Effect of Active and Total Calcium carbonates ratio on the statue of Potassium in paddy soils

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Abstract

Potassium (K) Quantity- Intensity (Q/I) relationship was utilized to evaluate the potassium status in soils cultivated with rice. Soil samples were collected from three different locations which are Jojer, Segrka and Barvamosa that belong to Akre area in Kurdistan region- Iraq. The results showed that the ratio of active to total calcium carbonates of the locations were (0.179, 0.080 and 0.150) respectively. The available and exchangeable potassium in Segrka were higher than other soils. The Q/I relationship showed that the values of potassium activity ratio at equilibrium (AR_e^k) were ($0.83*10^{-3}$, $2.99*10^{-3}$ and $1.19*10^{-3}$) (mole $L^{-1})^{0.5}$ respectively. The potassium buffering capacity (PBC^k) which was (16.77 cmol kg^{-1}(mole $L^{-1})^{0.5}$ was the highest inSegrka soil followed by Jojer(15.38 cmol kg^{-1}(mole $L^{-1})^{0.5}$) and thenBarvamosa(13.79)cmol kg^{-1}(mole $L^{-1})^{0.5}$. The negative values of Gibbs free energy (ΔG) represent spontaneous reaction were (-4202, -3443 and -3988) cal $mole^{-1}$ respectively, while the value of Gapon selectivity coefficient (K_G) were (1.025, 0.838 and 1.085)(L $mole^{-1})^{0.5}$respectively. The value of equilibrium exchangeable potassium (EK^o) were (1.721, 2.363 and 1.332)cmole kg^{-1} respectively.

Key words: potassiumavailability, potassium buffering, potassium supplying power, Q/I parameter.

تاثير نسبة كاربونات الكالسيوم النشطة الى الكلية على حالة البوتاسيوم لبعض حقول المزروعة بالرز

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الخلاصة

تهدف الدراسة الى استخدام علاقة الشدة والكمية لتقيم حالة البوتاسيوم في الترب المستغلة بزراعة الرز. اجريت هذه الدراسة في ثلاث مناطق مختلفة (سيكركا و جوجر و بارافاموسى) التابعة لقضاء عقرة اقليم كردستان العراق. بلغت نسبة كاربونات الكالسيوم النشط الى الكلي في المناطق الدراسة كانت كالاتي (0.179و 0.080و 0.150) على التوالي. وكانت كمية البوتاسيوم النشط و المتبادل في منطقة سيكركا اعلى من بقية الترب. اوضحت علاقة الشد والكمية بان قيم نسبة فعالية البوتاسيوم عند الاتزان كانت ($0.83*10^{-3}$و $2.99*10^{-3}$و $1.19*10^{-3}$) (مول لتر$^{-1}$)$^{0.5}$ على التوالي. و سجلت اعلى سعة التنظيمية لجهد البوتاسيوم (16.77)سنتي مول. كغم/(مول لتر$^{-1}$) لمنطقة سيكركا تليها منطقة جوجر (15.38)) سنتي مول. كغم/(مول لتر$^{-1}$) ومن ثم منطقة بارافاموسى (13.79)) سنتي مول. كغم/(مول لتر$^{-1}$). تشير قيم السالبة لطاقة الحره الاستبدالية على تلقائية التفاعل والتي كانت (4202-و 3443-و 3988-) سعرة مول$^{-1}$ على التوالي. اما ثابت كابون فقد بلغت (1.025و 0.838و 1.085) (لتر مول$^{-1}$)$^{0.5}$ على التوالي. و كانت قيم البوتاسيوم المتبادل عندالاتزان (1.721و 2.363و 1.332) سنتي مول كغم$^{-1}$ على التوالي.

Introduction

Rice is one of the major cereal crops worldwide in Iraq, it's also important crop for food security (Bhiah et al 2010). The Rice grown in Kurdistan region is Japonica type with having very much short grain and sticky when cooked. It's also well known a much high price, which locally known "Bazian and Akre". The main growing area of rice in Kurdistan is in Erbil, Sulamania and Duhok (Alnajjar 2005).Akre is the first largest rice producing area in Kurdistan region.Potassium is an essential plant nutrient that improves root growth and plant vigor, helps the prevent lodging and enhances crop resistance to pests and diseases. It's mobile in the plant and quite movable in the soil. Based on the degree of availability to crop soil, potassium can be found in four forms in soil which were available, exchangeable, non-exchangeable and as mineral (Tisdale et al., 1993; Johnston and Goulding, 1990), and all these forms are in equilibrium with each other.The direct supply of potassium from soil to plant and potassium buffering capacity of soil can be predicted by quantity/intensity (Q/I) model. The relationship between potassium quantity (Q) which represent the relate change (±ΔK) in the exchangeable potassium in soils against potassium intensity factor (I) which represent the potassium activity ratio AR^k in the soil solution determined by the Q/I curves as described by Backett (1964a,b).

Several essential parameter can be evaluate from the Q/I curve, such as potassium activity ratio at equilibrium (AR^k_e) which represent the value of activates rate when ΔK=0, Potential buffering capacityof potassium PBC^k measured from the line slops of Q/I curve. And both slowly exchangeable potassium (K_{ex}) and labile potassium value (ΔK^0) evaluate when the AR^k_e =0 by intercepting the line and curve of the Q/I diagram with quantity factor (±ΔK) can represent as specific and non-specific absorption of potassium respectively (Backett 1964a,b;Sinclair 1979; andJalali 2007).The capacity for maintaining the potassium intensity of soil solution, a higher PBC^k value is indicative of good potassium availability while a low PBC^k soil would suggest a need for fertilization. Potassium activity ratio at equilibrium has a positive relationship with exchangeable potassium while negative relation with PBC^k, pH, and activity of Ca+Mg in soil (Niranjana et al., 2000; and Uddin et al 2011). the desorption of potassium decrease with increasing equilibrium activity ratio (Noor et al., 1993).This study was aimed to discord the effect of active and total $CaCO_3$ ratio on the status of potassium in paddy soil.

Materials and Methods

Three soil samples were collected from surface soil (0-30) cmof different Rice fields at Akre Kurdistan region-Iraq. The soil samples were air dried and ground then pass through a 2 mm sieve for some chemical and physical analysis (Table 1), including particle size distribution, calcium carbonate equivalent, soil pH, organic matter (OM), Electrical conductivity (EC), cation exchange capacity (CEC),and exchangeable potassium (K_{ex}) were determined using standard method (Motsara and Roy 2008; and Sparks et al., 1996).

Table (1): Some physical and chemical properties of soil samples.

Location	Partial size g Kg^{-1}			Soil texture	pH	Ec dsm^{-1} at 25^0	CEC cmole Kg^{-1}	OM	$CaCO_3$equivlent		Ratio active/Total $CaCO_3$
	Sand	Silt	Clay						Total	Active	
								g Kg^{-1}			
Jojer	140.9	344.9	514.1	C	7.22	0.34	15.00	17.40	21.7	3.9	0.179
Segrka	156.1	547.3	296.5	SiL	7.10	0.46	20.00	29.20	22.00	1.9	0.086
Barvamosa	330.9	289.2	379.8	CL	7.43	0.36	12.70	19.90	22.00	3.3	0.150

Potassium exchange isotherms (Quantity- Intensity relations Q/I)

potassium Q/I isotherms were determined by equilibrating 2 g of duplicate sample soil in centrifuge tubes containing 40 ml of 0.01*M* $CaCl_2$ solution containing a series of potassium concentration (0, 0.25, 0.5, 0.75, 1, 2,4 and 8)mmole K L^{-1} as KCl. The suspensions of soil solution were shacked for 1 hour and let to stand for 24 hours for equilibrium, and then the suspensions were centrifuged. Concentrations of K, Ca, Mg, and EC were measured in supernatants (Beckett 1964a). After collection of supernatant the weight of each centrifuge tube with remaining soil was recorded. Forty milliliter of 1.0 *M* NH_4OAC was added to each centrifuge tube, again shacked 1 hour centrifuged, and filtered. The concentration of K, Ca, and Na in the filtrate was determined by flame photometer and concentration of Mg was determined by atomic absorption.The gain or loss of the potassium (±ΔK) by the soil solution during the equilibrium period gives the quantitative term (Q), whereas the potassium activity ratio AR^K_e in the equilibrated solution gives the intensity factor (I) of the relationship (Wang and Scott 2001). The ±ΔK was calculated from the difference in the concentration of potassium in prepared solutions and equilibrated solution (Rowell, 1996). Positive ΔK value indicates potassium adsorption by the soil solid phase whereas negative values indicate potassium release from the soil phase into solution. The relationships between the quantity factor and intensity factor for the studied soil samples were drawn according to Beckett (1964b). The values of potassium buffering capacity (PBC^k) and labile potassium (ΔK°) were calculated from the straight line equations of the quantity – intensity relationships (Beckett, 1964b). And the activity ratio of potassium (AR^K) was calculated as follow:

$$AR^K = \frac{aK}{(aCa + aMg)^{0.5}}$$

Where (a): is the activity in mol L^{-1}.

Equilibrium exchangeable potassium (EK^0) calculated when the ΔK =0 from the straight line equation of the K_{ex} and ΔK relationships.

Results and discussion

Soluble and exchangeable potassium:-

The data in table (2) shows that the amount of soluble potassium values were(0.01, 0.07and 0.02)cmol L^{-1} in Jojer, Segrka and Barvamosa respectively. The results were in agreement with those obtained by Al-Zubaidi and Al-Rubai (2002) for study potassium status in paddy soils in the middle part of Iraq. If the critical value is considered for soluble potassium is 0.05 cmol L^{-1} corresponding 240 kg $hectar^{-1}$ (IPI, 2001), then the value of soluble potassiumin Segrka soil is higher than the critical level when compared to the value was recorded in Jojer and Barvamosa soils.

Exchangeable Potassium (K_{ex})

The data in table (2) shows that the valuesof K_{ex} were(1.42, 2.07 and 1.03)cmol kg^{-1} for locationsJojer, Segrka and Barvamosa respectively. The critical level of K_{ex} in Iraqi Soil is 0.36 cmol Kg^{-1} according to Al-Zubaidi and pagel (1979);however the value of K_{ex} in studied soils is higher than the critical level.

Equilibrium Potassium Activity ratio (AR^k_e):-

The AR^k_e value is a measure of the available potassium in soil. Table (2) explains that the values of $AR^k_e$was(0.83 $*10^{-3}$, 2.99 $*10^{-3}$, and 1.19 $*10^{-3}$) (mole $kg^{-1})^{0.5}$ forJojer, Segrka and Barvamosa respectively. The value of AR^k_e depends on CEC, exchangeable potassium and Gapon exchange coefficient (Bahmand et al 2013). Therefore the highest exchangeable potassium and the AR^k_ewere recorded from segrka soil. This may be due to the low ratio of activity to total calcium carbonate in Segrka soil (0.08) as a comported with other samples (0.179 and 0.150) respectively. The value of AR^k_e in all sample were lower than was reported by Sparks and Liebhardt (1981). The potassium fertilization is necessary for the studied paddy field this result agree with Mehmedany (1999) , Al- Obaidi et al (2008) and Akrawi (2010).

Labile Potassium (ΔK^o):-

The parameter labile potassium ΔK^o refers to the potassium adsorbed to planar sites (Backett$_b$ 1964). The ΔK^o value were (-1.276, -4.125 and -1.992)cmol kg^{-1} forJojer, Segrka and Barvamosa soils respectively (Table 2 and Figure 1). The release of potassium to soil solution is greater in the presence of negative value of labile potassium (LeRoux and Sumner, 1968). Similar result is also obtained byAl-Obaidi et al 2008 and Al-Obaidi et al 2011.

Table (2): Soluble potassium, exchangeable potassium(K_{ex})and Q/I parameter:

Paddy field Location	Soluble K	K_{ex}	ΔK^o	AR^k_e	PBC^k	ΔG	KG	EK^o
	cmol kg^{-1}			(mol kg^{-1})$^{0.5}$ *10^{-2}	cmol kg^{-1} (mol kg^{-1})$^{0.5}$	Cal mole	(L mole^{-1})$^{0.5}$	cmol k^{-1}
Jojer	0.01	1.42	-1.276	0.083	15.38	-4202	1.025	1.721
Segrka	0.07	2.07	-4.125	0.299	16.77	-3443	0.851	2.363
Barvamosa	0.02	1.03	-1.992	0.119	13.79	-3988	1.320	1.332

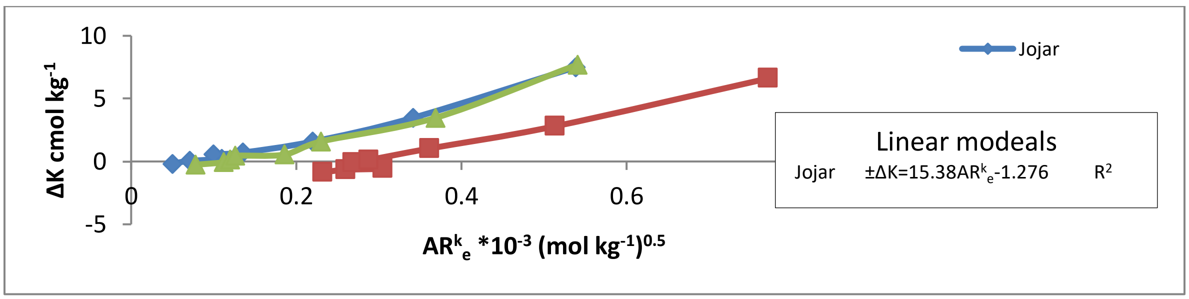

Figure (1) quantity/Intensity (Q/I) relationship for study soils.

Potassium Potential Buffering Capacity (PBC^k):

The results of PBC^k valuesshown in Table (2) were(15.38, 16.77 and 13.79)cmol kg^{-1} (mol kg^{-1})$^{0.5}$forJojer, Segrka and Barvamosa soils respectively. This study concluded that the high ratio for active to total $CaCO_3$ negatively affected on PBC^kvalues (Table 1). The low soil PBC^kvalue indicate that the soils more response and need frequent potassium fertilizer application that higher values (LeRoud and Sumner 1968).

Free energy (ΔG)

The result of calculating ΔG (Table 2) for the Jojer, Segrka and Barvamosa were (-4202, -3443 and -3988)calmole^{-1}respectively. This negative value of ΔG indicated to the shortage of potassium in soils according to Woodruff (1955). Its mean the supplying power ofpotassium in Segrka soils was medium while in Jojer and Barvamosasoils were low.

Potassium selectivity coefficient(K_G)

The results of K_G illustrated in Table (2) the values forJojer, Segrka and Barvamosasoils were (1.025, 0.838 and 1.085) (L mole^{-1})$^{0.5}$ respectively. The highest value was recorded in Barvamosa soils while the lowest value found for Segrka soil. The higher $K_G$represents greater deficiency of potassium. This, Barvamosa soils has the lowest efficiency in releasing potassium to soil solution compare to other location. Similar to our result founded by Hussien (2006), Mam Rasool (2008), Al-Obaidi and Hussien (2010).

Equilibrium exchangeable Potassium (EK°)

The EK^0 value were (1.721. 2.363 and 1.332)cmol kg^{-1} for Jojer, Segrka and Barvamosa respectively (Table 2 and Figure 2). Since the high power of potassium release is come from the highest EK° value (Uddin 2011), therefor Segrka should has the ability to release more potassium.

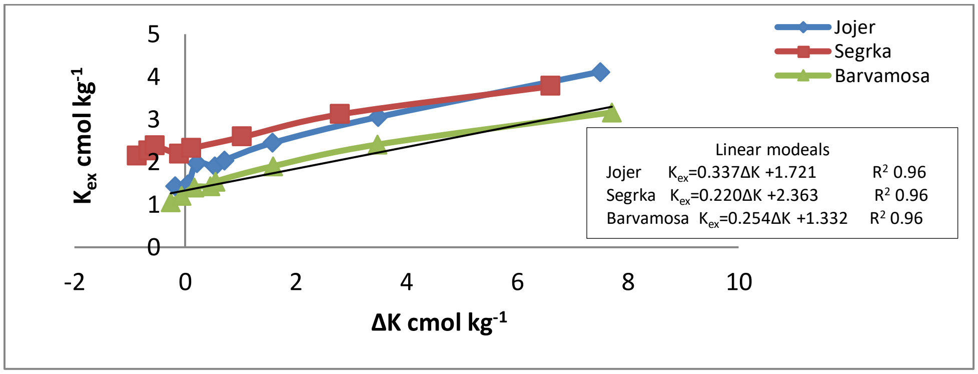

Figure (2) Relationship between ΔK and K_{ex}in studied soil.

Reference

1. **Akrawi, H. S. (2010).** Effect of clay minerals on K-thermodynamic and kinetic properties of some soil orders at Kurdistan region-Iraq.Ph D. Thesis Agric. Coll. Univ. of Salahaddin – Erbil Iraq.
2. **Al-Obaidi, M. A., F. R. Al-Kanah.and A. Noori (2008**). Study of Potassium Q/I relationships in some soils on Ninava-governorate. TikritUniv J. Agric Sci. 8: 225-234.
3. **Al-Obaidi, M. A. and A. S. Huessien (2010).** Kinetics of Potassium adsorption and desorption in some Nineveh governorate soils. Mesoptamia J. of Agric. 38: 50-59.
4. **Al-Obaidi, M. A.,M. T Said Khalil. and A. T. Dezaee(2011**). Study of potassium quantity – intensity parameters in some calcareous soils in northern Iraq.Mesoptamia J. of Agric. 39: 70-78.
5. **Alnajjar (2005),** Rice in Iraq, Expert in State Board of Agricultural Research, Iraq.
6. **Al-Zubaidi, A. H. and H. Pagel (1979).** Content of different potassium forms in some Iraqi soils. Iraqi J. of Agric Sci.14: 214-240.
7. **Al-Zubaidi, A. and B. M. Al- Rubai(2002).**Potassium Sstatus in rice soils. Iraqi J. of Agric Sci.,33: 1-8.
8. **Bahmani, M., I. H. Arefi., A. P. Pour (2013**). Comparison of potassium Quantity- Intensity parameters of vertisoils in two regions of arid and semi arid in Iran. International j of Agric. 3: 329-338.
9. **Beckett, P.H.T. (1964a).** Studies of soil potassium I: Confirmation of the ratio law: Measurement of potassium potential. J. Soil Sci. 15:9-23.
10. **Beckett, P.H.T. (1964b).** Studies of soil potassiumII: the immediate Q/I relations of label potassium. V. The stability of Q/I relations. J. Plant and Soil 25:435-455.

11. **Bhiah, K. M., C. Guppy, P. Lockwood. and R. Jessop(2010**). Effect of Potassium on rice loding under high nitrogen nutrition. 19th world congress of soil science, soil solution for changing world.136-139.
12. **Hussien A. S. (2006).** Physic-chemical behavior for potassium adsorption and desorptionin some Nineveh Governorate soils.Ph D. ThesisAgric and forest.Coll. Univ. of Mosul –Iraq.
13. **IPI (International Potash Institute) (2001).** Potassium dynamic and its availability.International Fertilizer Correspondent.1-5.
14. **Jalali, M.(2007).**Spatial variability in potassium release among calcareous soils of western Iran. J. Geoderma, 140:42-51.
15. **Johnston, A.E and K. W T Goulding (1990).**The use of plant and soil analysis to predict the K supplying capacity of soil.Proceeding of the development of K-fertilizer Recommendations.Basel, Switzer land. International Potash Institute., pp:177-204.
16. **LeRoux, J., and M. E. Summer(1968).**Labile potassium in soils, factors affecting the quantity-intensity parameters.J.Soil Sci. 106:35-41.
17. **Mam-Rasul, Gh. A. (2008).** Physic-chemical behavior of potassium in predomination soil orders of Sulaimani governorate. Ph D. Thesis Agric. Coll. Univ. of Sulaimani. Iraq.
18. **Mehmedany, L. A. (1999).** Potassium hpysico-chemical behavior for some calcareouse soils in Iraqi- Kurdistan region. M.Sc. Thesis. Agric. Coll. Univ. of Dohuk. Iraq.
19. **Motsara, M. R., R. N. Roy, 2008.** Guide to laboratory establishment for plant nutrient analysis. FAO.ISBN 978-92-5-105981-4.
20. **Niranjana, K.S., C.A. Srinivasamurthy, M. Ramegowda and K. Srinkantha (2000).** Q/I relationship of potassium in selected soil series of southern Karnataka. J. Indian Soc. Soil Sci. 48: 228-33.
21. **Noor, S., S.Z.K.M. Shamsad and M.S. Islam (1993).** Q/l parameters of potassium in three main soils of Bangladesh. J. Indian Soc. Soil Sci. 41: 161-163.
22. **Rowell, D. L. (1996).**Soil science.Methods and application.Univ. of Reading. UK.
23. **Sinclair, A. H.(1979).** Availability of potassium in ryegrass from Scottish soils. 1. Effect of intensive cropping on potassium parameters. J. Soil Sci. 30: 757-773.
24. **Sparks, D. L., and W. C. Liebhardt, (1981).**Effect of long-term lime and potassium application on quantity-intensity relationship in sandy soil. Soil Sci. Soc. Am. J. 45:768-790.
25. **Sparks, D. L., T. H. Carski, S. E. Fendorf, and C. V. Toner(1996**).Kinatic methods and measurements. p. 1275-1307. In D. L. Sparks (ed) Methods of soil analysis: Chemical methods. Soil Sci. Soc. Am. J. Madison, WI.
26. **Tisdale, S.L., W.L. Nelson, J.D. Beaton, and J.L. Havlin(1993).** Soil fertility and fertilizers. 5th edition. Macmillan Publishing Co., NY. Pp. 230-256
27. **Uddin M.S, M. J. AbedinMian, M. R. Islam, M. A. Saleque and M. S. Islam(2011).** Potassium status of four rice growing soils of Bangladesh.Bangladesh J. Agril. Res. 36(4): 633-646.
28. **Wang, J.G., A. D. Scott(2001**). Effect of experimental relevance on potassium Q/I relationships and its implications for surface and subsurface soils. J. Soil Sci. and plant Anal. 32:2561-2575.
29. **Woodurff, C. M. (1955).**Energies of replacement of Ca and K in soil. Soil Sci. Soc. Am. J. 19:167-171.