}$ dominated on other treatments , also suggests to the role of application of potassium fertilizers on availability of potassium which may not unlike from the percent of increase achieved in first incubation period (Urrutia et al. 2018).

It turns out from table (4) that there is significant increase of available potassium levels with the increase of organic matter addition as compared with no addition treatment where higher value was(836.3 ppm) at the level (M3) while the lowest value 548.8 ppm for control treatment (M0) , and this clearly refers to the role of organic matter in the increment of available potassium in soil through the gradual decomposition through incubation period and replace hydrogen ion produced from organic acid hydrolysis by potassium ion (K) on the exchange sites (Raghad Mouhamad 2016) and hence , show the role of organic matter in maintain potassium availability in soil .

In the other hand , the results of triple interaction between organic matter and soil type achieved 906 ppm of available potassium through the combination T1M2 as compared with the lowest value at the combination T2M0 , thus , it become clear that how important the role of soil texture in the values of available potassium associated with the increase of organic matter addition levels (M2).

As it turns out , the role of other factors including soil texture with its binary interaction with added potassium levels and organic matter levels through these stages , where the combination T1K3 gave better available potassium level (947.2 ppm) as well as the interaction of organic matter level (M2) with fertilizer addition for the combination M2K3 which was (1003 ppm) as compared with control treatment , this also suggests the role of organic matter by its content of potassium , also , its decomposition produces organic acids and carbon dioxide (CO2) which is consider key factor in minerals dissolution, consequently increase potassium availability .

Whereas the triple interaction , it shows surpass of the combination T1M2K3 (1067.8 ppm) as compared with lowest value for control treatment (243.9 ppm) , which refers clearly to the effect of interaction between these factors (organic matter , applied potassium) for first soil type , also suggests the role of the interaction between applied organic matter level associated with increase of applied potassium for the same soil in available potassium concentrations through this stage , and this agreed with (Mahdi Najafi-Ghiri et al. 2020).

Table 4. Available potassium concentration in soil at different levels of organic matter additions for second incubation period.

Treatment		Potassium level				T*M
		K0	K1	K2	K3	
T1	M0	279.3	545.2	668.2	841.7	583.6

	M1	469.4	614.2	752.4	932.1	692
	M2	693.9	881.5	980.9	1067.8	906
T2	M0	243.9	495.3	576.5	740.6	514.1
	M1	376	541.4	707.8	814.8	610
	M2	531.2	757.4	839.2	938.2	766.5
LSDT*M*K		54.1				27.1
K means	432.3	639.2	754.2	889.2		K means
LSDK		22.1				
T * K						T means
T1		480.9	680.3	800.5	947.2	727.2
T2		383.7	598	707.8	831.2	630.2
LSDK*T		31.1				15.6
M * K						M means
M0		261.6	520.3	622.3	791.2	548.8
M1		422.7	577.8	730.1	873.5	651
M2		612.6	819.4	910.1	1003	836.3
LSDK*M		38.3				19.1

3-Effect of incubation period and soil type on available potassium concentration:

As noted in the figure (1) below , extending of incubation period have a role in available potassium increase in soil , there is clearly rising trend in available potassium which stood at (678.7 ppm) at the incubation period D2 which significantly differs from incubation period D1 which amounted (612.9 ppm) , this due to that the second incubation period provided enough opportunity to achieve equilibrium with colloids surfaces which has been clearly reflected on available potassium concentrations no matter what is the soil type.

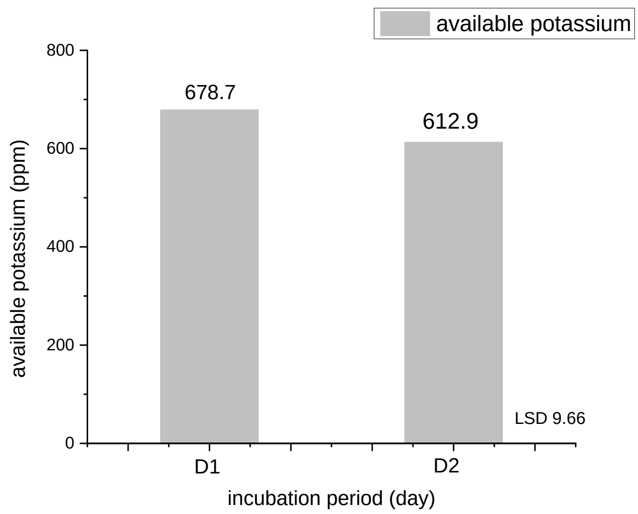

Fig. 1 Effect of incubation period on available potassium concentration in soil.

It was also becoming evident the role of potassium addition which also estimated from available potassium phases (Pandurang Gurav 2018) , especially this program didn't include biological experiment which usually shows potassium consumption (uptake) as plant age progressed .

While figure (2) indicated that there is significant decrease in available potassium concentration in Al-Numanya soil (coarse texture) (601.5 ppm) as compared with Al-Swera soil (fine texture) (690.2 ppm) , thus, the role of soil texture clearly appear for two locations in available potassium values , which may be moved down through the leaching for coarse texture as compared its retention by clay fraction in fine texture soil (Bell, Thompson, and Moody 2021) .

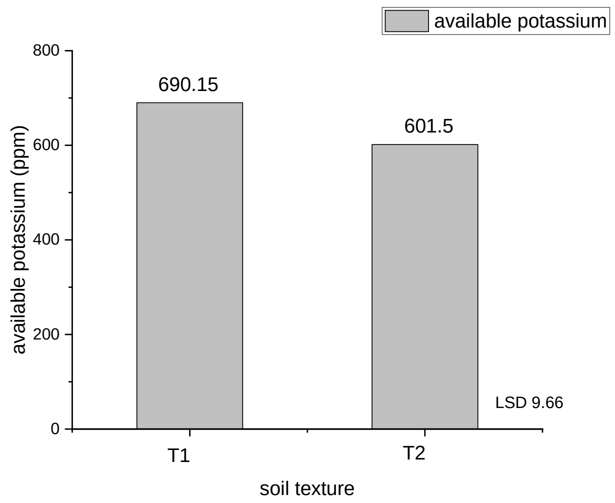

figure (2) indicated that there is significant decrease in available potassium

Conclusions:

there is important role of organic matter in increase of potassium availability in soil by reducing soil pH therefore , and so could benefit from potassium storage in soil , also it have effect on added potassium availability through its role in keeping potassium especially in fine texture soil by its high CEC. Applied potassium have a key role in the availability of this ion by its interaction with added organic matter , we can conclude that the studied factors have clear role in potassium availability especially with fine texture soil which due to the role of clay fraction and the dominant minerals in the soil which reflected on potassium availability .

Acknowledgment:

Many thanks, appreciation and grateful for scientific support provided by the Department of soil and water resources / college of agriculture/University of Wasit

and Department of Geography, Faculty of Basic Education / University of Misan – Iraq.

references

Abolfazl Azadia, and Sirous Shakeri. 2021. "Potassium Pools Distribution in Some Calcareous Soils as Affected by Climatic Conditions, Physiographic Units, and Some Physicochemical Properties in Fars Province, Southern Iran." Eurasian Soil Science 54(5): 702–15.

Abu-Zahra, T R, and A B Tahboub. 2008. "Effect of Organic Matter Sources on Chemical Properties of the Soil and Yield of Strawberry under Organic Farming Conditions." World Applied Sciences Journal 5(3): 383–88.

Bader, Basem Rahem et al. 2021. "Potassium Availability in Soil Amended with Organic Matter and Phosphorous Fertiliser under Water Stress during Maize (Zea Mays L) Growth." Journal of the Saudi Society of Agricultural Sciences (xxxx). https://doi.org/10.1016/j.jssas.2021.04.006.

Barré, Pierre et al. 2008. "Clay Minerals as a Soil Potassium Reservoir: Observation and Quantification through X-Ray Diffraction." Plant and Soil 302(1–2): 213–20.

Bell, Michael J., Michael L. Thompson, and Philip W. Moody. 2021. "Using Soil Tests to Evaluate Plant Availability of Potassium in Soils." Improving Potassium Recommendations for Agricultural Crops: 191–218.

Black, C. A. et al. 2016. "Methods of Soil Analysis: Part 2." Methods of Soil Analysis, Part 2: Chemical and Microbiological Properties: 1–1572.

Blume, H.-P. 1985. "Page, A. L., R. H. Miller and D. R. Keeney (Ed., 1982): Methods of Soil Analysis; 2. Chemical and Microbiological Properties, 2. Aufl. 1184 S., American Soc. of Agronomy (Publ.), Madison, Wisconsin, USA, Gebunden 36 Dollar." Zeitschrift für Pflanzenernährung und Bodenkunde 148(3): 363–64. https://onlinelibrary.wiley.com/doi/full/10.1002/jpln.19851480319 (July 23, 2021).

Dastbandan Nejad, Shirin, Tayeb Saki Nejad, and Shahram Lack. 2010. "Study Effect Drought Stress and Different Levels Potassium Fertilizer on K + Accumulation in Corn." Nature and Science 8(5): 23–27. http://free-journal.umm.ac.id/files/file/Study%0Aeffect%0Adrought%0Astress%0Aand%0Adifferent%0Alevels%0Apotassium%0Afertilizer%0Aon%0AK+%0Aaccumulation%0Ain%0Acorn.pdf%0Ahttp://free-journal.umm.ac.id/files/file/Study effect drought stress and different le.

Havlin, John, and Ron Heiniger. 2020. "Soil Fertility Management for Better Crop Production." Agronomy 10(9): 1–5.

Idris, A.D, J.O Olaniyan, K.O Affinnih, and O.N Ajala. 2017. "Forms and Distribution of Potassium in Red Laterite Soils of Patigi in North Central Nigeria." Bulgarian Journal of Soil Science 2(1): 42–52. https://doi.org/10.5281/zenodo.2585643#.XcgIr_hZEPM.mendeley.

Mahdi Najafi-Ghiri et al. 2020. "Potassium Fixation and Release in Some Calcareous Soils under Orange Cultivation." Eurasian Soil Science 53(7): 978–85.

Page, A L, H R Miller, and R D Keeney. 1982. Methods of Soil Analysis: Part 2: Chemical and Microbiological Properties. Monograph Number 9. https://www.amazon.com/Methods-Analysis-Chemical-Microbiological-Properties/dp/B000Z4UAHY (July 23, 2021).

Pandurang Gurav, Priya. 2018. "A Review on Soil Potassium Scenario in Vertisols of India." Open Access Journal of Science 2(1): 90–91.

"Potassium Fixation By Oxidized and Reduced Forms of Different." 2012.

Raghad Mouhamad, Ameera Alsaede and Munawar Iqbal. 2016. "Behavior of Potassium in Soil: A Mini Review." Chemistry International 2(1): 47–58. http://bosaljournals.com/chemint/images/pdffiles/25.pdf.

Raheb, A., and A. Heidari. 2012. "Effects of Clay Mineralogy and Physico-Chemical Properties on Potassium Availability under Soil Aquic Conditions." Journal of Soil Science and Plant Nutrition 12(4): 747–61.

Sh. Jarallah, Raid, and Jibreel Abbas Mohammed. 2018. "Effect of Organic and Mineral Fertilization on The Values of Soluble Potassium Insideand Outside Rhizosphere of ZeaMaize (Zea Mays L.)." Al-Qadisiyah Journal For Agriculture Sciences (QJAS) (P-ISSN: 2077-5822 , E-ISSN: 2617-1479) 8(1): 37–46.

Tian, Xiao-Fei et al. 2017. "Effects of Controlled-Release Potassium Fertilizer on Available Potassium, Photosynthetic Performance, and Yield of Cotton." Journal of Plant Nutrition and Soil Science 180(5): 505–15.

Urrutia, Oscar et al. 2018. "New Amphiphilic Composite for Preparing Efficient Coated Potassium-Fertilizers for Top-Dressing Fertilization of Annual Crops." Journal of Agricultural and Food Chemistry 66(19): 4787–99.

V, Elsevier Science Publishers B, D L Sparks, and T H Carski. 1985. "KINETICS OF POTASSIUM EXCHANGE IN HETEROGENEOUS Thermodynamic Data Can Predict Only the Final State of a System from an Initial Nonequilibrium Mode . However , to Rationalize Chemical Reaction Rates , a Knowledge of the Kinetics Is Required . Kinetic Stud." 1: 89–101.

Wani, Mushtaq Ahmad, and Samar C Datta. 2007. "Nonexchangeable Potassium Release to H+-Saturated Resin and Its Diffusion Characteristics in Some Soils of Lesser Himalayas." Soil science 172(7): 546–52.