

Studies on forms of Potassium and Nutrients status of soil in central and Eastern Vidarbha region of Maharashtra

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Forms of potassium, nutrients status and their interrelationship with total and available nutrient were investigated in forty-five soil samples representing fourteen profiles from five districts (Typic Haplusterts) of Central and Western Vidarbha region of Maharashtra. The available, water soluble, exchangeable, non exchangeable and lattice K contributed 1.97, 0.12, 1.88, 11.25 and 86.76 per cent towards total soil K in the given soils. The soils of Wardha, Nagpur, Chandrapur and Bhandara districts were slightly calcareous neutral to alkaline in reaction and the soils of Gondia district were non calcareous and slightly acidic in reaction. The Central Vidarbha soils are clay in texture having high CEC and organic carbon content. Where as the soils of Eastern Vidarbha are clay loam, sandy clay loam, low in CEC and organic carbon content. No definite trend was observed in the forms of potassium except exchangeable and available K they are decreased with increase in depth. The available K, exchangeable K, total K and lattice K, influenced by total N ($r=0.3268^*$, $r=0.3122^*$, $r=0.2950$, $r=0.3079^*$) respectively. The available K and exchangeable K is also affected by available N ($r=0.9784^{**}$, $r=0.9773^{**}$) respectively, in Vidarbha region. In Central Vidarbha available and exchangeable K influenced by total and available N respectively. In eastern Vidarbha the available K and exchangeable K influenced by total S and available N.

Key words : Forms of soil K, Soil depth, Relationship with total and Available nutrients.

INTRODUCTION

Soil potassium is believed to exist in dynamic equilibrium in four forms, viz... water soluble, exchangeable, non-exchangeable and lattice K, of which the first two are important for the growth of higher plants and microbes. The various forms of potassium in soil exist in equilibrium with one another and depletion of one form is replenished by other forms (Chandel *et al.*, 1976). The release of K from a soil depends on the interaction of soil properties and thus, all the forms of this nutrient present in soil and relationships with soil nutrients. Studies were carried out on these aspects in typic haplusterts of Central and Eastern Vidarbha Region of Maharashtra.

MATERIALS AND METHODS

The fourteen soil profiles were collected from Central and Eastern Vidarbha region. Eight profile samples were collected from Nagpur, two from Wardha, two from Chandrapur, one each from Bhandara and Gondia district as per the procedure laid down by Piper (1996). The soil samples were analysed for their particle size distribution by international pipette method, calcium carbonate and exchangeable K by standard method of Piper (1996) pH, EC (1:2.5), organic carbon, CEC, Total N, available P, K

and S by the procedure of Jackson (1967). Available N estimated by Subbiah and Asija (1956) total P and K estimated by Hesse (1971), total S by Chopra and Kanwar (1976), non exchangeable K by Wood and De Turk (1941), water soluble K determined by Dhawan *et al.*, (1968) and lattice K by Ranganathan and Satyanarayana (1980). Statistical analysis involved simple correlations between forms of potassium and soil properties as per the procedure of Panse and Sukhatme (1978).

RESULTS AND DISCUSSION

Total and available major nutrient status of soil:

The results showed the higher availability of total N,P,K and S (Table 1) in all the profiles. The total N,P,K and S ranged from 0.022-0.103, 0.011-0.090, 0.2250.90 and 0.0109-0.084 per cent. The availability of total N,P,K and S decreases with an increase in depth of the soil. This might be related to the higher values of organic form of these nutrients in this layer. The results are in conformity with Trivedi *et al.*, (2000). In Central and Eastern Vidarbha there is no trend of increase or decrease of total N,P,K and S except total P and S in Central Vidarbha it is consistently decreased with increase in depth. The alkaline permanganate extractable N in surface and subsurface of soil ranged from 218.4-430.08 and 100.8-378.06 kg ha⁻¹.

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Table 1 : Total and available nutrient status of soil.

Depth (cm)	Available major nutrients (kg ha ⁻¹)				Total major nutrients (%)			
	N	P	K	S	N	P	K	S
Regional Fruit Research Station Farm, Katol Dist. Nagpur								
0-20	306.10	23.60	496.80	38.75	0.094	0.067	0.775	0.0512
20-50	218.05	20.00	437.90	34.49	0.088	0.067	0.825	0.0476
50-80	141.10	14.00	440.00	36.73	0.077	0.054	0.900	0.0466
80 & above	163.80	12.00	322.70	42.78	0.056	0.017	0.900	0.0366
Department of Botany Farm, Nagpur								
0-20	218.40	24.35	308.00	26.21	0.043	0.024	0.500	0.0512
20-50	188.20	25.40	252.00	29.19	0.031	0.017	0.400	0.0476
50-80	100.80	23.60	252.00	24.19	0.029	0.017	0.487	0.0183
Botanical garden Farm, Phutala (Deep black soil), Dist Nagpur								
0-20	290.70	21.50	420.00	25.09	0.065	0.090	0.250	0.0366
20-50	315.80	16.25	411.00	27.33	0.050	0.058	0.225	0.0183
50-80	336.00	11.00	392.00	26.21	0.049	0.054	0.225	0.0109
College of Agriculture Farm, Nagpur								
0-20	393.10	19.65	388.00	35.39	0.072	0.034	0.475	0.0439
20-50	378.06	14.82	364.00	43.01	0.067	0.027	0.400	0.0256
50-80	342.65	15.12	280.00	36.23	0.058	0.018	0.525	0.0183
C.I.C.R.Panjri Farm (Deep black soil), Dist. Nagpur								
0-20	423.35	25.21	336.00	29.79	0.102	0.035	0.475	0.0439
20-50	302.40	15.75	268.00	39.20	0.050	0.024	0.400	0.0256
50-80	262.05	12.58	246.40	28.0	0.050	0.013	0.252	0.0183
C.I.C.R.Panjri Farm (Medium black soil), Dist. Nagpur								
0-20	403.2	36.55	392.00	29.79	0.091	0.035	0.550	0.0402
20-50	372.95	28.70	296.80	33.60	0.065	0.016	0.500	0.0366
50-80	268.80	17.20	257.60	28.45	0.052	0.013	0.475	0.0256
C.I.C.R.Panjri Farm (Shallow black soil), Dist. Nagpur								
0-20	337.60	16.41	268.80	29.79	0.103	0.044	0.600	0.0356
20-50	203.20	9.46	201.60	32.93	0.078	0.011	0.575	0.0183
Agricultural Research Station Farm, Tharsa, Dist. Nagpur								
0-20	427.80	28.00	223.30	31.81	0.077	0.064	0.675	0.0842
20-50	269.50	15.30	110.10	33.15	0.047	0.056	0.700	0.0366
50-80	250.85	13.15	156.80	33.60	0.045	0.041	0.700	0.0356
80 & above	189.90	13.90	142.80	22.40	0.043	0.015	0.676	0.0293
Agricultural Research Station Farm, Kutki, Dist. Wardha								
0-20	313.64	9.86	354.25	19.94	0.096	0.070	0.675	0.046
20-50	194.04	7.75	290.00	19.49	0.085	0.038	0.700	0.036
Agricultural Research Station Farm, Selsura, Dist. Wardha								
0-20	347.20	16.12	612.00	21.50	0.0748	0.047	0.375	0.038
20-50	302.40	11.25	556.00	20.83	0.0650	0.051	0.425	0.031

Contd... ..

Table 1 Contd.....

Depth (cm)	Available major nutrients (kg ha ⁻¹)				Total major nutrients (%)			
	N	P	K	S	N	P	K	S
50-80	179.20	9.25	586.00	21.28	0.0595	0.031	0.375	0.029
Agricultural Research Station Farm, Ekarjuna, Dist. Chandrapur								
0-20	336.10	14.38	273.20	21.50	0.096	0.028	0.650	0.0546
20-50	330.20	12.50	273.10	21.95	0.055	0.028	0.750	0.0539
50-80	235.20	9.41	149.70	21.28	0.039	0.019	0.750	0.0545
80 & above	168.05	7.48	123.80	21.06	0.096	0.016	0.800	0.0450
Agricultural Research Station Farm, Sindewahi, Dist. Chandrapur								
0-20	235.20	15.25	410.00	19.71	0.0470	0.032	0.750	0.0528
20-50	199.20	13.30	393.70	19.26	0.0306	0.019	0.725	0.0420
50-80	123.30	10.77	341.00	17.92	0.0215	0.019	0.700	0.0180
Agricultural Research Station Farm, Sakoli, Dist. Bhandara								
0-20	246.42	19.96	506.50	19.94	0.0974	0.080	0.825	0.0419
20-50	213.32	16.80	449.20	21.06	0.0925	0.080	0.825	0.0380
50-80	148.54	13.44	404.10	20.83	0.0896	0.078	0.825	0.0290
80 & above	126.22	12.32	301.10	20.16	0.0866	0.078	0.850	0.0160
Agricultural Research Station Farm, Hiwara, Dist. Gondia								
0-20	293.21	21.40	325.97	19.26	0.067	0.087	0.725	0.048
20-50	241.47	17.80	319.70	19.27	0.058	0.076	0.725	0.039
50-80	189.72	13.08	319.70	18.82	0.050	0.054	0.500	0.034
80 & above	137.98	09.51	307.16	18.14	0.028	0.054	0.450	0.0335

The sodium bicarbonate extractable P in surface and subsurface of soil ranged from 9.86-36.55 and 7.48-28.70 kg ha⁻¹. The neutral normal ammonium acetate extractable K in surface soil ranged from 110.10-586.00 kg ha⁻¹ this showed very low to very high availability of NPK in these soils. In surface soil the availability of these nutrients were higher. It was observed that, the soils of Vidarbha are low to medium in KMnO₄-N, medium in NaHCO₃ -P and very high in NH₄OAc-K alkaline. The availability of N and K decreased with the increase of depth, while the availability of P just slightly and slowly decreased with the depth. The available S ranged from 17.26-43.01 kg ha⁻¹ in profile samples and in control surface samples it ranged from 19.26-38.75 kg ha⁻¹. The highest S being recorded in Katol district Nagpur soil and lowest in Sindewahi soil. It is observed that, the soils of Central Vidarbha are low to medium in available S and soils of Eastern are very low to low medium in available S and soils of Eastern Vidarbha are very low to low in available sulphur.

Forms of potassium :

The total K content in profiles of central Vidarbha soils ranged from 2333.3 to 9000 mg kg⁻¹ (Table 2). The maximum content of total K in surface and subsurface soil in Katol soil and minimum in Phutala soil of Nagpur district. In eastern Vidarbha total potassium in profile ranged from 4500 to 8250 mg kg⁻¹ and in surface soil it ranged from 7250 to 8250 mg kg⁻¹. This value of total potassium is slightly higher than the range 1900 to 5500 mg kg⁻¹ reported by Deshmukh *et al.*, (1991) of Vidarbha soil. Definite trend of distribution of total K was not observed in profiles possibly because of active pseudoturbation process operating in pedons (Raskar and Pharande, 1997). The mineral potassium is bound within the crystal structure of soil mineral particles but it holds between adjacent tetrahedral layer of micas, Vermiculites and integrate clay minerals (Sparks, 1987). The contents of lattice K in soil profile ranged from 1783.52-8181.9 mg kg⁻¹ and in surface soil it ranges from 2121.93-7478.5 mg kg⁻¹. The maximum content of lattice K was observed

Table 2 : Distribution of forms of potassium (mg kg⁻¹) in the soil profile

Depth (cm)	Available K	Water soluble K	Exchangeable K	Non Exchangeable K	Total K	Lattice K
Regional Fruit Research Station Farm, Katol Dist. Nagpur						
0-20	92.00	7.4	84.6	653.25	7750	7004.74
20-50	97.34	6.5	90.86	738.91	8250	7413.75
50-80	62.99	6.5	56.46	755.11	9000	8181.90
80 & above	73.125	5.5	67.63	749.57	9000	8177.30
Mean	81.36	6.5	74.89	724.21	8500	7694.42
Department of Botany Farm, Nagpur						
0-20	97.50	7.4	90.1	669.00	5000	4233.5
20-50	84.01	7.3	76.7	498.00	4000	3417.99
50-80	45.00	6.5	38.5	813.50	4875	4016.5
Mean	75.50	7.1	68.5	660.17	4625	3889.33
Botanical garden Farm, Phutala (Deep black soil), Dist Nagpur						
0-20	129.77	3.7	126.07	242.30	2500	2127.9
20-50	140.98	3.7	137.28	325.50	2250	1783.5
50-80	150.00	4.5	145.50	242.60	2250	1857.4
Mean	140.25	3.97	136.28	270.13	2333.3	1922.95
College of Agriculture Farm, Nagpur						
0-20	175.49	6.5	168.99	741.95	4750	3832.6
20-50	168.78	3.7	165.08	487.50	4000	3343.7
50-80	152.97	4.5	148.47	522.50	5250	4574.5
Mean	165.75	4.9	160.84	583.98	4666.66	3916.9
C.I.C.R.Panjri Farm (Deep black soil), Dist. Nagpur						
0-20	188.99	5.5	183.49	881.55	5000	3929.46
20-50	135.00	3.7	131.30	888.45	5500	4476.55
50-80	116.99	3.7	113.29	724.50	5750	4908.51
Mean	146.99	4.3	142.69	831.50	5416.66	4438.17
C.I.C.R.Panjri Farm (Medium black soil), Dist. Nagpur						
0-20	180.00	3.7	176.30	608.00	5500	4712.0
20-50	166.49	3.7	162.79	605.00	5000	4228.5
50-80	120.00	3.7	116.30	686.00	4750	3944.0
Mean	155.49	3.7	151.79	633.00	5083.33	4294.84
C.I.C.R.Panjri Farm (Shallow black soil), Dist. Nagpur						
0-20	150.71	10.15	140.56	490.00	6000	5359.29
20-50	120.00	12.05	107.95	478.36	5750	5151.64
Mean	135.36	11.10	124.26	484.18	5875	5255.47
Agricultural Research Station Farm, Tharsa, Dist. Nagpur						
0-20	190.98	3.7	187.28	528.12	6750	6030.89
20-50	120.31	3.7	116.61	510.07	7000	6369.66
50-80	111.98	3.7	108.28	509.80	7000	6378.22
80 & above	84.78	3.7	81.08	479.50	6750	6185.72

Contd.....

Table 2 Contd.....

Depth (cm)	Available K	Water soluble K	Exchangeable K	Non Exchangeable K	Total K	Lattice K
Mean	127.01	3.7	123.31	506.87	6875	6241.13
Agricultural Research Station Farm, Kutki, Dist. Wardha						
0-20	140.01	9.25	130.76	747.50	6750	5862.49
20-50	86.62	8.3	78.32	814.5	7000	6098.88
Mean	113.31	8.77	104.54	781.00	6875	5980.69
Agricultural Research Station Farm, Selsura, Dist. Wardha						
0-20	155.00	6.5	148.5	334.40	3750	3260.60
20-50	135.00	6.5	128.5	450.90	4250	3664.10
50-80	80.00	6.5	73.5	431.50	3750	3238.50
Mean	123.33	6.5	116.83	405.60	3916.67	3387.70
Agricultural Research Station Farm, Ekarjuna, Dist. Chandrapur						
0-20	150.04	12.95	137.09	942.50	6500	5407.46
20-50	147.41	12.05	135.36	879.50	7500	6473.09
50-80	105.00	13.85	91.15	807.50	7500	6587.50
80 & above	75.02	12.05	62.97	858.00	8000	7066.98
Mean	119.37	12.725	106.64	871.88	7375	6383.76
Agricultural Research Station Farm, Sindewahi, Dist. Chandrapur						
0-20	105.00	8.3	96.70	920.00	7500.00	6475.00
20-50	88.92	7.4	81.53	1020.50	7250.00	6140.57
50-80	55.02	9.25	47.77	1001.50	7000.00	5943.48
Mean	82.98	8.32	74.67	980.67	7250.00	6186.35
Agricultural Research Station Farm, Sakoli, Dist. Bhandara						
0-20	110.00	5.5	104.5	661.50	8250	7478.5
20-50	95.23	9.25	85.98	681.50	8250	7473.27
50-80	66.31	5.5	60.81	754.50	8250	7429.19
80 & above	54.34	9.25	45.09	876.00	8500	7569.66
Mean	81.47	7.375	98.79	743.38	83120.50	7487.66
Agricultural Research Station Farm, Hiwara, Dist. Gondia						
0-20	130.89	16.65	111.24	919.50	7250	6199.61
20-50	107.79	11.10	96.69	878.00	7250	6264.21
50-80	84.67	13.85	70.82	948.00	5000	3967.33
80 & above	61.60	12.05	49.55	776.00	4500	3661.9
Mean	96.23	13.41	82.825	880.50	6000	5023.26
Total Mean	117.45	7.30	111.91	668.36	5936.01	5150.19

in Katol soil and minimum in botanical garden, Phutala soil. This is might be due to conversion of lattice K into exchangeable K because of its leaching in slopy soil. The contribution of lattice K towards total potassium is 86.76 % in general and about 86.81 %, 86.67% in Central and Eastern Vidarbha region respectively. Similar results were recorded by Pharande and Sonar (1996). In Central

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Vidarbha lattice K ranged from 1783.52-8177.30 mgkg⁻¹ in soil profile s and in surface layer it ranges from 2121.3-7004.5 mg kg⁻¹. Similarly in Eastern Vidarbha it ranges from 3661.9-7478.5 mg kg⁻¹. It was noticed that the range of lattice K in Eastern Vidarbha region is narrow than Central Vidarbha.

The lowest and highest value of non-exchangeable

Table 3 : Correlation coefficient between forms of potassium and total and available major nutrients of soil in Vidarbha region.

Parameters	Avail.K	Water soluble K	Exch. K	Non Exch. K	Total K	Lattice K
Total N	0.3268*	0.0707	0.3122	-0.0256	0.2950	0.3079*
Total P	-0.0058	0.1110	-0.0135	-0.1079	0.1548	0.1769
Total S	0.2699	0.2058	0.2487	0.2635	0.3457*	0.3279*
Avail. N	0.9784**	-0.2825	0.9773**	-0.3251*	-0.3702*	-0.3748*
Avail. P	0.2235	-0.0646	0.2250	0.0427	-0.0241	-0.0358
Avail. S	0.3290*	-0.5466*	0.3668*	-0.2966*	-0.0500	-0.0246

K being in Phutala and Sindewahi soils respectively. It recorded from 242.3-1020.5 mg kg⁻¹ in soils with a mean value of 668.36 mg kg⁻¹. In Central Vidarbha the non exchangeable K range from 242.6-8885.45 mg kg⁻¹ in surface. While the range of non exchangeable K in Eastern Vidarbha region was quit higher in surface sample (661.5-942.5 mg kg⁻¹) and (661.5-1020.5 mg kg⁻¹) in profile sample. This could be related to abundance of K fixing minerals in heavy rainfall area of Eastern Vidarbha. This form of K also did not exhibit any characteristics trend with depth. The variation in depth wise distribution pattern of non exchangeable K might be due to changes in particle size distribution in various layers (Brar and Sekhon, 1987). This highest content of non exchangeable K in surface horizon was related to clay content, which could fix the K in soils, due to the presence of illitic and other 2:1 type clay minerals. The exchangeable K in general range from 84.6-187.28 mg kg⁻¹ in surface and 38.5-187.28 mg kg⁻¹ in profile with the mean of 111.91 mg kg⁻¹ and which is 1.88% of total K. Central Vidarbha it ranged from 84.6-187.28 mg kg⁻¹ in profile with a mean of 120.39 mg kg⁻¹ which is 2.22% of total K. However as compared to Central Vidarbha and general range, Eastern Vidarbha soil recorded lower content of exchangeable K (1.25%) towards total K. where as, its range in surface sample (96.7-137.09 mg

kg⁻¹) and profile sample (4.09-137.09 mg kg⁻¹) is very narrow. Similar results were recorded by Pal and Sekhon, (1991). This clearly indicates that exchangeable K in soils related to organic carbon content.

The average water soluble K in soil of Central Vidarbha is 3.7-10.15 mg kg⁻¹ in surface layer and 3.7-12.05 mg kg⁻¹ in profile with average mean of 6.048 which is 0.11% of total K while in Eastern Vidarbha region its range from 5.5-16.65 mg kg⁻¹ in surface layer and profile samples with a mean of 10.46 mg kg⁻¹ which is 0.14% of total K, which shows its negligible contribution in forms of K. The maximum mean of water soluble K was recorded in Ekarjuna (12.73 mg kg⁻¹ and minimum in Tharsa and Panjri, medium black soil 3.7 mg kg⁻¹). In clay soils water soluble K decreased with depth, while in sandy clay and clay loam it increased with depth. This was possible due to leaching of K from surface layer to the lower layers. Similar results were reported by Mishra *et al.*, (1993). The mean content of available K in Central Vidarbha region is highest (126.42 mg kg⁻¹) than Eastern Vidarbha (95.01 mg kg⁻¹) which is 2.33% and 1.3% respectively of total K. But the range of availability of total K is narrow in Eastern Vidarbha than Central Vidarbha considering 49.01 mg kg⁻¹ available soil K as the general critical limit for crops (Murthy and Hirekerur, 1980).

Table 4 : Correlation coefficient between forms of potassium and total and available major nutrients of soil in Central Vidarbha.

Parameters	Avail.K	Water soluble K	Exch. K	Non Exch. K	Total K	Lattice K
Total N	0.4628*	0.3352	0.4371*	0.1472	0.2799	0.2654
Total P	0.1299	-0.1119	0.1367	-0.3759	-0.0098	0.0241
Total S	0.1662	0.0301	0.1664	0.2969	0.4087*	0.3914
Avail. N	0.9638**	-0.3110	0.9654**	-0.1568	-0.3488	-0.3683
Avail. P	0.2951	-0.1166	0.3021	0.1846	-0.1066	-0.1357
Avail. S	-0.0909	-0.0172	0.0873	0.3273	0.4715*	0.4549*

Table 5: Correlation coefficient between forms of potassium and total and available major nutrients of soil in Eastern Vidarbha.

Parameters	Avail.K	Water soluble K	Exch. K	Non Exch. K	Total K	Lattice K
Total N	0.2658	-0.2016	0.2874	0.3044	0.3044	0.3552
Total P	0.0327	-0.6410	0.0391	0.1941	0.1941	0.2287
Total S	0.6683**	0.4091	0.6339**	0.1740	0.1740	0.1467
Avail. N	0.9999**	0.1249	0.9952**	-0.2066	-0.2066	-0.2053
Avail. P	0.1412	0.1182	0.1307	0.1251	0.1251	0.1151
Avail. S	0.4998*	-0.1376	0.5184*	0.0194	0.0194	0.0710

Correlation between forms of potassium and total and available nutrients :

The available K was significantly correlated with total ($r=0.9784^*$) and available ($r=0.9784$) nitrogen and available sulphur ($r=0.3290^*$) (Table 3). Similar results were found in Central Vidarbha, but in Eastern Vidarbha available K was positively significant with total sulphur ($r=0.6683^*$), available nitrogen ($r=0.9999^{**}$) and available sulphur ($r=0.4998^*$). With the increase in availability of sulphur the solubility of potassium in water decreases ($r=-0.5466^*$). Further water soluble K did not show any significant correlation with total and available nutrients in Central and Eastern Vidarbha region soil. Exchangeable K showed positively significant correlation with total nitrogen ($r=0.3122^*$), available nitrogen ($r=0.9773^*$) and available sulphur ($r=0.3668^*$). Similar results were also observed in Central Vidarbha and Eastern Vidarbha region of Maharashtra.

Non exchangeable K was significantly and negatively correlated with available nitrogen ($r=-0.3251^*$) and available sulphur ($r=-0.2966^*$). It showed significant and negative correlation with available sulphur ($r=-0.4721^*$) in Eastern Vidarbha soil. The total K and lattice K showed significant positive with total sulphur ($r=0.3457^*$, $r=0.3279^*$) and lattice K showed significant and positive correlation with total nitrogen ($r=0.3079^*$). While it were significantly and negatively correlated with available nitrogen ($r=-0.3702^*$, $r=-0.3748^{**}$). In Central Vidarbha total K showed significant and positive correlation with total sulphur ($r=0.4087^*$) and available sulphur ($r=0.4715^*$). Where as lattice K was significantly and positively correlated with sulphur ($r=0.4549^*$). In Eastern Vidarbha region total and lattice K both did not show any significant relation with and available nutrient status.

Thus the content of total NPK and S is high in all the districts and it decreased with depth. The soils of Central Vidarbha region are medium in available N, low to medium in available P and S, high in available K. While the Eastern Vidarbha region are low in available N, low to medium in

available P and S, high to very high in available K. The "r" values suggests that the actual amount of K present in the soil is not the sole factor such as potassium dynamic in soil, clay content, soil pH, CaCO_3 , N,P,K and S also influence the availability of potassium.

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