



Cationic Micronutrients Distribution in Relation to Potassium Fractions in Acid Soils of the Western Ghats of Maharashtra

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The study to determine the relationship between micronutrient cations and potassium fractions in acid soils (pH 4.36-5.99) of Mango Research Sub-Centre, Rameshwar in Sindhudurg district of the Western Ghats of Maharashtra, India during 2022-2023 indicated DTPA-extractable iron (Fe), manganese (Mn), zinc (Zn), and copper (Cu) varied from 28.11- 64.10, 31.53 - 63.26, 0.58 - 4.89 and 2.67 - 7.20 cmol(p+) kg⁻¹ with mean of 38.93, 44.32, 3.37 and 5.57 cmol(p+) kg⁻¹, respectively. The available potassium (K) ranged from 326.74 - 686.55 kg ha⁻¹ with a mean of 480.08 kg ha⁻¹, while the water-soluble K content had a mean of 36.93±11.46 cmol(p+) kg⁻¹. These soils had large fraction of exchangeable K (113.74-233.22 cmol(p+) kg⁻¹), followed by non-exchangeable K (180.96 - 321.44 cmol(p+) kg⁻¹), and lattice K (4803.18 - 6786.66 cmol(p+) kg⁻¹). The total K in these soils ranged from 5243.00 - 7130.00 cmol(p+) kg⁻¹ with a mean of 5801.35 ± 439.35 cmol(p+) kg⁻¹. The soil pH had a strong association with DTPA-Fe, DTPA - Cu and DTPA - Zn, but a significant negative relationship with DTPA - Mn and total K. A strong positive correlation was found between soil pH and all the K fractions, barring total K. Conversely, there was a significant inverse relationship between DTPA - Fe and DTPA - Mn and total K. A strong positive relationship of DTPA - Cu was found with available K. DTAP - Mn showed a strong negative association with copper, water - soluble K, non - exchangeable K and lattice K. There was a positive correlation between DTPA - Zn and available K, water - soluble K and non - exchangeable K. DTPA - Cu also had a positive relationship with available K, non - exchangeable K and lattice K but a negative association with exchangeable K. DTPA - Fe was in close reliance with all K - fractions except exchangeable K and total K. All forms of K, except total K, exhibited a significant correlation with DTPA - extractable Fe, Zn and Cu, indicating a dynamic balance among various K fractions in the soil.

(Key words: Acid soil, Micronutrients, Potassium fractions, Soil pH)

Soil potassium is present in equilibrium in various forms such as water-soluble, exchangeable, non-exchangeable, lattice, and total K (Srinivasa Rao *et al.*, 1997; Prasad, 2010). Soil potassium exists mainly in mineral composition, and in non-exchangeable form, with a suitable amount as exchangeable, and water-soluble K, making up a tiny portion of the total K content in soil (Bell *et al.*, 2021). These forms are known to maintain a balance that is constantly changing between them; any decrease in one form is expected to lead to a shift in equilibrium that would restore that form (Nagwe *et al.*, 2012). Increasing micronutrient

deficiencies owing to their mining aggravated by application of high-grade chemical fertilizers (N, P, and K), minimal use of organic manures, and intensive cropping (Saini *et al.*, 2019) is of great concern. About half of the soils in India showed severe deficiencies of micronutrients (Baldantoni *et al.*, 2019). Since both macro and micronutrients are well known for their importance in plant physiology, understanding their inconsistency in the soil-plant organization is even more important. The arrangement of micronutrients in soils is tied to the make-up of the parent materials and impacted by landscape diversity, topographic features,

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and different climate conditions (Menezes-de-Souza *et al.*, 2006), and processes involved in soil formation that could have a significant impact on how trace elements are spread throughout the soil layers.

Accurate assessment and understanding of factors influencing soil nutrient distribution are essential for effective soil, management of crops, as well as financial profitability. Soil fertility is an inherent characteristic that shows the existence of necessary nutrients for plant growth (Saha *et al.*, 2023). According to Hegde *et al.* (2021), soil testing is an essential component of all nutrient management plans. The lack of water and multiple nutrient deficiencies in semi-arid conditions led to low crop productivity in large tracts of different eco-regions. Through intense farming practices, crops absorb and deplete potassium due to the availability of high-yielding varieties for planting or trading and depleting potassium reserves in the soil without sufficient potassium fertilization (Charankumar and Munaswamy, 2022; Vanitha and Subbarayappa, 2022). Prasad and Gajbhiye (1999), Gajare *et al.* (2015) and Srivastava *et al.* (2014) tried to develop a relationship among different micronutrient cations and some relevant soil properties in central India, but the information how these micronutrients affect the different forms of potassium and *vice-versa* is meagre. Thus, it could be helpful to assess the K-fixation/release in soils to comprehend the relationship between micronutrients and crop response to K fertilizer. Therefore, the present study was conducted in the acid soils of Western Ghats in Maharashtra state of India to study the relationship between the cationic micronutrients in relation to potassium fractions.

MATERIALS AND METHODS

The study area covers Mango Research Sub-Centre, Rameshwar (16° 52' N and 73° 35' E), a part of Western Ghat, in Sindhudurg district of Maharashtra during 2022-2023 comprising of rolling terrain with steep inclines that result in significant soil erosion, featuring a distinctive landscape known as laterites or locally referred to as *jambha katal* (hard rock) in many areas. The hard laterites are used as construction material and in places, support mango plantation under locally developed agro-management practices (Removing upper hard layer and putting organic/farm yard manure

(FYM) in pit for mango planting). The sub-optimum soil solum mostly of weathered fractured laterite allows roots to penetrate to draw the water and nutrients. This situation induces stress that results in intensive flowering and fruiting compared to planting on deep soils. The region has a hot and sub-humid climate and receives 2569 mm of mean rainfall annually.

Ninety soil samples (0-22.5 cm), comprising five samples from 18 mango orchards, were collected and the GPS coordinates were recorded. The soil samples were processed and analysed for soil pH (Jackson, 1973). Extraction of water-soluble K (WSK) was done in a soil-water ratio of 1:5 (Grewal and Kanwar, 1966); exchangeable K was extracted using a 1N NH₄OAc (Hanway and Heidel, 1952); non-exchangeable K was analysed using a 1 N boiling HNO₃ extraction method (Wood and De Turk, 1941). The lattice K was derived by subtracting the sum of water-soluble, exchangeable, and non-exchangeable K from total K (Wiklander, 1954). Total K was calculated by extracting the soil in a platinum crucible at 220-225°C using a mixture of H₂SO₄, HClO₄ and HF (Jackson, 1973). DTPA extraction method of Lindsay and Norvell (1978) was utilized to analyse iron (Fe), manganese (Mn), zinc (Zn), and copper (Cu) using an Atomic Absorption Spectrophotometer. The correlation between different variables was assessed by the statistical procedure outlined by Panse and Sukhatme (1961).

RESULTS AND DISCUSSION

The soils were extremely acidic (4.36) to moderately acidic (5.99) in reaction (Table 1). The low pH may be due to the influence of the base material and the removal of basic cations through intense rainfall in the monsoon season. Wahane *et al.* (2024) also reported low soil pH in the soils of Western Ghats of Maharashtra. A strong positive relationship was observed between soil pH and Fe ($r=0.665^{**}$), Cu ($r=0.374^{*}$) and Zn ($r=0.248^{*}$) owing to higher accumulation and mobility of Fe, and Cu from the underneath rock (Table 3). The presence of a large amount of organic carbon in the area likely impacted the iron availability by chelating and protecting it from oxidation, and precipitation, ultimately increasing the availability of iron. Kumar *et al.* (2021) also opined on a similar reasoning. Soil pH had significant and inverse relationship with manganese ($r=-0.566^{**}$), potentially

because of the formation of manganese hydroxides through heavy precipitation that is water-insoluble and thus unavailable to plants. Saha *et al.* (2023) put-forth a similar observation. A strong, positive correlation between soil pH and various forms of potassium, such as available K ($r=0.418^{**}$), water-soluble K ($r=0.466^{**}$), non-exchangeable K ($r=0.551^{**}$), and lattice K ($r=0.359^{**}$) suggesting a dynamic equilibrium with each other. Irshad *et al.* (2020) noted a strong and positive relationship between soil pH and all potassium fractions.

The DTPA-Fe varied from 28.11-64. 10 ± 38.93 $\text{cmol}(p+) \text{ kg}^{-1}$ (Table 1). At low pH, ferrous ions (Fe^{2+}) undergo precipitation as soluble $\text{Fe}(\text{OH})_2$, resulting in a reduction of plant available Fe in soil. Additionally, the creation of Fe-phosphates under low pH conditions may be caused by the presence of excess phosphates,

which would lower the concentration of Fe. Srinivasan *et al.* (2013) put similar views. The negative correlation between DTPA-Fe content (Table 3) and DTPA-Mn ($r=-0.686^{**}$), DTPA-Cu ($r=-0.512^{**}$), and a positive correlation was observed with available K ($r=0.631^{**}$), water-soluble K ($r=0.412^{**}$), non-exchangeable K ($r=0.515^{**}$), and lattice K ($r=0.523^{**}$), suggesting that as the availability of DTPA-Fe increases, the availability of available K, water-soluble K, and non-exchangeable K also increased in soil. Gupta *et al.* (1986) reported similar findings and put-forth their views on the basis of ionic radii. DTPA-Mn ranged from 31.53-63.26 \pm 9.53 $\text{cmol}(p+) \text{ kg}^{-1}$ in the soils (Table 1). The elevated manganese levels in these soils may result from their source being basaltic parent material with increased amounts of ferro-magnesium minerals. The presence of Mn in the soil is determined by the acidic pH levels and

Table 1. Soil pH and micronutrient cations in soils

Orchard No.	Location	pH	DTPA extractable micronutrients			
			[$\text{cmol}(p+) \text{ kg}^{-1}$]			
			Fe	Mn	Zn	Cu
1	16°52' 49.4" N; 73°35' 04.4" E	4.47	41.14	38.95	4.05	3.28
2	16°52' 55.9" N; 73°34' 98.0" E	4.90	44.67	48.02	3.16	5.78
3	16°52' 67.8" N; 73°34' 95.0" E	5.01	64.10	54.70	2.36	5.54
4	16°52' 55.9" N; 73°34' 94.5" E	4.57	53.69	31.54	0.58	2.68
5	16°52' 49.4" N; 73°35' 04.4" E	5.36	36.95	37.37	4.11	6.59
6	16°52' 55.9" N; 73°34' 98.0" E	5.46	40.54	46.06	2.16	6.06
7	16°52' 67.8" N; 73°34' 95.0" E	5.48	38.06	34.31	3.37	5.80
8	16°52' 55.9" N; 73°34' 94.5" E	5.49	37.30	42.62	3.29	4.89
9	16°52' 49.4" N; 73°35' 04.4" E	5.20	35.05	46.53	2.84	5.78
10	16°52' 55.9" N; 73°34' 98.0" E	5.85	28.69	38.03	4.90	6.78
11	16°52' 67.8" N; 73°34' 95.0" E	5.81	32.59	42.52	4.32	7.20
12	16°52' 55.9" N; 73°34' 94.5" E	5.52	31.91	38.44	1.70	4.26
13	16°52' 49.4" N; 73°35' 04.4" E	5.94	29.28	49.78	3.85	5.24
14	16°52' 55.9" N; 73°34' 98.0" E	5.59	28.11	63.27	4.72	5.68
15	16°52' 67.8" N; 73°34' 95.0" E	5.47	35.21	34.79	4.08	5.62
16	16°52' 55.9" N; 73°34' 94.5" E	5.26	41.12	57.16	2.84	7.13
17	16°52' 49.4" N; 73°35' 04.4" E	5.35	35.25	59.83	4.00	5.80
18	16°52' 55.9" N; 73°34' 97.7" E	5.81	37.41	33.89	4.39	6.31
	Minimum	4.47	28.11	31.53	0.58	2.67
	Maximum	5.94	64.10	63.26	4.89	7.20
	Mean	5.36	38.93	44.32	3.37	5.57
	Standard Error	0.05	2.09	2.24	0.26	0.28
	Standard Deviation	0.41	8.90	9.53	1.13	1.20

Zn: < 0.6 Low, 0.6 -1.0 Medium, >1.0 High; Fe: < 4.5 Low, > 4.5 High; Mn: 1.0 Low, >1.0 High; Cu: < 0.2 Low, > 0.2 High; Concentration expressed in $\text{cmol}(+) \text{ kg}^{-1}$

increased Fe concentrations.

These results align with the findings of Sahoo *et al.* (2020). DTPA-Mn had a strong negative correlation with soil pH ($r=-0.566^{**}$), DTPA-Fe ($r=-0.686^{**}$), DTPA-Cu ($r=-0.607^{**}$), water-soluble K ($r=-0.500^{**}$), non-exchangeable K ($r=-0.595^{**}$), lattice K ($r=-0.377^{**}$) and available K ($r=-0.322^*$) which suggested that increasing the Mn content in soil reduce the DTPA-Fe, DTPA-Cu, water-soluble K, non-exchangeable K, and lattice K. However, DTPA-Zn, exchangeable K and total K were found non-significant. This indicated that the higher concentration of Mn in the soil reduced the availability of Fe, Cu and water-soluble K, non-exchangeable K and lattice K.

DTPA-Zn varied from $0.58-4.90 \pm 3.37$ cmol(p+) kg⁻¹ (Table 1). With a critical level for zinc deficiency at 0.60 cmol(p+) kg⁻¹ (Lindsay and Norvell, 1978), these soils fall in the range of deficient to sufficient. The significant positive correlation was found between DTPA-Zn and soil pH ($r=0.248^*$), non-exchangeable K ($r=0.382^{**}$), available K ($r=-0.286$), water soluble K ($r=0.303^*$). This could be a result of differing intensities of soil formation processes and the interaction with organic matter leading to the chelation of Zn (Srinivasan *et al.*, 2013). Also, it indicated that the availability of Zn is controlled by soil pH and non-exchangeable K. The DTPA-Zn did not show a significant relationship with DTPA Fe, Mn and Cu, exchangeable K, lattice K and total K.

The copper content was found to be adequate, ranging from $2.68-7.20$ cmol(p+) kg⁻¹ (Table 1), surpassing the critical limit of 0.20 cmol(p+) kg⁻¹ (Lindsay and Norvell, 1978) possibly caused by the substantial presence of organic material. DTPA-Cu showed a strong positive correlation of 0.530^{**} with the amount of available K, soil pH ($r=0.374^*$), DTPA-Fe ($r=0.512^{**}$), non-exchangeable K ($r=0.248^*$) and lattice K ($r=0.287^*$). However, DTPA-Cu had strong but negative association with DTPA-Mn ($r=-0.607^{**}$) and exchangeable K ($r=0.230^*$). DTPA-Zn, water-soluble K and Total K does not show significant association with DTPA-Cu in the soil. The increased concentration of Cu in the soils can be attributed to the high Fe levels and

low pH. As per critical limits, it can be inferred that the soils of the area were sufficient in Fe, Mn, and Cu, but varied in deficiency/sufficiency levels.

The potassium levels indicated in Table 2 varied from 326.74 and 686.55 kg ha⁻¹ (mean 480.08 kg ha⁻¹). The relationship between available K and non-exchangeable K was found to be strong and positive ($r=0.411^{**}$), as well as with lattice K ($r=0.363^{**}$), soil pH ($r=0.418^{**}$), DTPA-Fe ($r=0.631^{**}$), DTPA-Cu ($r=0.530^{**}$), DTPA-Zn ($r=0.286^*$), water-soluble K ($r=0.295^*$) whereas, it had strong but negative relationship with DTPA-Mn ($r=-0.322^*$) and total K ($r=-0.339^*$) and non-significant with exchangeable K. This shows that water-soluble potassium is being removed directly, matching the crops' needs with exchangeable potassium. Such results were put-forth by Charankumar and Munaswamy *et al.* (2022). The intense weathering affecting primary and secondary potassium minerals such as micas, feldspar, and micaceous minerals within the clay components seems to maintain a continuously shifting equilibrium of various potassium forms. Further, Maji and Chatterjee (1990) stated that the availability of potassium is mainly dependent upon the mineral composition of the soil. According to Bastin *et al.* (2022), significant weathering of K-rich minerals, leaching, external potassium fertilization, and crop harvesting can all contribute to medium to high levels of potassium in soil. Bashir *et al.* (2016) also recorded that the presence of potassium in lateritic soils was positively associated with non-exchangeable and lattice potassium levels.

The soil's water-soluble potassium levels varied from $26.60-70.60$ cmol(p+) kg⁻¹ (Table 2), indicating a slight influence on the soil's total potassium content. There was a strong positive association between water-soluble K and exchangeable K ($r=0.867^{**}$), non-exchangeable K ($r=0.975^{**}$), and lattice K ($r=0.693^{**}$), soil pH ($r=0.466^{**}$), DTPA-Fe ($r=0.412^{**}$), DTPA-Zn ($r=0.303^*$) and strong but negative relationship with DTPA Mn ($r=-0.500^{**}$) and total K ($r=-0.229^*$). This indicated that the water-soluble potassium is influenced by exchangeable, non-exchangeable, and lattice potassium and all forms of K was in equilibrium. These results are in line of findings of Chatterjee *et al.* (1983), Kundu *et al.* (2014) and Charankumar and Munaswamy

Table 2. Potassium fractions distribution in soil samples

Orchard	Av. K ₂ O (kg ha ⁻¹)	Potassium fractions [cmol(p+) kg ⁻¹]				
		WSK	Exch K	Non-Exch K	Lattice K	Total K
1	363.73	27.12	135.26	180.96	6786.66	7130.00
2	428.44	31.76	159.51	220.56	4992.77	5404.60
3	441.95	39.12	158.18	241.76	5381.34	5820.40
4	326.74	27.48	113.74	198.48	5050.90	5390.60
5	442.64	29.60	168.01	257.84	5398.75	5854.20
6	476.83	33.88	178.99	209.92	5431.61	5854.40
7	428.67	26.60	164.77	257.52	5304.91	5753.80
8	499.79	39.80	183.32	271.76	4992.72	5487.60
9	680.56	70.60	233.22	321.44	5484.94	6110.20
10	509.65	41.96	185.56	277.84	5262.44	5767.80
11	439.35	28.36	167.78	243.68	4803.18	5243.00
12	612.35	60.48	212.89	260.96	4956.27	5490.60
13	457.63	32.28	172.02	230.40	6048.70	6483.40
14	556.62	33.72	214.77	242.88	5074.23	5565.60
15	523.08	38.08	195.44	282.59	5429.44	5945.60
16	492.91	35.66	184.39	205.96	5284.59	5710.60
17	506.91	34.92	191.38	235.92	5316.58	5778.80
18	453.62	33.36	169.16	280.80	5149.89	5633.20
Minimum	326.74	26.60	113.74	180.96	4803.18	5243.00
Maximum	680.55	70.60	233.22	321.44	6786.66	7130.00
Mean	480.08	36.93	177.13	245.62	5341.66	5801.35
Standard Error	19.43	2.70	6.61	8.25	107.18	103.55
Standard Deviation	82.47	11.46	28.07	35.00	454.74	439.35

WSK-Water-soluble K, Exch K-Exchangeable K, Non-Exch K-Non-exchangeable K

(2022). Leaching is responsible for the low water-soluble potassium in lateritic soils, whereas the presence of potash-bearing minerals is the probable reason for the high lattice potassium content (Chatterjee *et al.*, 1983).

The exchangeable K varied from 113.74 and 233.22 cmol(p+) kg⁻¹, averaging 177.13 cmol(p+) kg⁻¹ (Table 2). Exchangeable K were found higher in the soils, primarily because of use of manures and K fertilizers containing exchangeable sites in the clay-humus complex, resulting in a rise in available potassium

levels. These results are in confirmation with those of Vanitha and Subbarayappa (2022). The correlation coefficient of 0.737** in Table 3 showed a strong positive significance between exchangeable K and non-exchangeable K and water-soluble K ($r=0.867^{**}$). Likewise, there was a significant correlation between exchangeable K and lattice K, with a correlation coefficient of 0.634** (Table 3). The exchangeable K had a negative but significant association with DTPA-Cu ($r=-0.230^*$), however, it did not show a significant relationship with soil pH, DTPA-Fe, DTPA, Mn, DTPA-

Zn and available K. The relationship between this kind of K, and others indicates that the different types of K are continuously changing. Prasad (2010) and Charankumar and Munaswamy (2022) reported similar findings. This shows that it replaced exchangeable K that was lost from non-exchangeable K in these soil types. The immobile potassium content in the soil ranged from 180.96 to 321.44 cmol(p+) kg⁻¹ (Table 2), likely compensating for the decrease in water-soluble

and exchangeable potassium. There was a significant positive relationship between fixed potassium and available potassium ($r=0.411^{**}$), water-soluble potassium ($r=0.975^{**}$), exchangeable potassium ($r=0.737^{**}$), and lattice potassium ($r=0.663^{**}$) as shown in Table 3. The strong and significant association was observed between soil pH ($r=0.551^{**}$), DTPA-Fe ($r=0.515^{**}$), DTPA Zn ($r=0.382^{**}$), DTPA-Cu ($r=0.248^{*}$). However, it had strong but negative

Table 3. Correlation coefficients (r) between available micronutrients with different K fractions

Soil Properties	pH	DTPA -Fe	DTPA -Mn	DTPA -Zn	DTPA -Cu	Available K ₂ O	WSK	Exch K	Non-Exch K	Lattice K	Total K
pH	1										
DTPA-Fe	0.665**	1									
DTPA-Mn	-0.566**	-0.686**	1								
DTPA-Zn	0.248*	0.051	-0.011	1							
DTPA-Cu	0.374**	0.512**	-0.607**	0.134	1						
Available K ₂ O	0.418**	0.631**	-0.322*	0.286*	0.530**	1					
Water-Sol K	0.466**	0.412**	-0.500**	0.303*	0.099	0.295*	1				
Exch K	0.171	0.110	-0.189	0.071	-0.230*	-0.001	0.867**	1			
Non-Exch K	0.551**	0.515**	-0.595**	0.382**	0.248*	0.411**	0.975**	0.737**	1		
Lattice K	0.359**	0.523**	-0.377**	-0.199	0.287*	0.363**	0.693**	0.634**	0.663**	1	
Total K	-0.256*	-0.325*	0.013	-0.017	0.180	-0.339*	-0.229*	-0.140	-0.236*	-0.335*	1

* = 5% and ** = 1% level of significance; WSK-Water-soluble K, Exch K-Exchangeable K, Non-Exch K-Non-exchangeable K

relationship with DTPA-Mn ($r=-0.595^{**}$) and total K ($r=-0.236^{*}$). The relationship between this type of K and others indicated that different forms of K are in a constant state of balance (Prasad, 2010; Kundu *et al.*, 2014). This suggested that the potassium available for exchange at the time of testing was probably in a state of balance and could have been associated with the level of non-exchangeable potassium (Bashir *et al.*, 2016). This implies that whenever bound potassium is released, it migrates downwards in stages to forms available for plant absorption. The conversion of potassium that can be exchanged and dissolved in water into potassium that cannot be exchanged is an ongoing

process, and maintaining this balance is essential for the plants' potassium intake.

The lattice K (Table 2) ranged from 4803.18 to 6786.66 cmol(p+) kg⁻¹. The strong positive correlations between lattice K and available K, water-soluble K, exchangeable K, and non-exchangeable K ($r=0.363^{**}$, 0.693^{**} , 0.634^{**} and 0.663^{**} , respectively) in Table 3 suggested an equilibrium among these forms as also opined by Prasad (2010). The lattice K had positive relationship with soil pH ($r=0.359^{**}$), DTPA-Fe ($r=0.523^{**}$), DTPA-Cu ($r=0.287^{*}$) and a negative relationship with DTPA-Mn ($r=-0.377^{**}$) and total K ($r=-0.335^{*}$) but did not show any relationship with

DTPA-Zn. It was also observed that lattice K was the most prevalent form, while water-soluble K made up the smallest amount of potassium, likely because of the extensive breakdown of K minerals. Irshad *et al.* (2020) and Charankumar and Munaswamy (2022) also reported similar findings. The mean value for the total content of K ranged from 5243.00-7130.00±5801.35 cmol(p+) kg⁻¹. The total K had negative relationship with soil pH ($r=-0.256^*$), DTPA-Fe ($r=-0.325^*$), available K ($r=-0.339^*$), water-soluble K ($r=-0.229^*$), non-exchangeable K ($r=-0.236^*$) and lattice K ($r=-0.335^*$). However, a significant association was not found between DTPA-Mn, DTPA-Cu, DTPA-Zn and exchangeable K. The total K exhibited a negative correlation with both available K and lattice K, suggesting a stronger connection to parent material rather than land use.

CONCLUSION

It may be concluded that the pH and cationic micronutrients are key factors in determination of soil potassium fractions. The soil pH had a positive and strong correlation with available K, water-soluble K, non-exchangeable and lattice K, but a negative and significant relationship with total K. There was a strong positive correlation between K forms and DTPA extractable Fe, Zn, and Cu; however, a negative and significant correlation was observed with DTPA extractable Mn in the soils of Mango Research Sub-Centre. A positive correlation was found between different forms of K, suggesting a balance among the easily available forms; however, lattice K is the most prevalent fraction among all the potassium fractions in the acid soil of the Western Ghats of Maharashtra.

CONFLICTS OF INTEREST

The authors declare no competing interests.

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