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Short Communication

Quantity-Intensity Relationships of Potassium in Semi-arid Soils

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For better understanding of availability and supplying power of potassium in soils, Q/I relationship approach proposed by Beckett (1964) is generally used. In this approach, immediate availability of potassium is related to intensity, quantity and potassium buffering capacity factors of soil. Potassium supply capacity is influenced by numerous factors including texture. Much work has been done on Q/I parameters in relation to crop yields (Jimenez and Parra, 1991), extractants used (Sparks and Huang, 1985) and influence of different soil parameters on K dynamics in arid soils (Joshi *et al.*, 1978, 1982; Joshi, 1986, 1992; Dutta and Joshi, 1989). In this paper, the quantity-intensity parameters of K using conventional approach in some texturally different semi-arid soils have been reported.

Five surface soil samples (0-20 cm) from medium black and grey brown soil groups, each representing a different textural class, were collected from five villages of Udaipur district of Rajasthan. The samples were ground to pass through a 60 mesh stainless steel sieve and analyzed for certain relevant physico-chemical properties using standard procedures as outlined by Jackson (1978) (Table 1).

The quantity and intensity parameters of soil K were measured according to the procedures given by Beckett (1964). Five gm soil and 50 ml $CaCl_2$ solution containing graded concentrations of K (0, 2.5, 5.0, 10.0, 15.0 and 20.0 ppm) in the form of potassium chloride were taken in a series of centrifuged tubes of 100 ml size. The soil suspension was shaken on a horizontal shaker for half an hour at 25±2°C. The suspension was kept for equilibration for 24 hrs and then centrifuged and supernatant solution was analyzed for K and Ca + Mg. The potassium was measured using flame-photometer and Ca + Mg by EDTA titration method. The loss or gain of K (±ΔK) was obtained by difference. The amounts of K gained or lost were plotted against activity ratio (AR_o^k) which was calculated from the equation:

$$AR_o^k = a_k/a_{(Ca\ +\ Mg)}^{1/2}$$

where,

a_k and $a_{(Ca+Mg)}^{1/2}$ are the activities of K and Ca + Mg expressed as mol l^{-1} in the equilibrium solution. The intercept of the Q/I curve on the AR_o^k axis, where $\Delta K = 0$, gave the soil potassium activity ratio at equilibrium (AR_o^k). The potential buffering capacity (PBC^k) was calculated

Table 1. Physico-chemical characteristics and potassium status of soils

Parameters	Soil-1	Soil-2	Soil-3	Soil-4	Soil-5
pH (1:2)	7.50	7.40	8.20	8.10	8.10
EC (dS m^{-1})	0.37	0.35	0.50	0.38	0.35
OC (%)	0.72	1.35	0.99	0.99	0.83
CEC [cmol (P+) kg^{-1}]	18.40	17.30	18.10	20.00	12.00
Textural class*	scl	sl	zcl	cl	ls
H_2O-K (mg kg^{-1})	11.20	7.20	6.40	6.00	6.90
NH_4OAc^{-k} (mg kg^{-1})	75.00	125.00	80.00	65.00	60.00
HNO_3^{-k} (mg kg^{-1})	800.00	1120.00	2400.00	1200.00	640.00

*scl = sandy clay loam; sl = sandy loam; zcl = silty clay loam; cl = clay loam; ls = loam sand.

by slope of the curve. The standard free energy change of the K replenishment (ΔGr) was calculated from the following equation:

$$\Delta G_r = -2.303 \text{ RT log } [a_k/a_{(Ca+Mg)}^{1/2}]$$

where,

a_k and $a_{(Ca+Mg)}^{1/2}$ are the activities of K and Ca+Mg, respectively, in the equilibrium solution; R and T are the gas constant and temperature on Kelvin scale, respectively.

The Quantity/Intensity relationships of K for all the five soils are depicted in Fig. 1. The nature of the curves were almost similar, however, quantitative differences were observed. The values of different Q/I parameters are given in Table 2. The value of K_L for soil-4 (CEC 20.0 c mol (P+) kg^{-1}] was 0.85 c mol (P+) kg^{-1}, and for soil-5 (12.0 c mol (P+) kg^{-1}) 0.40 c mol(P+) kg^{-1}. The results clearly pointed out that soils with higher clay content showed higher values of K_L than with lower clay content and this may be attributed to the higher exchange capacity of clay fraction (Joshi, 1992; Roy and Kumar, 1933).

The activity ratio of potassium (AR_o^k) also showed higher values in fine textured soils and may possibly be due to higher ionic strength of potassium in comparison to Ca and Mg ions in the soil solution. Lower values of AR_o^k in light textured soils may be due to their lower cation retention power, which implies that only a small amount of potassium would remain in soil solution in these soils.

The values of PBC^k for soil-1 to soil-5 were 56, 54, 62, 64, and 43 [me$(ML^{-1})^{-1/2}$], respectively. PBC^k denotes the rate of change of quantity with intensity and is represented by the slope of the curve. Fine textured soils showed higher values of PBC^K than coarse textured soils, indicating their higher potential to replenish K- concentration in soil solution.

Since nutrient ions are adsorbed on the exchange sites of soil, some energy is required to remove these ions from the adsorption surface. The magnitude of this energy is known as chemical potential of the ions. The standard free energy change of the change reaction (ΔG_r) is a measure of difference between the chemical potential of K and Ca+Mg and is referred to here as the free energy of K - (Ca + Mg) exchange. The values of ΔG_r were found

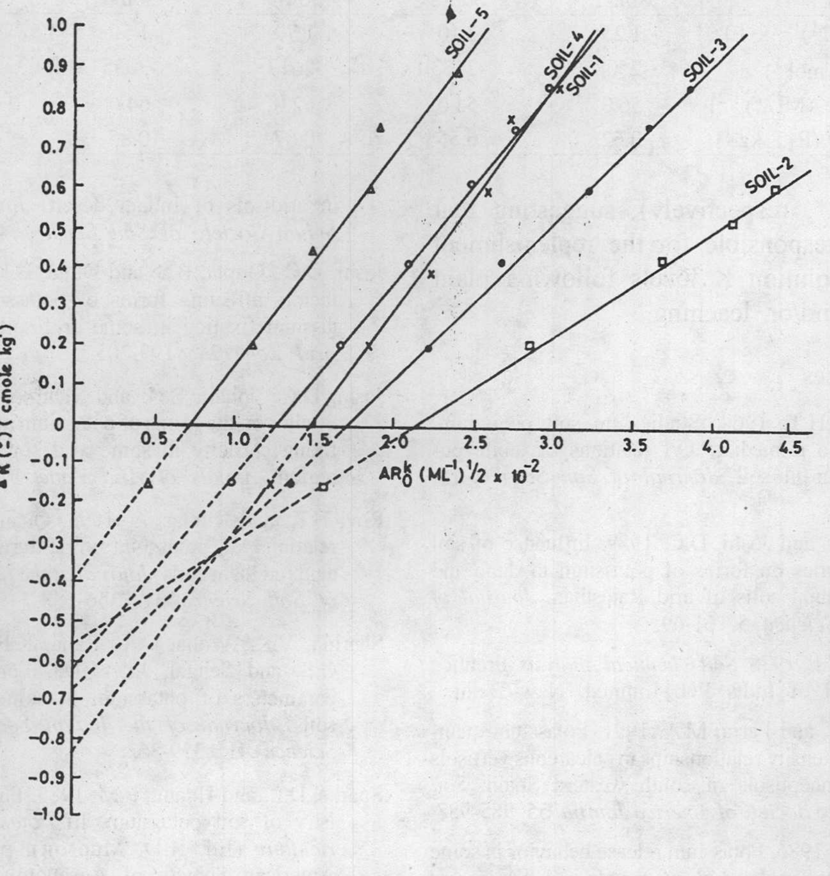

Fig. 1. Quantity-Intensity relationships of potassium in some semi-arid soils.

negative for all the soils tested. These values suggest a higher preference of K as compared to Ca+Mg ions on the exchanger. The values of ΔG_r varied from -2306 to -3035 cal mol^{-1}, irrespective of sign, the highest being for clay loam (soil-4) and the lowest for loamy sand (soil-5). When compared with the critical limit of 3800 cal mol^{-1} (Woodruff, 1955), these soils appeared sufficient in potassium availability. The values of aG_r, obtained in the present study are consistent with those reported by Sharma *et al*. (1993) for some alluvial soils of India.

Coefficient of correlations between soil properties and Q/I parameters indicated that $AR_o{}^k$ had positive relationship with organic carbon and cation exchange capacity (r = 0.80 and 0.67, respectively) and negative with pH (r = -0.40). Cation exchange capacity of the soil was positively correlated with PBC^k, ΔGr, and KL (r = 0.94*, 0.77,

Table 2. Q/I Parameters of different soils

Parameters	Soil-1	Soil-2	Soil-3	Soil-4	Soil-5
AR_0^K $(ML^{-1})^{1/2} \times 10^{-2}$	1.25	2.10	1.70	1.50	0.62
ΔG_r (Cal mol^{-1})	-2508	-2433	-2617	-3035	-2306
PBC^K [me $(ML^{-1})^{-1/2}$]	56.0	54.0	62.0	64.0	43.0
K_L [cmol (P+) kg^{-1}]	0.62	0.55	0.67	0.85	0.40

and 0.91*, respectively), suggesting that ECE is responsible for the replenishment of soil solution K levels following plant uptake and/or leaching.

References

Beckett, P.H.T. 1964. Studies on soil potassium. II. The immediate Q/I relations of labile potassium in soil. *Journal of Soil Science* 15: 9-23.

Dutta, B.K. and Joshi, D.C. 1989. Influence of soil properties on forms of potassium in dune and interdunal soils of arid Rajasthan. *Journal of Soil Science* 5: 61-69.

Jackson, M.L. 1978. *Soil Chemical Analysis*. Prentice - Hall of India Pvt. Limited, New Delhi.

Jimenez, C. and Parra, M.A. 1991. Potassium quantity-intensity relationships in calcareous vertisols and inceptisols of south western Spain. *Soil Science Society of America Journal* 55: 985-988.

Joshi, D.C. 1986. Potassium release behavior in some arid soils. *Journal of the Indian Society of Soil Science* 34: 56-63.

Joshi, D.C. 1992. Relationship between the quantity and intensity parameters of labile potassium in aridisols of Indian desert. *Journal of the Indian Society of Soil Science* 40: 431-438.

Joshi, D.C., Gupta, B.S. and Dutta, B.K. 1982. Soil factors affecting forms of potassium and potassium fixation in some arid soils. *Annals of Arid Zone* 21:. 199-205.

Joshi, D.C., Johari, S.N. and Sharma,. V.C. 1978. Studies on the forms of potassium and potassium fixing capacity in some arid soils of Jodhpur region. *Annals of Arid Zone* 17: 273-278.

Roy, H.K. and Kumar, A. 1993. Quantity-intensity relations of potassium in texturally different acid red loam soils. *Journal of the Indian Society of Soil Science* 41: 356-358.

Sharma, V.K., Walia, C.S., Rana, K.P.S., Sekhon, G.S. and Sehgal, J.L. 1993. Forms and Q/I parameters of potassium in some benchmark soils. *Journal of the Indian Society of Soil Science* 41: 359-362.

Sparks, D.L. and Huang, P.M. 1985. Physical chemistry of soil potassium. In *Potassium in Agriculture* (Ed. R.D. Munson), pp. 201-276. American Society of Agronomy, Madison.

Woodruff, C.M. 1955. Ionic equilibrium between clay and dilute salt solutions. *Soil Science Society of America Proceedings* 19: 36-40.