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Quantity Intensity Relations of K in Three Alluvial Soils

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ABSTRACT

A laboratory study was conducted to observe the effect of lime (1, 5 and 10%), K fertilization (50, 100 and 150 mg kg^{-1}) and texture (fine, medium, coarse) on K availability i.e. intensity, quantity and buffering capacity. After completion of three alternate wetting and drying cycles, soluble cations and extractable K were determined. Intensity, quantity and buffering capacity for K were calculated. Intensity was maximum in coarse soil and least in fine soil while quantity was reverse i.e. maximum in fine soil and minimum in coarse soil. Both these parameters increased with the increasing rates of K and decreased with the increasing levels of $CaCO_3$. Buffering capacity was more like to quantity in fine soils and least in coarse soil. This parameter was mainly affected by texture and was increased by adding K and decreased slightly by the addition of $CaCO_3$.

Key Words: Potassium; Alluvial Soils; Buffering capacity

INTRODUCTION

Potassium (K) supply from soil depends on the quantity and forms present and the rate at which the exchangeable K is replenished from non-exchangeable sites. A low level of exchangeable K results in the release of non-exchangeable K; whereas, high level leads to its fixation. The amounts of water soluble, exchangeable and non-exchangeable forms of K are used to evaluate the K supplying power of soil. One way of expressing the available K i.e. labile pool (Q) and soluble K is the quantity/intensity relationship (Beckett, 1964). The intensity i.e. activity ratio aK/a $(Ca + Mg)^{1/2}$ is said to be less in clayey soils and more in sandy soils, while the quantity (Q) i.e. the amount of exchangeable K is vice versa, probably due to more CEC and high clay content (Deshmukh & Khera, 1993) and these parameters can be used for predicting K absorption by plants (Classen *et al.* 1986). The quantity, intensity and buffering capacity seem to be permanent characteristics of soil (Sinclair, 1979) and can be used for making K fertilizer recommendations (Jimenez & Parra, 1991).

Calcium carbonate effects K availability, which is decreased due to an increase in K fixation (Mehdi & Ranjha, 1995). Chouhan (1980) studied K equilibria in calcareous soils of Pakistan and observed that fixation of applied K was increased as the level of $CaCO_3$ increased from 6 to 18%. Lime addition increased the CEC and pH of soil resulting in decreased quantity of available K (Magdoff & Bartlett, 1980). Sparks and Liebhardt (1981) found that K values increased with increasing K fertilization and liming in Kalmia soil, while Mehdi and Ranjha (1995) found that K fixation increased with the K fertilization but the percentage fixed was decrease. They further noted that fixation of applied K was more in fine soils than coarse textured soils. Keeping all this in view, present study was conducted to observe the effect of lime, K fertilization and texture on K availability in three soil series of Pakistan.

MATERIALS AND METHODS

A laboratory study was conducted to observe the effect of lime, K fertilization and texture on K availability, i.e. intensity (I), quantity (Q) and buffering capacity (Q/I) in three soil series viz., the Kotli, the Pindorian and the Wazirabad. Surface soil (0-15 cm) samples were collected, air-dried, ground and passed through a 2 mm sieve, thoroughly mixed and analysed (Table I). Two hundred grams of the processed soil from each series was added to 500 ml plastic beaker.

Table I. Physical and chemical characteristics of the soils

Soil series	Texture	pH_s	EC_e ($dS\ m^{-1}$)	$CaCO_3$ (%)	CEC ($cmol\ kg^{-1}$)
Kotli	Clay	7.49	1.67	0.54	31.54
Pindorian	Loam	7.82	1.47	0.83	12.31
Wazirabad	Sandy loam	7.73	1.21	0.34	7.23

Three levels of $CaCO_3$ i.e. 1, 5 and 10% and four rates of K i.e. 0, 50, 100 and 150 mg kg^{-1} soil in all possible combinations were studied in the three soil series following CRD with three replications. Potassium as K_2SO_4 and lime as $CaCO_3$ pure powder were applied. The soil samples, after the application of all the treatments were made wet with distilled water to field capacity and then air-dried. After air-drying to a constant weight, these samples were crushed and made wet again with distilled water in the same beakers and in this way three alternate wetting and drying cycles were completed. After this, samples were analyzed for water soluble K, Ca + Mg and 1 N NH_4OAc extractable K. Analyses were done according to the methods described by U.S. Salinity Lab. Staff (1954) and Moodie *et al*. (1959).

Intensity (activity ratio) was calculated by using formula: aK a $(Ca + Mg)^{1/2}$. The activity coefficients of K and Ca + Mg were determined by applying Debuy Huckle

2nd approximation. Quantity (Q) was calculated by subtracting soluble K from extractable K (1 N NH_4OAc). Buffering capacity (PBC) was calculated by the formula PBC = Q/I. Data were statistically analysed according to completely randomized design (Steel & Torrie, 1980).

RESULTS AND DISCUSSION

Effect of texture on Q, intensity (I) and Q/I of K in soil. The quantity of K increased but intensity decreased by increasing clay contents (Table II).

Table II. Quantity, Intesity and Buffering capacity of K in three Soil Series

Soil series	Quantity (mmol kg^{-1})	Intensity (mmol kg^{-1})	Buffering capacity
Kotli (fine)	5.292	3.506	152.294
Pindorian (medium)	2.500	3.983	40.745
Wazirabad (coarse)	1.404	6.917	19.511

PBC also increased with increasing clay contents of soil. The intensity is said to be less in clayey soil and more in sandy soils while quantity (Q) of K is considered more in clay soil probably due to more CEC and less in sandy soils due to less CEC. So texture has a direct effect on quantity and intensity of soil K (Sharma & Mishra, 1989; Subba Rao *et al*., 1991; Deshmukh & Khera, 1993).

Effect of K fertilization and $CaCO_3$ on quantity of K. The results (Table III) revealed that quantity (Q) of K increased with increasing level of K application and this effect was more prominent in fine textured soil (Kotli series). In fine and medium textured soils, application rate significantly increased the quantity of K while in coarse textured soil the difference of 100 and 150 mg kg^{-1} was non-significant. The results are in line with those of Deshmukh and Khera (1993). Calcium carbonate application significantly decreased the quantity of K in all the soil series most probably due to fixation of applied K, 1 and 5% $CaCO_3$ levels in Wazirabad (coarse soil), where these were non-significant. Similar results were reported by Johnston (1986). The interaction between $CaCO_3$ levels and K application rates was also significant in all the soil series. The minimum quantity of K was recorded in the combination of 10% $CaCO_3$ and 0 K application and maximum in 1% $CaCO_3$ and 150 K application rate in all the three soils. The values were greater in fine soil and minimum in coarse soil. Similar findings were reported by Jhonston (1986).

Effect of K fertilization and $CaCO_3$ on Intensity. The intensity of K (Table IV) increased significantly by the application of K and maximum values were noted at 150 mg kg^{-1} of application rates while increasing levels of $CaCO_3$ decreased the intensity significantly. An increase in the intensity of K may be due to increasing concentration of K in soil solution by the addition of K fertilizer while a decrease in intensity due to $CaCO_3$ might be due to an increase in the activity of Ca with the addition of $CaCO_3$ resulting a decrease in the intensity of K. Similar results were reported by Johnston (1986) and Deshmukh and Khera (1993). The K fertilization and $CaCO_3$ interaction was also significant in all the three soils. The maximum intensity was noted in the combination of 1% $CaCO_3$ and 0 K treatments in all the three soils. Similar results were reported by Deshmukh and Khera (1993).

Effect of K fertilization and $CaCO_3$ on buffering capacity. Buffering capacity of K gives a complete view of K status of a soil for its regular availability to plants. The results (Table V) indicated that buffering capacity increased by K fertilization up to 50 mg kg^{-1} in fine textured soil, 100 mg kg^{-1} in medium textured and 150 mg kg^{-1} in coarse textured soils.

Table III. Effect of K fertilizer and $CaCO_3$ on Quantity (m moles kg^{-1}) in the three soil series

K application	Kotli				Pindorian				Wazirabad			
Rates (mg kg^{-1} soil)	$CaCO_3$ (%)				$CaCO_3$ (%)				$CaCO_3$ (%)			
	1	5	10	Mean	1	5	10	Mean	1	5	10	Mean
0	3.9 g	3.2 h	2.8 h	3.3 d	1.8 eg	1.5 f	1.1 g	1.5 d	0.7 d	0.6 d	0.5 d	0.6 c
50	5.5 de	5.3 ef	4.9 f	5.2 c	2.3 d	2.1 de	2.0 e	2.1 c	1.6 abc	1.50 bc	1.4 c	1.5 b
100	6.3 abc	6.1 bc	5.9 cd	6.1 b	3.2 abc	3.1 bc	2.9 c	3.1 b	1.8 ab	1.7 abc	1.6 abc	1.7 ab
150	6.7 a	6.5 ab	6.4 ab	6.5 a	3.5 a	3.4 ab	3.1 bc	3.3 a	1.9 a	1.8 ab	1.8 ab	1.8 a
Mean	5.6 a	5.3 b	5.0 c		2.7 a	2.5 b	2.3 c		1.5 a	1.4 ab	1.3 b	

Table IV. Effect of K fertilizer and $CaCO_3$ on Intensity (m moles L^{-1}) in the three soil series

K application	Kotli				Pindorian				Wazirabad			
Rates (mg kg^{-1} soil)	$CaCO_3$ (%)				$CaCO_3$ (%)				$CaCO_3$ (%)			
	1	5	10	Mean	1	5	10	Mean	1	5	10	Mean
0	2.4 h	2.3 h	2.1 h	2.67 def	4.9 f	4.1 g	3.9 g	4.30 d	5.1 i	4.3 j	4.1 j	4.50 d
50	3.3 fg	3.1 fg	2.8 g	3.06 c	6.1 d	5.6 e	5.3 ef	5.67 c	7.3 fg	7.1 g	6.8 h	7.07 c
100	4.1 c	3.8 cd	3.6 de	3.83 b	7.1 bc	6.7 c	6.2 d	6.56 b	8.1 bc	7.7 de	7.5 ef	7.77 b
150	5.3 a	4.8 b	4.5 b	4.87 a	7.8 a	7.3 b	6.9 bc	7.33 a	8.8 a	8.3 b	7.9 cd	8.33 a
Mean	3.77 a	3.43 b	3.25 c		6.47 a	5.93 b	5.76 c		7.33 a	6.85 b	6.58 c	

Table V. Effect of K fertilizer and $CaCO_3$ on Buffering capacity in the three soil series

K application	Kotli				Pindorian				Wazirabad			
Rates (mg kg^{-1} soil)	$CaCO_3$ (%)				$CaCO_3$ (%)				$CaCO_3$ (%)			
	1	5	10	Mean	1	5	10	Mean	1	5	10	Mean
0	6.625 d	139.1 f	133.3 g	145.0 c	36.7 d	36.6 d	28.2 e	33.8 c	13.7 d	14.0 d	11.0 e	12.9 c
50	166.7 c	171.0 b	175.0 a	170.8 a	37.7 d	37.5 d	37.7 d	37.7 b	21.9 abc	21.3 bc	20.6 c	21.3 b
100	153.7 e	160.5 d	163.9 d	158.7 b	45.1 bc	47.3 ab	46.8 a	46.0 a	22.2 ab	22.1 ab	21.3 bc	21.9 ab
150	126.4 h	135.4 g	142.2 f	134.7 d	44.9 c	46.6 b	44.9 c	45.5 a	21.6 abc	21.7 abc	22.8 a	22.0 a
Mean	152.3 ab	151.5 b	153.1 a		41.1 b	41.7 a	39.4 a		20.9 a	19.7 b	18.9 b	

The effect of $CaCO_3$ was inconsistent on buffering capacity. With increase in K application rates, the amount of K in soil although increased yet the supplying power of the soil remained inconsistent. York *et al*. (1953) also observed that there was little increase in quantity, and potential buffering capacity on K fertilization to calcareous soils. The interaction between K fertilization and $CaCO_3$ was significant. However, the results were inconsistent in all the three soils series. At each rate of K application, the results were non significant on all $CaCO_3$ levels. Verma and Verma (1970) also reported similar types of results. While Nafady and Lamm (1973) showed that quantity/intensity relations were unaffected by addition of K up to 1000 kg ha^{-1} and by fixation of K up to 6000 kg ha^{-1}.

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