Evaluation of Potassium Status Using Thermodynamic Relationships in some Soils of Ismailia Governorate, Egypt

Mohamed S. Abd Elbary*, Ozoris M. Ali, Noha A. Mahgoub and Elsikhry,E.M.
Soil and Water Department, Faculty of Agriculture, Suez Canal University, Ismailia, Egypt.

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Abstract: Quantity – intensity (Q/I) isotherms were used to evaluate the dynamics of potassium in eight soil samples of Ismailia Governorate, Egypt. The results showed that the potassium activity ratio (AR_e^k) values for all soils increased as the K^+ concentration of the equilibrating solutions increased. El Qantara West soil had the highest AR_e^k value (12.0 (mole $l^{-1})^{0.5} \times 10^{-3}$) while Eltal Elkebier soil had the lowest value (3.20 (mole $l^{-1})^{0.5} \times 10^{-3}$). El Qantara West soil had the highest labile K value (0.56 cmole Kg^{-1} soil), while the Eltal Elkebier soil had the lowest labile K value (0.10 cmole Kg^{-1}), and the exchangeable K in this sample was higher than the labile K. The results showed that the potassium potential buffering capacity (PBC^k)values of the investigated soils ranged between 23.1 and 46.7 (cmole Kg^{-1}) / (mole $l^{-1})^{0.5}$. Free energy ($-\Delta G$) values ranged between 4.36 - 5.70 Kcal $mole^{-1}$. In addition, the results showed that the Gapon selectivity coefficient (K_G) varied between 3.81 and 51.9. The exchangeable K and $-\Delta K_e^o$ had a positive correlation coefficient (r = 0.70). AR_e^K values were highly correlated with logarithmic values (pK- 0.5pCa+Mg) obtained from equilibration of a single sample (r = -0.87). The potential buffering capacities were highly correlated with the exchangeable K (r = 0.83). Q/I parameters were influenced by soil properties and K forms. It could be used to sustained K fertilizer management in order to rationalize and increase fertilizer use efficiency (FUE).

Key words: Quantity, Intensity, Activity ratio, Potential buffering capacity, Free energy

INTRODCUTION

Potassium (K^+) is one of the most important macronutrients in soils which are required relatively larger amounts for plant growth. There are four different pools of K^+ viz., water soluble, exchangeable, non-exchangeable and mineral or structural exist in soil which are in a state of dynamic equilibrium with each other (Sparks, 1987 and Johnston and Goulding, 1990). Plants absorb K^+ mainly from the soil solution which is buffered by the rapidly exchangeable forms (Idigbor *et al.,* 2009). The availability of K^+ in the soil solution, and the capacity of soil to buffer this concentration are among the important parameters that determine the effective available K^+ for plant nutrition (Raheb and Heidari, 2012 and Hamed and Amin, 2017). Also, Bangroo *et al.,* (2021) reported that the change of potassium status depends on labile form in the solid phase, potassium concentration in the soil solution and the rate at which K release occurs from the solid phase to the liquid phase. Changes in biomass production and vegetative cover have a direct effect on the forms and dynamics of soil potassium (Moges *et al.,* 2013). The thermodynamic approach most often used in understanding, characterizing and evaluating the K^+ supplying capacity of soil is the quantity-intensity (Q/I) isotherm of K^+(Beckett, 1964 a and b). In the Q/I curve the equilibrium activity ratio of K^+ (AR_e^K) is a measure of availability or intensity of labile K^+ in soil. Bilias and Barbayiannis (2018) referred that ΔG could be used as a precise indicator of K availability, if CEC and illite K are taken into account, assisting in overcoming limitations arising from the complexity of K release and fixation dynamics, which make conventional extraction methods often inadequate. Different soil exhibiting the same value of AR_e^K values may not possess the same capacity for maintaining AR_e^K when soil K^+ is depleted by plant roots (Diatta *et al.,* 2006).The ability of soil to resist variations in the amount of available potassium under the influence of anthropogenic and natural influences is known as the potassium potential buffering capacity (PBC^K) (Zharikova, 2004). Higher values of labile K^+ indicated a greater K^+ release into soil solution resulting from a larger pool of soil K^+. A high value of the potential buffering capacity for K^+(PBC^K) in soil is indicative of a good K^+ availability while a low PBC^K value would suggest a need for K^+ fertilization (Wang *et al.,* 2004). As growth in plants is not directly constrained by the levels of exchangeable soil

*Corresponding author email: ag5769293@gmail.com

potassium (K), it is required to investigate this phenomenon through equilibrium studies to assess the quick ability of soil to provide K to plants. The aim of this study is to evaluate the dynamics of potassium in some soils of Ismailia Governorate by using the quantity-intensity (Q/I) concept. The aim of the current study is to evaluate the status of potassium in the soils of Ismailia Governorate using the quantity-intensity (Q/I) concept.

MATERIALS AND METHODS

Soil samples and characteristics: Eight representative surface soil samples (0–20 cm) were collected from some soils of Ismailia Governorate: Suez Canal University Farm (S.C.U Farm), Elferdan, El Qantara West, Sarabium, Abu Sultan, Elmanayef, Fanara and Eltal Elkebier). The soil samples were air-dried, crushed and passed through a 2mm sieve, prior to chemical analysis. Soil pH, electrical conductivity (EC), the soluble cations and anions, total $CaCO_3$, organic matter, available K^+, exchangeable K^+, the cation exchange capacity (CEC) of the soils were determined according to Page *et al.,* (1982). The total potassium was estimated according to Wu *et al.,* (1996) and the reserve potassium (soluble in 1N HNO_3) was determined according to Rouse and Bertramson, (1950). Particle size distribution was determined by the pipette method according to Singer and Janitzky, (1986).

Potassium intensity: This parameter was made by calculating the minus logarithm of the potassium adsorption ratio from the data of potassium, calcium and magnesium activities in soil suspensions made by equilibrating 5g soil with 50 ml 0.01M $CaCl_2$ solution. The suspensions were shaken for two hours, left to equilibrate overnight, then, filtrated. The filtrates were analyzed for potassium, calcium and magnesium (Hagin and Feigenbaum,1962).

Potential buffering capacity (PBC^K): The PBC^K values of the selected soils determined according to Acquaye and MacLean (1966), by equilibrating 5 g of air-dried soil with 50 ml of 0.01M $CaCl_2$ solution containing different amounts of potassium chloride in 100 ml cups to provide initial activity ratios. The amounts of potassium chloride used were 0, 0.1, 0.2, 0.3, 0.4, 0.5, 1, 2, 3, 4 and 5 mM l^{-1}. The cups were shaken for two hours, the suspensions were allowed to stand overnight and filtered. The filtrates were analyzed for calcium, magnesium and potassium. The activity ratio of potassium AR_{K-D} ($a_K / a_{(Ca+Mg)}^{0.5}$) was calculated from the composition of the filtrates and the activity coefficients of potassium derived from the second approximation of Debye and Huckel equation (Moore,1972). Criteria of the " quantity – intensity " relation (Q/I) of potassium of the selected soils were calculated following the approach of Beckett (1964b). The gain or loss of potassium by the soil (±ΔK) in cmole kg^{-1} soil was obtained as the difference in concentration of the initial and the equilibrated solutions. Values of ± ΔK were plotted against AR_{k-D} when no potassium was gained or lost, i.e., Δk= 0, or intercept at AR_{k-D} = 0, was obtained by extrapolation of the linear part of the curve. The potential buffering capacity (PBC^K) of the soil for potassium, as represented by the ratio ($-\Delta K/AR^e_{K-D}$), was used as a measure of the capacity of soil to maintain the potential of potassium against depletion.

RESULTS AND DISCUSSION

Soil characteristics: The data from Table (1) indicated that the examined soils exhibited variations in their textural classifications. The soils of S.C.U Farm, El Qantara West, Abu Sultan, Fanara, and Eltal Elkebier had a sandy clay loam texture. Sarabium presented a texture characterized by a loamy sand texture. In addition, sandy texture was noted in the soils of Elferdan and Elmanayef. The electrical conductivity (EC) ranged from 0.83 to 6.46 dSm-1. The soil pH ranged from 7.61 to 8.26 at El Qantara West and S.C.U Farm, respectively. The highest value of available K was in El Qantara West (6.60 cmole Kg-1) while the lowest value in Elmanayef (1.02 cmole Kg-1). Also, the reserve potassium ranged between 1.01 to 8.87 cmole kg-1 dry soil. This reserve potassium is believed to be important in plant growth as it constitutes most of the moderately available form. Total potassium ranged between 23 – 71.6 cmole kg-1 dry soil. The richest soils in the total potassium were in El Qantara West. The least value was in Fanara as shown at

Table(2). The cation exchange capacity varied between 13 cmole kg-1 for Elmanayef, to 59.7 cmole kg-1 for Eltal Elkebier. In comparison to the other soils, the fine textured soil had a comparatively high amount of exchangeable potassium.

Relationship between potassium quantity and intensity (Q/I):

Potassium activity ratio (AR_e^k): The Q/I relationship, which represents the relationship between the amount of potassium in the soil and its availability to plants, was analyzed for the soils under investigation and is shown in Figs (1). The Q/I relationship is divided into two distinct regions: an upper linear portion at moderate to higher ARek values, and a curved lower region at low ARek values. The ARek is a measure of soil labile potassium, which represents the portion of potassium that is readily available to plants. To determine the ARek, soil samples mixed with CaCl2 solutions including different amounts of KCl. The potassium content of the resulting solutions was then determined, and the ARek was calculated by comparing the potassium concentration in the solution to the potassium concentration in the soil. The data in Fig. (1) showed that the AR_e^k values for all soils increased as the K^+ concentration of the equilibrating solutions increased. El Qantara West soil had the highest AR_e^k value (12 (mole $l^{-1})^{0.5} \times 10^{-3}$) while Eltal Elkebier soil had the lowest value (3.2 (mole $l^{-1})^{0.5} \times 10^{-3}$) (Table 3).The lower AR_e^k values observed in some soils could be due to a greater number of specific K^+ sites.

The labile K (-ΔKeo): The labile K values of different soil samples ranged from 0.1 to 0.56 cmole Kg^{-1}dry soil, that can bind or fix potassium, making it less available for plant uptake. Furthermore, the higher ARek values in most of the studied soils were attributed to the adsorption of K+ primarily at planar positions, which increases the intensity of K+ supply. According to Hamed and Amin (2017), the clay soil had the highest ARek values compared to the other soils studied. This could be attributed to the smaller percentage of exchangeable potassium in the clay soil. Additionally, the low values of exchangeable calcium and magnesium in the soil may have contributed to the higher ARek values, as reported by Lalitha and Dhakshinamoorthy (2015). Al-Hamandi *et al.,* (2019) demonstrated that the potassium activity ratio (AReK), which ranges between 0.44 to 11.39 x 10-3 (mole l^{-1})0.5, is related to changes with labile potassium at equilibrium and increased along with rising K+ concentrations. In addition, Metwally *et al.,* (2021) found that ARek values ranged from 2.88 to 15.01 (mole l-1)0.5. Al-Sultan and Al-Obaidi (2022) reported that the values of ARek varied between 20-80 × 10-3 (mole l^{-1})0.5. Uzoho *et al.,* (2023) pointed out ARek values ranged from 1.16-2.03 × 10-3 (mole l^{-1}) 0.5. The behavior of soils in releasing or fixing potassium, as well as the relationship between this behavior and the equilibrium activity ratio of potassium (ARek), are illustrated in Fig. (1). The data presented in the figure indicates that the upper portions of the curves describing this relationship are linear. Differences in ARek values between soils could be attributed to several factors, including the concentration of potassium in the equilibrating solutions, the duration of the equilibration period, and the levels of calcium and magnesium in the soil. Additionally, the mineralogical structure of the soil may also contribute to these differences (Yawson *et al.,* 2011 and Panda and Patra, 2018). According to Lalitha and Dhakshinamoorthy (2015) and Hamed and Amin (2017), labile K(-ΔKeo) refers to the amount of potassium that is available for ion exchange during the equilibrium between soil solids and solution. To maintain a balance between potassium on the soil colloids and potassium in the soil solution, there must be ionic exchange. As shown in Table (3) and Fig. (1). El Qantara West soil sample had the highest labile K value (0.56 cmole Kg-1dry soil), which may be attributed to its high CEC value and the presence of loosely bound K+ ions in exchangeable sites, as reported by Samadi (2006). Additionally, Yawson *et al.,* (2011) reported that high values of labile K can result from the release of K into the soil solution, which increases the amount of labile K in the soil.In contrast, Eltal Elkebier soil sample had the lowest labile K value (0.10 cmole Kg^{-1}dry soil) , and the exchangeable K was higher than the labile K. This may be because some of the exchangeable K was not subject to the ion exchange equilibrium described by immediate Q/I relations, as reported by (Rao *et al.,* 1984 and Panda and Patra, 2018). The high clay content of the soil, which is dominated by illite minerals, gives it a strong capacity to adsorb K^+ onto the clay colloids, as reported by Sanyal (2001). As a result, potassium is likely to be released primarily through exchange processes rather than solubility or diffusion processes (Diatta *et al.,* 2006). According to Abaslou and Abtahi (2008), labile K in Q/I adsorption curves was more t than releasing curves. Due to the fact that these variations in K labile quantity during adsorption and release according to various fixation capacities were not comparable. In adsorption curves, the correlation between exchangeable potassium and labile potassium will be lower than in releasing curves.

Potassium potential buffering capacity (PBCk): The slope of the linear portion of the Q/I plot represented the soil PBCk in response to K^+ depletion due to crop removal and leaching losses (Hamed and Amin, 2017 and Panda and Patra, 2018). In general, a high PBCk value indicates that the soil has a greater capacity to retain its K concentration for longer periods of time, though this frequently leads to low K intensity. While the soil with a low PBCk value, requires frequent K fertilization and is unable to maintain a given supply of K for an extended period (Yawson *et al.,* 2011).

The results in Table (3) showed that the PBCk values of the investigated soils ranged between 23.1 and 46.7 (cmole Kg^{-1}) / (mole l^{-1})0.5. Zharikova (2004) reported that PBCk values are categorized as very low (< 20 (cmole Kg-1)/(mole l^{-1})0.5), low (20-50 (cmole Kg^{-1}) / (mole l^{-1})0.5), medium (50-100 (cmole Kg^{-1})/ (mole l^{-1})0.5) elevated (100-200(cmole Kg^{-1})/ (mole l^{-1})0.5) and high (>200 (cmole Kg^{-1})/ (mole l^{-1})0.5). Based on these categories, it appears that the PBCk values of the investigated soils in this study are low and very low. The difference in the organizational capacity of the soils can be attributed to the variation in the number of specific sites of soil potassium. According to Al-Zubaidi *et al.,* (2008), the variations in soil texture, organic matter content, and mineralogy may also contribute to the low PBCk values observed in some soils. The low values of PBCk may be due to the presence of a small number of soluble K sites, which is reflected in the Q/I isotherms of soils with low buffering capacity. Also, Ajiboye *et al.,* (2015) reported that the K-buffering capacity of soils ranged from 88.1 to 373 (cmole Kg^{-1}) / (mole l^{-1}) 0.5. It demonstrates that these soils have a significant capacity for retaining K in soil solution. A soil with a high PBCK does not rapidly enhance the activity ratio (AReK) when K^+ is added to it, and it rapidly decrease in ARK when K+ is removed from it.

Free energy (-ΔG): It is an index about the status of available potassium in the soil, it describes the simplicity with which an ion transitions from a solid part (soil) to a liquid phase, and then from there to the surface of a plant root. This is a measurement of the chemical effort of potassium in comparison to the chemical voltage of calcium in the soil. The data in Table (3) showed that -ΔG values ranged between 4.36-5.70 Kcal $mole^{-1}$. The low of free energy values (-ΔG) are always found in the soils with higher exchangeable-k (Samadi, 2006 and Al-Zidan *et al.,* 2022). Also, Bangroo *et al.,* (2012) reported that the exchange of K- (Ca + Mg) was spontaneous if the free energy change was negative. More negative values of ΔG would lead to more K release, whereas less negative values of ΔG would imply less K+ ion bonding. The changes in free energy caused by the difference in the mineral types and the equilibration between the soil solution and the solid phase (Al-Hamandi *et al.,* (2019).

Gapon selectivity coefficient (KG): The Gapon selectivity coefficient for K describes the proximity that soils may develop towards K in the presence of Ca and Mg under equilibrium conditions, both in the soil solid phase and in the soil solution. The results showed that the KG varied between 3.81 and 51.9 (Table 3). Samadi (2006) reported that KG ranged between 2.30 and 5.30. Also, Abaslou and Abtahi (2008) found that the values of KG varying from 4.20 to 12.9. Also, Al-Sultan and Al-Obaidi (2022) found that KG values ranged from 8.44 to 12.8. The amounts of exchangeable Ca and Mg are primarily responsible for the fluctuations in KG values (Panda and Patra, 2018). The preferential attraction of K ions over Ca and Mg at particular planar sites of soil colloids may also be responsible for the selective behavior of soil for K in contrast to dominant Ca and Mg (Al-Hamandi, 2019).

Table (1): Some Physico-chemical analysis of the investigated soils

Soil location	pH	EC (dSm-1)	Soluble Cations (meq l-1)				Soluble Anions (meq l-1)				CaCO3 (%)	O.M (%)	Soil texture
			Ca2+	Mg2+	Na+	K+	Cl-	CO32-	HCO3-	SO42-			
S.C.U Farm	8.26	1.98	10.6	1.70	6.13	1.37	8.67	-	10.7	0.43	1.88	0.55	Sandy Clay Loam
Elferdan	8.02	0.83	5.16	2.00	0.30	0.84	1.67	-	5.80	0.83	0.39	0.55	Sandy
El Qantara West	7.61	6.46	7.30	19.7	34.4	3.17	39.7	-	15.7	9.20	8.96	1.97	Sandy Clay Loam
Sarabium	7.81	2.68	14.8	9.67	0.20	2.13	9.30	-	6.20	11.3	0.91	0.89	Loamy Sand
Abu Sultan	7.84	2.67	12.0	9.67	1.97	3.06	9.30	-	16.3	1.10	2.94	1.45	Sandy Clay Loam
Elmanayef	8.15	1.05	5.67	3.83	0.32	0.68	2.50	-	5.17	2.83	0.84	0.77	Sandy
Fanara	7.93	2.67	8.30	6.30	10.8	1.17	4.30	-	6.30	16.1	28.8	0.06	Sandy Clay Loam
Eltal Elkebier	7.63	1.39	6.70	3.70	3.00	0.50	3.70	-	9.30	0.90	2.56	0.96	Sandy Clay Loam

Table (2): Available, reserve and total K and exchangeable cations, CEC and soluble cations of the investigated soils

Soil location	Available K	Reserve K	Total K	Exchangeable cations				CEC	Soluble cations			
				K	Na	Ca	Mg		K^{+}	Na^{+}	Ca^{2+}	Mg^{2+}
	(cmole kg^{-1} dry soil)											
S.C.U Farm	2.24	1.34	35.8	2.10	4.43	11.0	11.8	29.4	0.14	0.61	0.80	0.43
Elferdan	1.27	1.01	48.6	1.20	1.56	5.60	5.60	14.2	0.07	0.30	0.52	0.20
El Qantara West	6.60	8.87	71.6	6.28	8.00	7.80	30.0	52.2	0.32	3.45	1.06	1.97
Sarabium	6.21	1.56	30.7	6.00	1.00	3.50	2.50	13.2	0.21	0.15	1.48	1.07
Abu Sultan	3.71	2.91	63.9	3.40	3.20	23.0	7.40	37.8	0.31	0.33	1.20	0.97
Elmanayef	1.02	1.05	63.9	0.95	1.86	4.80	5.30	13.0	0.07	0.03	0.53	0.42
Fanara	1.04	1.29	23.0	0.92	1.10	7.00	4.98	14.5	0.12	1.09	0.87	0.73
Eltal Elkebier	3.24	2.40	48.6	3.19	3.93	35.8	16.1	59.7	0.05	0.30	0.67	0.37

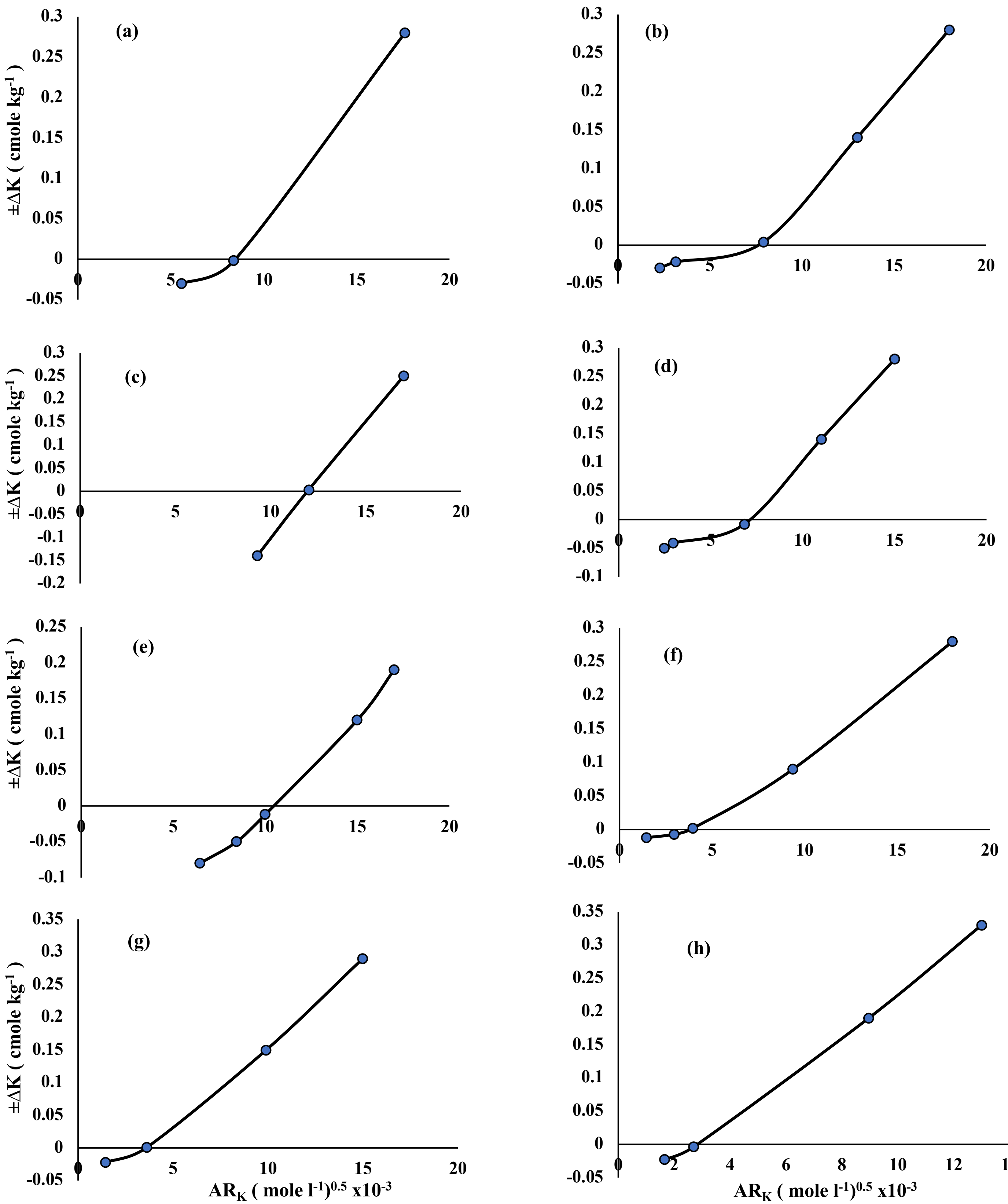

Fig. 1. Quantity-intensity of potassium of the studied soil samples where (a) S.C.U Farm, (b) Elferdan, (c) El Qantara West, (d) Sarabium, (e) Abu Sultan, (f) Elmanayef, (g) Fanara and (h) Eltal Elkebier.

Table (3): Potassium quantity-intensity (Q /I) parameters of the studied soils

Soil location	AR_e^K (mole l^{-1})$^{0.5}$ x10^{-3}	$-\Delta K_e^o$ (cmole kg^{-1})	PBC^K (cmole kg^{-1}/ (mole l^{-1})$^{0.5}$)	ΔG (Kcal $mole^{-1}$)	Gapon coefficient (K_G)
S.C.U farm	8.40	0.21	25.0	4.72	5.27
Elferdan	8.00	0.23	28.8	4.78	7.63
El Qantara West	12.0	0.56	46.7	4.36	6.10
Sarabium	6.80	0.24	35.3	4.93	51.9
Abu Sultan	10.4	0.27	26.0	4.51	3.81
Elmanayef	5.20	0.12	23.1	5.46	9.70
Fanara	4.60	0.13	28.3	5.60	5.61
Eltal Elkebier	3.20	0.10	31.3	5.70	8.87

Relation of ΔK_e^o to exchangeable K, non-exchangeable K and pK-0.5pCa+Mg: The linear portion of the Q/I (quantity/intensity) relation's intercept at AR^K = zero is denoted as -ΔK_e^o. It provides an approximate estimate of the amount of the potassium labile pool in the soil. The -ΔK_e^o values of the eight investigated soils ranged between 0.1 and 0.56 cmole.kg^{-1} (Table 3), as determined by the intercept of the relation Q/I relation curves at AR^K = 0. The relationship between ΔK_e^o and other potassium measurements in soil can vary depending on factors such as soil type, pH, and management practices. Generally, there is a positive correlation between ΔK_e^o and available potassium, as both are indicators of the amount of K that can be taken up by plants. The data showed that the exchangeable K and -ΔK_e^o had a positive correlation coefficient (r = 0.70) as shown at Table (4). This result incompatible with Al-Hamandi *et al.,* (2019) who found that the relationship between ΔK_e^o and exchangeable K in soils were positively correlated with the exchangeable K content in the soils (r = 0.44). The positive result indicates a considerable release of potassium into the soil solution, whereas the negative value is a measure of the potassium (unstable) that exists on planer surface sites. Similarly, Abaslou and Abtahi (2008) found that labile K was positively correlated with exchangeable K (r = 0.71). Zharikova (2004) stated that according to a strong association between -labile K, the amount of nonexchangeable potassium, and the amount of clay fraction, it is conceivable to hypothesis that under certain conditions, potassium ions fixed on ion-exchange sites with high energy of bonds may become available for plants.

Relation of AReK to exchangeable K, non-exchangeable K and pK-0.5pCa+Mg: The AReK values for K = zero derived from the curves by interpolation ranged between 3.2x10-3 and 12x10-3 (mole l-1) 0.5 (Table 3). El Qantara West had the highest value, while Eltal Elkebier had the lowest one. AReK values were highly a negatively correlated with logarithmic values (pK-0.5pCa+Mg) obtained from equilibration of a single sample (r = - 0.87). Hamed and Amin (2017) found that the potassium activity ratio (AReK) has a negative correlation with exchangeable potassium (r= - 0.444). This result in contrary with Diatta et al., (2006) who found that there was a significant positive correlation (r= 0.51) between AReK and exchangeable K.

Relation of PBCK to exchangeable K, non-exchangeable K and pK-0.5pCa+Mg: The potential buffering capacities were highly correlated with the exchangeable K (r= 0.83) as shown in Table (4). Furthermore, the PBCK values appear to show some relation to the estimates of the non-exchangeable K where the correlation coefficient between PBCK and step potassium was (0.87) as shown in Table (4). The PBCK test measures how well the soil can retain the level of K+ in the soil solution constant.

Table (4): Correlation coefficients of $-\Delta K_e^0$, AR_e^K and PBC^K relating to exchangeable K, non-exchangeable K and pK-0.5pCa+Mg

	AR_e^K	$-\Delta K_e^0$	PBC^K
Exchangeable K	0.49	0.70	0.83
Non-exchangeable K released HNO_3 (step K)	0.65	-	0.87
pK-0.5pCa+Mg	-0.87	-	-

CONCLUSION

Quantity-intensity (Q/I) isotherms can provide a good information of potassium dynamic in soils. Soil properties like $CaCO_3$ content, clay fraction content as well as CEC were found more affected on K status in the soil. The higher the clay fraction content, the higher the potential buffering capacity. Such obtained results should be considerable when potassium fertilizer recommendations are made. Q/I parameters were influenced by soil properties and K forms. In conclusion Q/I concept could be useful for estimation of K in the soil. K status in order to sustained K fertilizer management in order to increase fertilizer use efficiency (FUE).

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تقييم حالة البوتاسيوم باستخدام العلاقات الثرموديناميكية في بعض أراضي محافظة الاسماعيلية ، مصر

محمد سمير عبد الباري ، أوزوريس محمد علي ، نهى عادل محجوب ، السيد محمد السخري

قسم الأراضي و المياه ، كلية الزراعة ، جامعة قناة السويس ، مصر

المستخلص: استخدمت العلاقة بين عاملى الشدة و الكمية للبوتاسيوم لتقييم ديناميكية البوتاسيوم في ثمان عينات ممثلة لمحافظة الاسماعيلية . و أوضحت النتائج أن نسبة نشاط البوتاسيوم (AR_e^K) زادت بزيادة تركيز البوتاسيوم في المحاليل المتزنة . و كانت أعلى قيمة لنشاط البوتاسيوم في عينة القنطرة غرب (12.0×10^{-3} (مول لتر$^{-1}$)$^{0.5}$) بينما أقل قيمة كانت في عينة التل الكبير (3.20×10^{-3} (مول لتر$^{-1}$)$^{0.5}$) . كما كانت أعلى قيمة للبوتاسيوم المتغير في عينة القنطرة غرب حيث بلغت (0.56 سنتي مول كجم$^{-1}$) بينما أقل قيمة كانت في عينة التل الكبير(0.10 سنتي مول كجم$^{-1}$) و كانت قيمة البوتاسيوم المتبادل أعلى من للبوتاسيوم المتغير في هذه العينة. كما أوضحت النتائج أن السعة التنظيمية قد تراوحت بين 23.1 – 46.7 (سنتي مول كجم$^{-1}$)/ (مول لتر$^{-1}$)$^{0.5}$. كما تراوحت قيم الطاقة الحرة للعينات بين 4.36 – 5.70 كيلو كالوري مول$^{-1}$. بالاضافة الى ذلك فقد أوضحت النتائج أن قيم معامل جابون بين 3.81 – 51.9 . كما اتضح من النتائج أيضا أن هناك ارتباطا معنويا (0.70) بين البوتاسيوم المتبادل و المتغير ، كما أن هناك ارتباطا معنويا سالبا (-0.87) بين نسبة نشاط البوتاسيوم عند الاتزان و القيم اللوغاريتمية (pK-0.5pCa+Mg) التي تم الحصول عليها من المحاليل المتزنة . كما ارتبطت قيم جهد السعة التنظيمية معنويا بالبوتاسيوم المتبادل (0.83) . و قد أظهرت الدراسة تأثر و ارتباط المؤشرات (Q/I) بخواص التربة المختلفة و كذلك بصور عنصر البوتاسيوم .
و من هنا فانه يمكن استخدام هذه المؤشرات لتحقيق الادارة المستدامة لبرنامج التسميد البوتاسي تحت ظروف الأراضي المختلفة من أجل زيادة كفاءة استخدام ذلك السماد و ترشيد استخدامه من الناحية الاقتصادية و البيئية.