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Potassium Fixing Capacity of Some Base Unsaturated Western Ghat Soils of Karnataka Under Paddy Land Use Cover

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Abstract The Potassium Fixing Capacities of 20 representative soils of Western Ghat regions of Karnataka were collected and determined for Potassium Fixing Capacity by using standard procedure. The Potassium Fixing Capacity of soils of Chikmagalore, Shimoga, Hasana and Coorg districts varied from 0.23 to 0.26 cmol (p^+) kg^{-1}, 0.30 to 0.35 cmol (p^+) kg^{-1}, 0.19 to 0.25 cmol (p^+) kg^{-1} and 0.22 to 0.26 cmol (p^+) kg^{-1}, respectively. However, the soils of Shimoga had relatively high Potassium Fixing Capacity and those of Hasana had low Potassium Fixing Capacity compared to the soil of other districts. The amounts of K fixed significantly correlated with the clay content and the pH content of soils.

Keywords Potassium fixation, Potassium dynamics, Western Ghats.

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Introduction

Potassium fixation in soils i.e. transformation of available K forms into unavailable ones, has a direct effect on K availability and on the degree of fertilizer K uptake by plants. Consequently, the study of K fixation problems in soils is of particular agronomic and practical interest. It permits a better understanding of the soil behavior to the application of fertilizer and it generally contributes to the more effective evaluation of crop needs for potassium. Hence it is imperative to know the fixation characteristics of soils with a view to making rational recommendations about K-fertilizers. Soils differ in tendencies to fix applied K in forms unavailable to plants and each soil as its fixing capacity for K which must be satisfied before a change in soil solution occurs. Among the various factors affecting K fixation, soil clay (quantity and type) constitutes the most important one. It determines the magnitude of the soil fixing capacity and it generally controls the K fixation-release processes [1].The progress of our knowledge with respect to the effect of clay mineral constitutions of soils on K dynamics showed that K fixation in soils is due to soil clay

Table 1. Physico-chemical properties of hilly zone soils of Karnataka under paddy land use cover.

Sl. No.	Districts	Taluk/Locations	Sand (%)	Silt (%)	Clay (%)	Texture	pH	EC [dsm^{-1}]	OC (%)	CEC (cmol (P^+) kg^{-1})
1	Chickmagalore	ZARS, Mudigere	74.39	7.21	18.40	Sandy Loam	5.17	0.205	2.32	12.35
2	Chickmagalore	Balehonnur	80.75	4.30	14.95	Sandy Loam	5.30	0.206	1.98	13.07
3	Chickmagalore	Shringeri	79.64	4.98	15.38	Sandy Loam	5.22	0.202	2.15	13.00
4	Chickmagalore	Narasipura	81.24	8.40	10.36	Sandy Loam	5.26	0.207	2.00	13.06
5	Chickmagalore	Magundi	80.20	4.20	15.60	Sandy Loam	5.21	0.201	1.96	12.96
6	Shimoga	Thirthahalli-1	70.30	4.80	24.90	Sandy Clay Loam	4.90	0.196	2.78	15.85
7	Shimoga	Sagara-1	73.65	4.60	21.75	Sandy Clay Loam	5.12	0.157	2.30	10.16
8	Shimoga	Soraba-1	69.86	5.98	24.16	Sandy Clay Loam	4.98	0.193	2.73	14.75
9	Shimoga	Ulavi	69.96	7.25	22.79	Sandy Clay Loam	4.91	0.188	2.81	15.73
10	Shimoga	Agrahara	72.90	5.27	21.83	Sandy Clay Loam	5.21	0.155	2.36	10.36
11	Hasana	Cheekanahalli-1	69.48	15.52	15.00	Sandy Clay Loam	5.32	0.230	2.21	13.20
12	Hasana	Nagenahalli-1	68.60	15.10	16.30	Sandy Clay Loam	5.26	0.210	2.26	13.20
13	Hasana	Hanabalu-1	75.66	7.38	16.96	Sandy Clay Loam	5.26	0.206	2.16	13.33
14	Hasana	Bettadamane-2	76.38	7.95	15.67	Sandy Clay Loam	5.31	0.213	2.27	13.32
15	Hasana	Alur-1	77.31	8.31	14.38	Sandy Clay Loam	5.29	0.203	2.06	13.21
16	Coorg	Madikeri-1	57.84	17.83	24.33	Sandy Clay Loam	5.39	0.198	2.01	13.21
17	Coorg	Napoklu-1	61.13	15.24	23.63	Sandy Clay Loam	5.29	0.206	2.01	13.19
18	Coorg	Kodlipete-1	75.15	9.67	15.18	Sandy Clay Loam	5.28	0.228	2.22	13.28
19	Coorg	Suntikoppa	72.36	12.28	15.36	Sandy Clay Loam	5.27	0.225	2.26	13.23
20	Coorg	Ponnampet-1	61.30	14.31	24.39	Sandy Clay Loam	5.26	0.210	2.28	12.95

minerals of the 2:1 type. Our knowledge concerning K fixing capacities of these soils is very limited. Therefore, the present investigation was conducted; with a view to study the K fixation characteristics of 20 representative soils Western Ghat acid soils of paddy land use cover of Karnataka.

Materials and Methods

Two hundred surface (0–15cm) soil samples used in this study were collected from the Western Ghats area of Karnataka under paddy land use cover during 2015. Off which twenty soil samples were selected to study the potassium fixing capacity of soil. The soil samples were air dired and ground to pass through a 2 mm sieve and determined the Physical, physico-chemical and chemical properties such as prticle size distribution, pH, EC, N, P, K and different forms of potassium by using standard methods.

Same 20 surface soil samples (varied in their available K status) representing four districts (5 samples from each district) were selected and used for the K fixation study. 10 ml of KCl solution containing 10 mg of K was added to 10 g of soil taken in a 250 ml conical flask. The soil-water suspension was evaporated to dryness on a steam bath and the dried sample was evaporated to dryness after adding 5 ml of KCl solution and distilled water. Again it was treated with 2.5 ml KCI solution plus 7.5 ml of water and the suspension was evaporated to dryness once again. Then the sample was treated with 10 ml of distilled water and was dried on the steam plate and repeated three times. Finally, K in the dried sample was extracted with Neutral Normal Ammonium Acetate and the K content in the extract was measured by Flame Photometry as described by Jackson [2]. In the mean time, another portion of soil sample (10 g) was treated with 10 ml of KCl solution containing 10 mg of K and immediately the available K was extracted with Neutral Normal Ammonium Acetate. The K content in the extract was determined. The difference obtained between the two procedures was considered as fixed K and expressed as cmol (p^+) kg^{-1} of soil.

Results and Discussion

The important Physical, physico-chemical and chemi-

Table 2. Available nutrient contents in hilly zone soils of Karnataka under paddy land use cover.

Sl. No.	Districts	Taluk/Locations	Avail N (kg ha^{-1})	Avail P_2O_5 (kg ha^{-1})	Avail K_2O (kg ha^{-1})	Exch Ca (c mol (P^+) kg^{-1})	Exch Mg (c mol (P^+) kg^{-1})
1	Chickmagalore	ZARS, Mudigere	3.56	13.09	261.82	4.86	1.12
2	Chickmagalore	Balehonnur	3.33	13.31	258.15	4.60	1.09
3	Chickmagalore	Shringeri	3.44	13.61	243.36	4.63	1.21
4	Chickmagalore	Narasipura	3.34	11.89	265.51	4.31	1.13
5	Chickmagalore	Magundi	3.32	13.15	252.03	4.38	1.16
6	Shimoga	Thirthahalli	3.87	09.50	230.08	4.62	1.18
7	Shimoga	Sagara-1	3.55	13.10	220.69	3.80	1.01
8	Shimoga	Soraba-1	3.83	12.93	210.68	3.71	0.98
9	Shimoga	Ulavi	3.89	12.86	219.18	3.69	0.99
10	Shimoga	Agrahara	3.88	09.36	242.28	4.39	1.16
11	Hasana	Cheekanahalli-1	3.49	13.68	209.63	5.31	1.18
12	Hasana	Nagenahalli-1	3.51	13.49	213.15	5.39	1.19
13	Hasana	Hanabalu-1	3.45	13.01	231.30	5.89	1.26
14	Hasana	Bettadamane-2	3.52	13.16	230.62	5.93	1.23
15	Hasana	Alur-1	3.38	12.92	221.36	5.41	1.22
16	Coorg	Madikeri-1	3.35	13.96	220.30	3.48	0.98
17	Coorg	Napoklu-1	3.35	14.03	221.31	3.57	1.06
18	Coorg	Kodlipete-1	3.49	13.39	230.13	3.40	0.98
19	Coorg	Suntikoppa	3.52	13.54	228.71	3.47	0.98
20	Coorg	Ponnampet-1	3.53	13.03	220.25	3.55	1.03

cal properties of the soils are presented in the Table 1. The data on the particle size distribution revealed that, sand fraction contribute largely to the soil volume, and the total sand content of the soil ranged from 57.84 to 81.24%.Silt content ranges from 4.20 to 17.83%. Similarly clay content of the soils varied from 14.38 to 24.90%. The soils are sandy loan, sandy clay loam in texture. The soils are acidic in nature (pH=4.90 to 5.39). EC is low (0.155 to 0.230). Organic carbon content of the soils is high (1.96 to 2.81). The higher organic carbon in the soils is due to the deposition of organic carbon from the surrounding upland. The cation exchange capacity (CEC=10.16–15.85 (cmol (p^+) kg^{-1}) is low.

Available nutrients

The available nutrient status of soils depicted in Table 2. Available nitrogen content under paddy land use cover was madium and ranged from (332–389 kg ha^{-1}. Whereas, the available phosphorus content in soil ranged from (9.36 to 14.03 kg P_2O_5 ha^{-1}) indicating the low status of phosphorus in soils due to the fixation of phosphorus by oxides and hydrous oxides of iron and aluminum as a result of acidic pH. The available potassium content in the soils of this ranged from (209.63 to 261.82 kg ha^{-1}). The large variations in the content of available potassium in soils may be attributed to the amount of organic matter present in the upper layer. This is also in corroboration with the earlier findings [3—6]. Lower quantities of exchangeable (3.40 to 5.89 cmol (p^+) kg^{-1}) and (0.98 to 1.26 cmol (p+) kg^{-1}) ions were observed as associated exchangeable cations to K^+ ion. Lower amounts of exchangeable bases may be due to their leaching losses and low content of bases in parent materials [3, 4, 6]. These acid soils are reported to be drived from acidic parent materials like granite, grano-diorite, gneiss and quartzite.

The micronutrient status of soils depicted in the Table 3. The zinc content in soils ranges from 2.80 to 4.33 mg kg^{-1}. The lowest and highest content of copper in soils ranges from 3.84 and 5.10 mg kg^{-1} respectively. The manganess status in soil ranges from 13.25–17.60 mg kg^{-1}. The lowest iron content in soil was found to be 43.13 mg kg^{-1} and highest was found to be 56.23 mg kg^{-1}. Water soluble boron content in soils ranges from 0.17–0.26 mg kg^{-1}.

Table 3. Micronutrient status (ranges) of hilly zone soils of Karnataka under paddy land use cover (mg kg^{-1}).

Sl. No.	Districts	Taluk/Locations	Zinc	Copper	Manganese	Iron	Water soluble boron
1	Chickmagalore	ZARS, Mudigere	3.26–3.71	4.26–4.81	13.55–17.11	44.12–52.01	0.81–0.23
2	Chickmagalore	Balehonnur	3.06–4.00	4.20–4.55	14.02–17.40	46.55_51.11	0.22–0.24
3	Chickmagalore	Shringeri	2.90–3.86	3.96–5.10	13.75–16.60	45.16–54.31	0.23–0.26
4	Chickmagalore	Narasipura	3.20–3.61	4.16–4.71	13.25–16.80	46.21–56.23	0.17–0.25
5	Chickmagalore	Magundi	3.01–4.20	4.12–4.55	14.00–17.40	48.35–51.35	0.21–0.24
6	Shimoga	Thirthahalli	2.97–3.91	3.91–5.02	13.65–16.70	44.13–52.00	0.21–0.25
7	Shimoga	Sagara-1	3.36–3.91	4.25–4.71	13.35–17.11	45.13–55.10	0.17–0.25
8	Shimoga	Sagara-1	3.12–3.89	3.99–4.35	14.01–17.40	48.25–51.00	0.21–0.24
9	Shimoga	Ulavi	2.93–3.96	3.96–5.01	13.55–16.71	46.14–53.10	0.21–0.23
10	Shimoga	Agrahara	3.28–3.61	4.12–4.88	13.45–17.12	44.13–55.20	0.19–0.25
11	Hasana	Cheekanahalli-1	3.26–4.10	4.20–4.85	14.12–17.10	48.15–54.22	0.22–0.23
12	Hasana	Nagenahalli-1	2.93–3.76	3.84–4.93	13.75–16.69	44.12–53.11	0.21–0.25
13	Hasana	Hanabalu-1	3.21–3.61	4.21–4.68	13.61–16.80	47.13–54.21	0.18–0.26
14	Hasana	Bettadamane-2	3.36–4.33	4.11–4.55	14.22–17.60	46.62–51.33	0.20–0.25
15	Hasana	Alur-1	2.80–3.76	3.85–4.90	13.65–16.70	44.13–53.10	0.22–0.26
16	Coorg	Madikeri-1	3.36–3.79	4.11–4.71	13.35–17.20	43.13–53.10	0.18–0.25
17	Coorg	Napoklu-1	3.14–4.22	4.30–4.75	14.13–17.40	47.63–52.21	0.21–0.24
18	Coorg	Kodlipete-1	2.70–3.96	3.86–5.10	13.45–16.75	45.23–54.20	0.22–0.25
19	Coorg	Suntikopa	3.32–3.81	4.28–4.71	13.55–17.12	46.15–56.42	0.17–0.23
20	Coorg	Ponnampet-1	3.09–4.10	4.10–4.65	14.21–17.20	48.55–52.04	0.21–0.24

Potassium fixing capacity (KFC) of soils

The potassium fixing caacity and results of the study are presented in Table 4. The results revealed that the Potassium Fixing Capacity in soils of Chickmagalore, Shimoga, Hasana and Coorg varied from 0.23 to 0.26 cmol (p^+) kg^{-1}, 0.30 to 0.35 cmol (p^+) kg^{-1}, 0.19 to 0.25 cmol (p^+) kg^{-1} and 0.22 to 0.26 cmol (p^+) kg^{-1}, respectively. However, the soils of Shimoga had relatively high potassium fixing capacity and those of Hasana had low potassium fixing capacity compared to the soils of other districts.

Availability of potassium to plants is controlled by various physical and chemical processes that are taking place in soils. Among those, the fixation of potassium in soil is most important one. The potassium fixing capacity of surface soils of different districts in hilly zone of Karnataka under paddy land use cover (Table 3) showed slight variations (0.19 cmol (p^+) kg^{-1} to 0.35 cmol (p^+) kg^{-1}) in their capacity to fix the added potassium. This may be related to the K saturation of the exchange complex of the soils and the nature and amount of clay minerals present in the soils. In general there is considerable evidence that potassium fixation of highly weathered and intensively leached soils is very low. The low potassium fixation of these soils may be attributed to the 1:1 type of clay mineral (kaolinite) and acidic nature of these soils [3—6].

Simple correlation matrix (r=values) between Potassium Fixing Capacity (KFC) and soil properties

Correlation coefficients (r) observed between Potassium Fixing Capacity of soils and certain soil properties are shown in Table 5. The results indicated that there was positive and significant correlation between Potassium Fixing Capacity (KFC) and pH (r= 0.6680**), clay (r=0.4900*) and non exchangeable potassium (r=0.4079*) contents in soils. But, Potassium Fixing Capacity of soils recorded a negative correlation with sand (r= -0.0027*) and organic carbon (r=0.5123*) contents of the soils.

Further, it was noticed that correlation co-efficient (Table 4) values indicates that the fixation of K in the soil increased with the increase in pH of the

Table 4. Potassium Fixing Capacity of soils under paddy land use cover in hilly zone of Karnataka.

Sl. No.	Locations	Taluk/Locations	Districts	Classification great soil groups	K fixing capacity (cmol (P^+) kg^{-1})
1	ZARS, Mudigere	Mudigere	Chickmagalore	Ustic hapluhumolts	0.24
2	Balehonnur	Koppa	Chickmagalore	Lithic ustropepts	0.26
3	Shringeri	Shringeri	Chickmagalore	Typic ustropepts	0.23
4	Narasipura	Koppa	Chickmagalore	Lithic ustropepts	0.30
5	Magundi	N.R. Pura	Chickmagalore	Typic ustropepts	0.26
6	Thirthahalli	Thirthahalli	Shimoga	Kandic Paleostalling	0.30
7	Sagara-1	Sagara	Shimoga	Kandic Paleostalfs	0.35
8	Soraba-1	Soraba	Shimoga	Kandic Paleostalfs	0.34
9	Ulavi	Soraba	Shimoga	Ustic kanapohumults	0.32
10	Agrahara	Sagara	Shimoga	Ustic kanapohumults	0.31
11	Cheekanahalli	Belur	Hasana	Ustic haplunumolts	0.19
12	Nagenahalli	Belur	Hasana	Kandic paleostalfs	0.22
13	Hanabalu-1	Sakaleshapura	Hasana	Ustichaplu humolts	0.23
14	Bettadamane-2	Sakaleshapura	Hasana	Ustichaplu humolts	0.25
15	Alur-1	Alur	Hasana	Ustichaplu humolts	0.20
16	Madikeri-1	Madikeri	Coorg	Typic paleostalf	0.26
17	Napoklu-1	Madikeri	Coorg	Rhodic paleostalfs	0.25
18	Kodlipete-1	Somavarapete	Coorg	Typic paleostalf	0.24
19	Suntikoppa	Somavarapete	Coorg	Kanaphic haplustalfs	0.22
20	Ponnampet-1	Virajpete	Coorg	Kandic Paleostalfs	0.23

soil. The positive relationship between pH and K fixation by soils confirms this results. This is in agreement with the results of [7, 6]. When the concentration of H_30^+ ions having similar radii as K^+ ion would find it easy to occupy specific position on the clay surfaces that cause entrapment [7].

Potassium fixation by soil recorded positive realationship with clay while negative relationship with sand content. The finer fraction has more K specific sites and specific surface area than coarser fraction and hence there was greater fixation. A positive relationship of K fixing capacity with CEC of soils was observed. Increase in CEC of soils indicate an increase in the exchange capacity of soils and dominance of 2:1 type of clay minerals pertaining to greater amount of K to enter in to the exchange complex and get trapped [5].

Table 5. Correlation coefficient (r) between Potassium Fixing Capacity (KFC) and soil properties. **=Significant at 1%, *=Significant at 5%.

Sl. No.	Soil characteristics v/s Potassium Fixing Capacity (KFC)	(*r*=values)
1	KFC with sand	-0.0027*
2	KFC with silt	-0.5012*
3	KFC with clay	0.4900*
4	KFC with pH	0.6680**
5	KFC with EC	-0.4593*
6	KFC with OC	-0.5123*
7	KFC with CEC	-0.0165
8	KFC with Exchangeable Ca	-0.4460*
9	KFC with Exchangeable-K	-0.0801
10	KFC with Non-Exchangeable-K	0.4079*

The negative correlation co-efficient between K fixing capacity and OC has also observed, this might be due to the fact that organic matter having very high CEC results compete with absorption of K^+ in the exchangeable form and result in large amount of added K entrapped in the inorganic exchange complex [6]. Thus, low fixation of potassium in the soils of high rainfall area of Karnataka is mainly due to soil acidity.

Conclusion

The K fixing capacity of the soils varied from 0.20 to 0.34 cmol (p^+) kg^{-1} which indicates that the soils have low capacity to fix potassium. This may be ascribed to the presence of large amounts of kaolinite and sesquioxides in soils. Further, a positive and significant correlation was observed between the K fixing capacity and clay content of these soils.

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