

FORMS AND AVAILABILITY OF K IN THE MEDIUM TEXTURED ALLUVIAL SOILS OF ARID RAJASTHAN

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ABSTRACT

The potential and available forms of potassium were studied in medium textured alluvial soils in south-eastern parts of arid Rajasthan. The soils had better contents of potential and available forms but the potassium saturation percentage was lower than that in the dune and interdunal soils. Correlation of soil parameters and multiple regression analyses with different forms of K revealed that various soil parameters better accounted for the variabilities in available forms than for the potential forms of K. The dynamic relation between various forms has been discussed.

INTRODUCTION

Vast area of dominantly alluvial soils occurring in south-eastern part of arid Rajasthan is characterised by the medium and fine textured alluvial soils with occasional patches of salt affected soils. These have developed from alluvium derived from Aravalli rocks. Alluvial soils are generally considered adequate with respect to available potassium (Verma and Verma, 1968, and Ramamoorthy and Bajaj, 1969). Only a few reports are available on the potassium status of such soils in Rajasthan (Dutta and Joshi, 1983, Bhatnagar et al., 1973). Because of their occurrence in better rainfall zone (250-500 mm) and availability of ground water for irrigation, these form a part of agriculturally potential zone in the arid region of Rajasthan. In the present study attempts have been made to characterise these soils with respect to the forms and availability of potassium.

MATERIAL AND METHODS

Twenty two representative surface soils and five profile soil sample in the medium textured alluvial plain area were collected from different locations in Barmer, Jodhpur Pali, Nagaur and Ganganagar districts having annual rainfall between 250 to 450 mm. The soils samples were processed and analysed for soil colour, pH_2 and EC_2 . Cation exchange capacity, particle size distribution, calcium carbonate and organic carbon contents were determined following standard methods.

Soils were analysed for potential and available forms of potassium i.e. total (semi-micro digestion method, Jackson, 1967), Con. HCl Soluble K (Piper, 1950), 1 N HNO_3 soluble K (Wood and De-Turk, 1941), NH_4OAC -K (Hanway and Heidal

1952), cold H_2SO_4 -K (Hunter and Pratt, 1957), 3 N HCl and 0.75 N HCl K (Jaworski and Barber, 1959), $NaHCO_3$ -K (Olsen et al., 1954, and water soluble K (MacLean, 1961), in surface and profile soil samples from different sites.

RESULTS AND DISCUSSION

Physico-chemical characteristics and organic carbon content of these soils are reported in Table 1. The pH_2 variation from 7.5 to 9.2 indicated alkaline range. The EC_2 values varied from 0.15 to 0.39 and, in seven soils, from 8.3 to 15.3 dSm^{-1} indicating that first group was non-saline but second group had high salinity. The $CaCO_3$ content varied from traces to 41.3 per cent and 50 per cent samples were moderately calcareous (2-10% $CaCO_3$) whereas another 25 per cent highly calcareous. The organic carbon content of seven soils was very low (<0.02%) whereas another fourteen samples had slightly higher (0.2-0.49%) values. The cation exchange capacity of these soils ranged from 7.2 to 29.2 with mean value of 12.5 C. mol (P⁺) Kg^{-1} .

These soils varied from loamy sand to loam in texture. The clay and silt content varied from 4.9 to 20.2 and 5.2 to 25.5 per cent respectively. These soils varied in colour from grayish brown to brown and dark brown. (USDA, 1975) and have been classified as calciorthids/Camborthids.

Profile distribution of K

Total and NH_4OAC -K were uniformly distributed with depth in all the profiles (Fig. 1). The fixed K was irregular in distribution in Asop, Panchroli and Parbatsar. While in Bhopalgarh and Khajwan profile the distribution was irregular. The distribution of HNO_3 K was uniform in Asop and Panchroli, decreased in Parbatsar and irregular in Bhopalgarh and Khajwan profile.

Distribution of K in surface soils

The contents of forms of potassium and K saturation per cent are reported in Table 2. The HCl K varied from 42.5 to 300 mg with the mean of 100.5 mg $100 g^{-1}$. These values are comparable with the alluvial soils (77.5 to 350 mg, Dutta and Joshi 1983) but were higher than those obtained for dune and interdunal soils (45.8 mg $100 g^{-1}$, Dutta and Joshi, 1989). Only 10 to 18 per cent of total K has been recovered in the HCl extract which was quite low than the value of Punjab (30%, Kanwar and Grewal, 1966) and Uttar Pradesh soils (23-30%, Singh and Ram, 1976). The HNO_3 soluble and fixed potassium, respectively, ranged from 16.0 to 110 mg and 6 to 93 mg $100 g^{-1}$. The values of fixed K content were quite low when compared with the medium black soils of Rajasthan (110 mg, Bhatnagar et al., 1973), Punjab (117.6 mg, Kanwar and Grewal, 1966) and Bihar (134.3 mg Tiwari et al., 1967). However, compared to the dune and interdunal soils (Dutta and Joshi, 1989) these soils contained higher amounts

Table 1. Physico-chemical characteristics and particle size distribution of the medium textured alluvial soils

Location	pH ₂	EC ₂ (dS m ⁻¹)	CaCO ₃ (%)	Organic carbon (%)	CEC (C mol (P+) kg ⁻¹)	Mechanical separates (%)		
						Clay	Silt	Fine sand
Tilwara-A	8.0	0.37	4.1	0.165	12.2	13.8	15.0	63.3
Tilwara-B	7.8	0.21	5.8	0.229	17.4	13.3	11.6	65.3
Rakhi-A	7.7	15.30	0.3	0.394	6.9	4.8	10.0	65.3
Siyali	8.0	10.28	2.6	0.274	7.2	9.8	8.3	50.6
Dabli-A	8.2	8.99	10.1	0.227	8.8	17.3	10.1	46.2
Dabli-B	8.2	8.63	20.0	0.197	7.8	11.5	19.1	34.0
Khandap-A	8.2	8.63	22.1	0.157	10.5	13.1	10.8	38.0
Khandap-B	8.2	8.32	23.6	0.121	9.7	12.3	5.7	36.0
Rakhi-B	7.7	8.42	1.1	0.075	8.7	17.1	15.8	56.2
Karmabas	7.3	0.28	41.3	0.006	9.1	8.1	12.5	34.9
Newai	8.5	0.15	10.1	0.131	11.3	10.6	20.0	51.3
Motisar	8.2	0.20	2.2	0.409	8.5	14.8	25.5	50.3
Gajsinghpura	8.9	0.22	7.4	0.314	11.5	20.2	20.4	40.1
Asop	9.2	0.39	4.5	0.314	12.6	17.8	18.7	24.4
Pipar	8.4	0.08	1.2	0.181	9.5	12.0	11.2	50.7
Murdabas	7.6	0.14	4.5	0.490	29.2	15.1	14.9	57.0
Chandawal	7.5	0.15	0.0	0.309	7.5	6.5	12.5	40.5
Jaitaran	7.3	0.15	0.0	0.281	16.0	8.1	18.3	44.5
Pali	7.8	0.20	3.3	0.329	20.2	13.0	15.5	51.8
Kharachi	7.5	0.10	0.0	0.448	11.7	6.5	13.3	39.4
Parbatsar	8.1	0.14	0.0	0.166	12.7	8.9	5.3	83.4

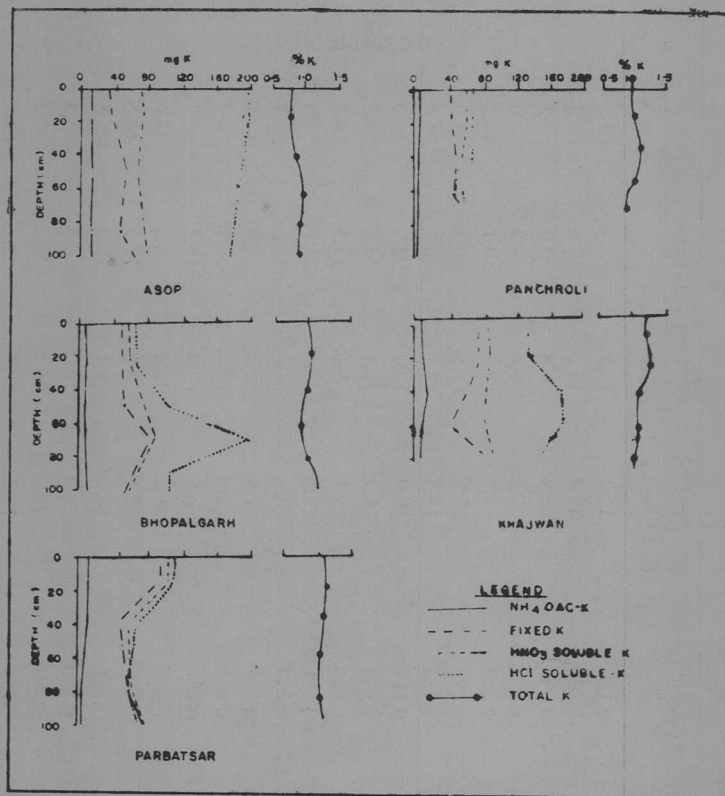


Fig. 1. PROFILE DISTRIBUTION OF FORMS OF POTASSIUM IN MEDIUM TEXTURED SOILS

which was due to the higher silt and clay content. The HNO_3 soluble and fixed K was inversely related with CaCO_3 ($r = -0.544 - 0.597$, $P = 0.01$). The $\text{NH}_4\text{OAC-K}$ showed narrow range of 13.4 to 40.0 mg 100 g^{-1} and the mean values were higher than those observed for dune, inter-dune soils (Dutta and Joshi, 1989). The HCl, HNO_3 and $\text{NH}_4\text{O AC}$ soluble forms of potassium were not significantly related with the studied soil attributes. Among different forms fixed K was more variable followed by $\text{NH}_4\text{OAC-K}$.

The K saturation per cent in these soils ranged between 0.2 to 10.4 with the mean value of 2.2. These values were low than the dune interdunal soils (5%, Dutta and Joshi, 1989) and soils of Jodhpur region (5.1 to 9.9% Joshi et al., 1978). The fluctuations in the K saturation per cent between 2 to 5 do not seriously affect the ability of soil to release K for crop growth. The soils in the present study were marginal in this respect. The K saturation per cent values were not related with the soil attributes but showed significant positive relationship with $\text{NH}_4\text{O AC-K}$ ($r = 0.799$, $P = 0.01$). Significant correlations of $\text{HNO}_3 - \text{K}$ with the fixed and NH_4OAC

Table 2 : Forms of K ($\text{mg } 100\text{g}^{-1}$ soil) in medium textured alluvial soils

Location	K soluble in				K saturation (%)
	HCl	HNO ₃	NH ₄ OAC	Fixed	
Tilwara-A	170.0	103.0	9.5	93.5	1.0
Tilwara-B	130.0	100.0	7.5	92.5	0.2
Rakhi-A	138.7	51.0	7.2	43.8	2.1
Siyali	115.0	24.5	4.7	19.8	1.3
Dabli-A	67.5	30.0	7.5	22.5	1.9
Dabli-B	61.2	6.0	3.5	12.5	1.2
Khandap-A	92.5	19.5	5.0	14.0	0.7
Khandap-B	97.5	17.5	6.5	11.0	0.9
Rakhi-B	212.5	101.0	21.5	79.5	0.5
Karmabas	45.0	13.5	8.0	5.5	1.5
Newai	105.0	30.0	20.0	10.0	4.3
Motisar	300.0	58.0	9.0	49.0	1.9
Gajsinghpura	50.0	26.5	12.7	13.8	2.7
Asop	105.0	58.5	11.7	46.8	2.0
Pipar	112.5	110.0	40.0	79.0	10.4
MurJabas	85.0	20.0	18.5	1.5	1.4
Char.dawal	62.5	80.0	15.5	64.5	2.5
Jaitaran	70.0	90.0	28.5	61.5	4.0
Pali	95.0	61.0	23.0	38.0	2.4
Kharchi	120.0	103.0	21.5	81.5	3.3
Parbatsar	42.5	51.0	6.0	45.0	1.8
Ganganagar	115.0	93.0	6.2	86.8	0.4
Mean	100.1	53.3	13.0	44.2	2.2
CV (%)	57.0	66.0	68.0	71.1	96.0

soluble K ($r = 0.824$, $P = 0.01$ and $r = 0.430$, $P = 0.05$) indicated equilibrium between these forms. These observations are in agreement with Joshi et al. (1978).

The multiple regression analysis of soil parameters on the forms of potassium (Table 3) revealed the negative influence of CaCO_3 on HNO_3 and NH_4OAC extractable and fixed potassium. All the soil parameters together gave better predictability for HNO_3 -K (57.3%) than the fixed, NH_4OAC and HCl soluble potassium (39.7 to 44.8%).

The available K extracted by H_2SO_4 , 0.75 N HCl, NaHCO_3 and water are reported in Table 4. The H_2SO_4 -K ranged from 4.0 to 47.0 mg with mean value of 17.4 $\text{mg } 100^{-1}$. The H_2SO_4 -K furnishes best index of the release of non exchangeable K during cropping (Hunter and Pratt, 1957). In our studies H_2SO_4 -K was negatively correlated with CaCO_3 ($r = -0.448$, $P=0.05$). Similarly, Negi et al. (1981) reported inverse relationship of this fraction with CaCO_3 . The 3 N HCl-K ranged between 8.0 to 70.0 mg with mean value of 22.7 $\text{mg } 100 \text{ g}^{-1}$. This fraction of K was positively related with clay and silt ($r = 0.548$, 0.482 , $P = 0.01$). The 0.75 N HCl-K

Table 3. Multiple regression analysis relating forms of K with soil parameters in medium textured alluvial soils
(Equation $Y = a + b x_1 + c x_2$)

Dependent variable	Intercept		Coefficient (r) for independent variable										R ² (%)
	(C)		Clay	Silt	CEC	Organic carbon	CaCO ₃	K(%)	pH	Fine sand			
HCl-K	344.1		3.83 (3.62)	4.23 (2.95)	-4.82 (2.90)	122.68 (16.9)	-0.99 (1.53)	-	-34.8 (33.8)	1.44 (1.25)		39.7	
HNO ₃ -K	253.2		0.59 (1.81)	1.28 (1.48)	0.069 (1.46)	-157.15 (81.2)	-2.1* (0.77)	-	-22.14 (16.90)	0.16 (0.63)		57.3	
NH ₄ OAC-K	49.8		-1.08 (0.54)	0.47 (0.44)	0.51 (0.44)	-44.8 (24.3)	-0.59** (0.23)	-	-0.49 (5.08)	-0.31 (0.18)		44.8	
Fixed-K	76.4		0.007 (1.51)	0.349 (1.97)	-0.054 (1.32)	-80.6 (70.9)	-2.00** (0.65)	-0.11 (3.14)	-	-		43.6	

* Figures in parentheses denote CV; significance : * at 5%, ** at 1%

Table 4. Available K ($\text{mg } 100\text{g}^{-1}$) in medium textured alluvial soils

Location	K extracte by				
	H_2SO_4	3 N HCl	0.75N HCl	NaHCO_3	H_2O
Tilwara-A	42.0	31.0	8.5	13.0	4.5
Tilwara-B	31.0	26.0	6.7	18.0	6.0
Rakhi-A	10.5	19.5	24.3	20.0	1.6
Siyali	10.5	19.0	15.4	6.5	1.0
Dabli-A	6.0	13.0	19.5	6.0	1.0
Dabli-B	4.0	11.5	15.4	5.0	2.5
Khandap-A	12.5	11.5	10.5	5.5	2.0
Khandap-B	8.5	8.0	15.6	5.5	3.0
Rakhi-B	47.0	39.0	22.9	10.0	4.5
Karmabas	4.5	26.0	19.2	7.5	2.5
Newai	6.0	22.0	6.0	13.0	1.0
Motisar	30.0	70.0	4.5	14.0	2.6
Gajsinghpur	11.0	25.0	7.2	8.0	0.6
Asop	10.5	14.0	7.9	8.5	1.7
Pipar	8.5	14.0	19.5	6.5	2.2
Murdabas	14.5	15.0	9.0	6.5	2.2
Chandawal	19.5	13.0	27.0	7.5	8.0
Jaitaran	14.5	14.0	25.1	10.0	3.5
Pali	38.5	15.0	7.9	12.5	4.0
Kharchi	16.0	28.0	36.0	15.5	6.5
Parbatsar	20.0	9.0	17.2	4.5	7.0
Ganganagar	18.0	62.0	4.5	17.0	2.5
Mean	17.4	22.9	14.9	10.0	3.2
CV of (%)	72.0	69.0	57.0	46.0	65.0

varied from 4.5 to 36.0 mg with mean value of $14.9 \text{ mg } 100 \text{ g}^{-1}$. This fraction of K was negatively related with pH, clay and silt ($r = -0.599, -0.565, -0.433$). The 0.75 N HCl extracted less amount than 3 N HCl. In alluvial soils of Agra, Prakash and Singh (1986) also reported similar range of 0.75 N HCl-K ($55 \text{ to } 180 \text{ mg } 100 \text{ g}^{-1}$) and observed good correlation with plant uptake and relative yield of wheat. The K extracted by NaHCO_3 varied from 4.5 to 20.0 mg with mean value of $10 \text{ mg } 100 \text{ g}^{-1}$ and did not show significant correlation with any of the studied soil attributes. The water soluble K varied from 0.6 to 8.0 mg with mean value of $3.2 \text{ mg } 100 \text{ g}^{-1}$. Water soluble K was negatively correlated with pH ($r = -0.479$). Our values are comparable to the values reported for other arid soils ($0.2 \text{ to } 5.2 \text{ mg } 100 \text{ g}^{-1}$; Joshi et al., 1978) and Karnataka soils ($0.7 \text{ to } 3.9 \text{ mg } 100 \text{ g}^{-1}$; Kalbande and Swamynath 1976). Limited correlation with soil attributes indicated that the amount of K present in soil solutions was independent of soil factors. Coefficient of variation values indicated more variability in H_2SO_4 , 3 N HCl and water soluble K (72, 69, 65 per cent) than in NaHCO_3 -K (46.0%).

Thus the amount of K extracted by different solution varied widely and was in the decreasing order : 3 N HCl, H₂SO₄, NaHCO₃, 0.75 N HCl and water. Prakash and Singh (1986) also observed similar order of extraction when compared with the dune and interdune soils, the medium textured soils generally contained slightly higher amount of available K. According to limit of Muhr et al. (1963) these soils had medium to high status of potassium.

There was significant correlation of HNO₃-K with H₂SO₄-K; H₂SO₄-K with 3 N HCl (r = 0.418) and water soluble K (r = 0.500) and 3 N HCl-K with NaHCO₃ soluble K (r=0.560). Fixed K was correlated with H₂SO₄-K (r=0.605) and NaHCO₃ K (r=0.549). These observation suggested that HNO₃ soluble and fixed forms of potassium contributed to the available pool. The regression of forms of K on fixed K given below explained 88.9% variation in fixed K and thus indicated contribution to the available K as measured by different extractants :

$$\begin{aligned} \text{Fixed K} = & - 31.4 + 1.9 \text{ KSP} - 0.48 \text{ NH}_4\text{OAC} + 0.56 \text{ HNO}_3 \\ & + 0.12 \text{ H}_2\text{SO}_4 - 0.08 \text{ HCl} + 0.34 \text{ 3N HCl} + 0.76 (0.75 \text{ N}) \\ & \text{HCl} + 1.59 \text{ NaHCO}_3 + 3.79 \text{ water [R}^2 \text{ (\%)} = 88.9 \text{]} \end{aligned}$$

Multiple regression analysis (Table 5) revealed that 3 N HCl K was significantly and positively influenced by clay, silt, organic carbon and fine sand and negatively by CEC and pH. While 0.75 N HCl K was negatively influenced by CEC, fine sand, CaCO₃ and pH. The NaHCO₃-K was also positively influenced by the fine sand fraction. The water and H₂SO₄ soluble K were not influenced significantly by the soil parameters and thus the K solubility by these extractants could be considered independent of the soil parameters. All the soil parameters accounted much better for variability in 3N HCl and 0.75 N HCl soluble K (80.6% and 76.5%) than in H₂SO₄, NaHCO₃ and water soluble forms of K (43.6 to 49.2%).

It is inferred that the medium and fine textured alluvial soils contained slightly higher values of potential and available forms of potassium than the dune and interdunal soils. However the K saturation % was less in these soils. Different soil parameters accounted for low variability in the potential than the available forms of potassium. There was dynamic equilibrium between the potential and available forms of this nutrient.

Table 5. Multiple regression of soil attributes on the available forms of K in medium textured alluvial soils
(Equation $Y = a + x_1 + Cx_2 + dx_3$)

Dependent variable	Intercept	Coefficient of independent variable								R ² (%)
		pH	organic carbon	CaCO ₃	Clay	Silt	Fine sand	CEC		
H ₂ SO ₄ -K	97.1	-12.9 (6.56)	-13.9 (13.4)	-0.39 (0.29)	0.61 (0.70)	0.48 (0.57)	0.33 (0.24)	-0.01 (0.56)		49.2
3N HCl-K	71.9	-16.4** (5.1)	61.6* (24.8)	0.19 (0.23)	2.43** (0.55)	1.51** (0.45)	0.56* (0.14)	-1.27* (0.45)		80.2
0.75N HCL K	140.6	-11.03** (3.05)	-8.24 (74.6)	-0.43** (0.14)	0.07 (0.33)	0.50 (0.27)	-0.32* (0.11)	-0.78* (0.26)		76.5
NaHCO ₃ -K	11.04	- 3.03 (2.47)	19.05 (11.8)	0.035 (0.11)	0.300 (0.265)	0.3160* (-216)	0.215* (0.091)	.0 1 (.212)		47.5
Water K	22.80	- 2.06 (1.16)	- 5.36 (5.54)	-0.09 (0.05)	-0.04 (0.12)	-0.03 (0.10)	-0.005 (.04)	0.03 (0.09)		43.6

*Significant at 5% **Significant at 1%

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