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Soil fertility status of cashew growing soils of Dakshina Kannada district of coastal Karnataka

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Abstract

Soil fertility status of six pedons of cashew growing regions of coastal Karnataka in Dakshina Kannada district were determined. The soils were acidic in reaction, non-saline in nature (free of soluble salts) and low (subsurface soil) to high (surface soil) in organic carbon status. The clay distribution, cation exchange capacity and base saturation of the soils varied from 24.5 to 66.4 per cent, 7.60 to 19.8 cmol (p+) kg^{-1} and 4 to 32 per cent, respectively. The macronutrients status of the soil samples indicated that the available nitrogen content varied from low to medium in all the pedons, the soils were low in available phosphorus, low to medium in available potassium and available sulphur. Among the DTPA extractable micronutrients, iron and manganese were in sufficient range in most soils, available copper was sufficient and available zinc was deficient. The available macronutrient and micronutrient content were found to decrease with increasing the depth of the soils. Phosphorus and zinc were highly deficient in all the pedons of the cashew growing areas of Dakshina Kannada.

Keywords: Cashew, fertility status, macronutrient, micronutrient, pedons

Introduction

Soil fertility, compactability and erodibility are the elements of soil quality. Among these, the problem of decline in soil fertility endangers maximum productivity (Katyal, 2003). Warren and Agnew (1988) described that of all the threats to sustainability, the threat due to soil fertility depletion is the most serious. Depending upon the cropping pattern, leaching, erosion *etc*., soil loses a considerable amount of nutrients every year. If cropping is continued over a period of time without nutrients being restored to the soil, its fertility will be reduced and crop yields will decline. Poor soil fertility conceives sparse plant cover, which promote erosion vulnerability. This happens because 90 per cent of plant available nitrogen (N) and sulphur (S), 50-60 per cent potassium (K), 25-30 per cent phosphorus (P) and almost 70 per cent of micronutrients reside in organic matter (Stevenson, 1982). Soil fertility is meant for highlighting the nutrient needs, based on fertility status of soils (and adverse soil conditions which need improvement) to realize good crop yields. In India, cashew is mostly grown on laterite and red soils and coastal sands in the states of Andhra Pradesh, Goa, Karnataka, Kerala, Maharashtra, Tamil Nadu, Orissa and West Bengal. The fertility status of these soils varies widely. The most fertile soil on which cashew are grown is the forest soils on the western slope of the Western Ghats in Kerala and Dakshina Kannada district of coastal Karnataka. The coastal sands of Dakshina Kannada district on which cashew are often grown are very poor in fertility and the yields are low in these soils unless the trees are fertilized regularly. The laterite soils of Dakshina Kannada district vary considerably in depth, texture and other

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physical and chemical properties. Available macro and micronutrient status in soil profile help in determining the potential of the soil to supply nutrients for crop growth. Soil testing provides information regarding nutrient availability in soils which forms the basis for the fertilizer recommendations for maximising crop yields. In order to provide information on soil fertility status, the present study was undertaken in major cashew growing soils of Dakhsina Kannada district of coastal Karnataka.

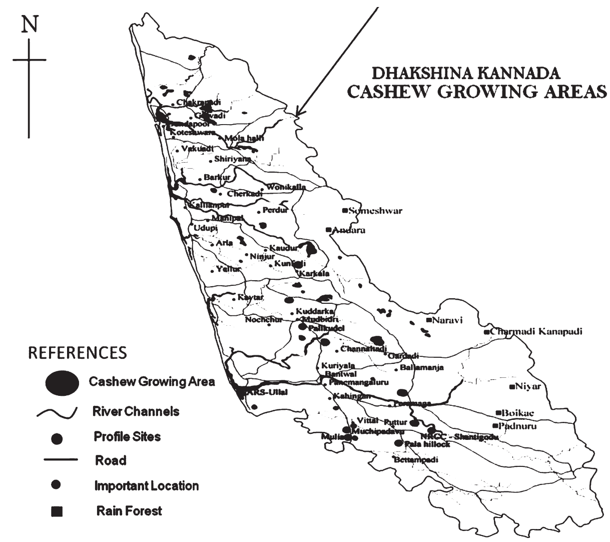

Fig. 1. Location map of study area

Materials and methods

The study was undertaken in six pedons from four taluks of Dakshina Kannada district of coastal Karnataka (Table 1). The research work was carried out at College of Agriculture, UAS, GKVK, Bangalore collaboration with NBSS & LUP, Hebbal, Bangalore. The experimental site, situated in a cashew growing belt, has typical lateritic soils of the west coast, located 87 m above mean sea level with a latitude of 12.77°N and longitude of 75.22°E (Fig. 1). The climate is hot and humid throughout the year with an average annual rainfall of 3,500 mm, distributed mainly from June to September. The mean annual temperature is 27.6 °C and mean maximum and minimum temperatures are 36 °C and 20 °C respectively. The area has *ustic* moisture regime and isohyperthermic temperature regime. The soil samples were collected horizon-wise, air-dried, powdered and sieved using 2 mm sieve. Particle-size analysis of the samples was carried out by international pipette method. Electrical conductivity, pH, organic carbon, cation exchange capacity and base saturation were determined by standard methods (Jackson 1973). Available nitrogen was estimated by alkaline permanganate method (Subbaiah and Asija, 1956). For available posphorus determination, extraction was done using Brays extractant and then subsequent estimation by Jackson, (1973) method. Available potassium was extracted using neutral normal ammonium acetate and measured with flame photometer (Jackson, 1973). Sulphur was extracted using 0.15 per cent $CaCl_2$ solution and was made to react with $BaCl_2$ to form turbid solution of $BaSO_4$. The intensity of turbidity was measured using spectrophotometer at a wavelength of 420 nm (Jackson, 1973). Exchangeable calcium and magnesium were determined using versenate (EDTA) titration method. Available micronutrients such as iron, copper, manganese and zinc were extracted using standard DTPA extract at pH 7.3 and the concentration was measured in an atomic absorption spectrophotometer (Lindsay and Norvell, 1978).

Results and discussion

Ranges and means of physical, chemical and physico-chemical properties of different pedons are given in Table 2. All the six pedons were moderate to strongly acidic with pH ranging from 4.8 to 6.0 and non-saline in nature (free of soluble salts). The acidic pH of the soil might be attributed mainly to

Table 1. Major cashew growing areas in Dakshina Kannada district, coastal Karnataka

Taluk	Village	Pedon number	Land use
Puttur	Pala hillock	1	Forest with plantation of cashew
Puttur	NRCC-Shanthigodu	2	Well maintained cashew farm with intercrops of pineapple and onion
Bantwal	Muchipadavu	3	Poorly maintained cashew plantation with other tree species
Bantwal	Mulia	4	Degraded cashew plantation in the hillock
Mangalore	ARS-Ullal	5	Well maintained cashew farm
Karkala	Palikudel	6	Patches of cashew plantation with tree species and shrubs

Table 2. Ranges and means of physical, chemical and physico-chemical properties of soils collected from cashew growing areas of Dakshina Kannada District of coastal Karnataka

Properties	Range	Mean
pH (1: 2.5)	4.80-6.00	5.43
EC (dSm^{-1})	0.00-0.62	0.12
Organic carbon (%)	0.13-3.07	0.91
Clay (%)	24.5-66.4	45.5
CEC (NH_4OAc pH 7.0)	7.60-19.8	11.2
Base saturation (%)	4.00-32.0	18.9
Available (Av.) and exchangeable (Ex.) macronutrients		
Av. nitrogen (kg ha^{-1})	31.3-429.1	229
Av. phosphorus (kg ha^{-1})	1.90-17.5	6.95
Av. potassium (kg ha^{-1})	8.7-176	64.1
Av. sulphur (mg kg^{-1})	6.25-20.0	9.83
Ex. calcium (cmol (p^+) kg^{-1})	0.36-2.11	0.96
Ex. magnesium (cmol (p^+) kg^{-1})	0.27-1.60	0.71
DTPA extractable micronutrients		
Fe (mg kg^{-1})	2.20-50.0	13.7
Mn (mg kg^{-1})	0.92-13.3	5.20
Zn (mg kg^{-1})	0.04-0.96	0.32
Cu (mg kg^{-1})	0.28-1.52	0.77

the leaching of the bases due to the existing high rainfall conditions and to some extent due to the acidic parent materials. The organic carbon content of the soils varied from 0.13 to 3.07 per cent and was found to be high in surface soils and low in sub-surface soils, decreasing with increasing depth (Fig. 2). This is attributed to the addition of plant residues and farmyard manure to surface horizons. The clay distribution of all the six pedon varied from 24.5 to 66.4 per cent. The CEC in all the pedons estimated varied from 7.6 to 19.8 cmol (p^+) kg^{-1} soils which correspond to clay content in the horizons,

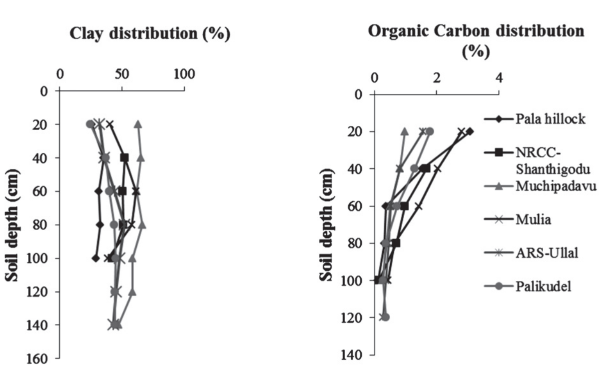

Fig. 2. Depth wise distribution of clay and organic carbon contents of soils

low organic carbon content and also type of clay mineral present in the soil. Base saturation values varied from 4 to 32 per cent in all the six profiles. Low base saturation might be attributed to the occurrence of high leaching conditions combined with heavy rainfall in the study areas.

Available macronutrients

Data on available macronutrient contents of soils of different pedons are given in Table 3. The available nitrogen content in all the pedons was rated as low to medium and the range of available nitrogen varied from 31.3 to 429.6 kg ha^{-1} throughout the depth. However, available N content was found to be maximum in surface horizons and decreased regularly with soil depth, which might possibly be due to the accumulation of plant residues, debris and rhizosphere. The available nitrogen was less than 280 kg ha^{-1} hence rated low (Srinivasamurthy *et al.*, 1999).

The available phosphorus content in the pedons varied from 1.9 to 17.5 kg ha^{-1} and was rated as low. However, the highest available P was observed in the surface horizons and decreased regularly with depth. Higher P in the surface horizon might be due to the confinement of crop cultivation to this layer and supplementing of the depleted phosphorus externally through fertilizers. Low available phosphorus of soils was due to the prevalence of heavy rainfall which leached all the base cations leaving mostly Fe and Al oxides, which fixes available phosphorus.

Available potassium ranged from 8.7 to 176.1 kg ha^{-1} and in most of the study area soils were with low level of potassium. The highest available K content was noticed in the surface horizons and showed decreasing trend with depth. This could be attributed to more intensive weathering, release of labile K from organic residues and application of K fertilizers. The fertility status of some typical soils of coastal Karnataka reported that the available potassium varied from 30 to 220 kg ha^{-1}. Coarse textured and gravelly soils with deeper solum are particularly low in available potassium, possibly due to faster and deeper leaching and physico-chemical properties (Badrinath *et al.*, 1986). Ratings for available potassium indicate that values less than

Table 3. Depth wise distribution of available macronutrients in major cashew growing soils of Dakshina Kannada District, coastal Karnataka

Depth (cm)	Horizon	OC (%)	N	P	K	Ca	Mg	S
			Available macronutrients					
			< ------- kg ha^{-1}-------- >			(cmol (p$^+$) kg^{-1})		(mg kg^{-1})
Pedon-1 (Pala hillock)								
0-21	A1	3.07	429.6	6.8	158.5	1.90	1.60	9.37
21-41	Bw/BA	1.53	232.0	5.8	47.9	0.57	0.27	8.75
41-68	Bt 1	0.38	188.1	6.8	34.4	0.82	0.64	8.75
68-95	Bt 2	0.32	144.2	8.7	33.0	0.50	0.50	6.25
95-123	BC	0.13	125.4	7.8	32.3	0.49	0.60	3.75
Pedon-2 (NRCC-Shanthigodu)								
0-19	Ap	1.68	285.3	8.7	176.1	0.82	0.89	12.50
19-42	Bw	0.97	200.7	7.8	49.2	0.36	0.81	8.12
42-71	CB	0.70	181.8	4.8	43.1	0.57	0.80	11.87
71-90	Cr 1	0.14	119.1	3.9	33.7	0.65	1.05	11.25
Pedon-3 (Muchipadavu)								
0-25	Ap	0.97	216.3	4.8	59.3	1.37	0.52	6.87
25-50	Bt 1	0.82	206.9	5.8	47.9	2.11	0.39	6.25
50-84	Bt 2	0.50	169.3	9.7	50.6	0.82	0.39	10.00
84-128	Bt 3	0.40	153.6	10.7	34.4	0.38	0.84	11.87
128-160	Bt 4	0.26	232.0	7.8	24.9	0.63	0.60	20.00
160-206	Bt 5	0.12	181.8	6.8	16.8	0.65	0.71	14.37
206-210	BC	0.14	203.8	8.7	8.7	0.45	0.62	32.50
Pedon-4 (Mulia)								
0-17	A	2.80	366.9	8.7	87.7	1.24	0.60	15.62
17-41	AB/BA	2.04	363.7	8.7	69.5	1.38	0.61	9.37
41-60	Bt 1	1.42	326.1	6.8	74.9	1.46	0.82	9.37
60-90	Bt 2	0.65	279.1	5.8	82.3	1.54	1.12	8.12
90-215	BC	0.43	197.5	6.8	32.3	1.09	0.73	8.12
Pedon-5 (ARS-Ullal)								
0-20	Ap	1.56	370.0	17.5	134.9	0.43	0.36	14.37
20-40	BA	0.83	263.4	6.8	68.1	0.44	0.29	9.37
40-70	Bt 1	0.13	254.0	1.9	82.3	0.73	0.62	8.75
70-99	Bt 2	0.45	272.8	1.9	135.6	1.75	1.05	8.75
99-127	Bt 3	0.36	257.1	2.9	70.1	1.59	1.13	9.37
127-165	Bt 4	0.27	244.6	3.9	55.3	1.09	0.93	10.00
165-191	Bt 5	0.03	191.3	5.8	63.4	0.92	0.95	15.00
191-210	BC	0.03	50.1	7.8	71.5	0.80	0.62	17.50
210-220	Cc	0.22	31.3	9.7	51.2	0.67	0.50	9.37
Pedon-6 (Palikudel)								
0-28	A	1.79	304.1	13.6	119.4	1.58	0.67	11.87
28-55	Bw	1.30	188.1	9.7	29.0	0.74	0.49	10.00
55-90	Bt 1	0.73	137.9	4.8	24.3	0.58	0.60	8.75
90-130	Bt 2	0.36	122.3	3.9	16.8	0.76	0.78	6.25
130-180	Bt 3	0.28	112.8	4.8	21.6	0.84	0.56	12.50
180-210	BC	0.23	75.2	3.9	19.5	0.47	0.80	15.00
210-235	C 1	0.07	68.9	2.9	23.6	0.81	0.73	7.50

168 kg ha^{-1} are low 168 to 337 kg ha^{-1} as medium as and more than 337 kg ha^{-1} as high (Srinivasamurthy *et al*., 1999).

The available sulphur in the soils varied from 6.25 to 20 mg kg^{-1} and most of the soils were very low in ratings. Muchipadavu and Palikudel soils had higher amount of available sulphur compared to other locations. Due to higher amount of organic matter in surface layers than in deeper layers, the available sulphur was more in surface horizons than the sub-surface horizons.

Exchangeable calcium and magnesium in all the six profiles were low and ranged from 0.36 to 2.11 cmol (p+) kg^{-1} and 0.27 to 1.60 cmol (p+) kg^{-1} respectively, this is due to the prevalence of excess and frequent rainfall in the study areas which leached most of the basic cations like calcium, magnesium, potassium and sodium from the surface soil to lower horizons. The clay complex was dominated by exchangeable Ca in surface and sub-surface horizons of most soils followed by Mg. Exchangeable Ca and Mg showed irregular trend with depth of soils.

Available micronutrients

The examination of the data on available micronutrients of the soils presented in Table 4 revealed that the DTPA extractable iron, manganese, zinc and copper content varied from deficiency to toxicity level in all the pedons. The depth wise distribution of available micronutrients is shown in figure 3. The DTPA extractable Zn ranged from 0.26 to 0.96 mg kg^{-1} soil in surface and 0.04 to 0.44 mg kg^{-1} soil in subsurface horizons. Vertical distribution of Zn exhibited little variation with depth. Considering 0.60 mg kg^{-1} as critical level for zinc deficiency (Lindsay and Norvell 1978), these soils could be classified as deficient in Zn except surface soils of pedon 1 and 2. The relatively high content of available zinc in surface horizons may be attributed to variable intensity of the pedogenic processes and complexing with organic matter which resulted in chelation of Zn.

All the pedons were found to be sufficient in available copper (0.28 to 1.52 mg kg^{-1}) as all the values were well above the critical limit proposed (0.20 mg kg^{-1}) by Lindsay and Norvell (1978). A decreasing trend with depth was noticed in all the pedons except in 2 and 3 which showed in irregular trend with depth. The available Cu content was more in surface layers and decreased with depth, which might be due to association with organic carbon.

The DTPA extractable Fe content varied from 2.20 to 50 mg kg^{-1} soil. According to critical limit of 4.5 mg kg^{-1} (Lindsay and Norvell, 1978), the soils were rich in available iron except Bt2, Bt3, Bt4, Bt5 and BC horizons of pedon 3. The higher concentration of DTPA-Fe in subsurface horizons of pedons 1, 2, 4, 5 and 6 might be due to the accumulation of iron brought down as a result of illuviation of clay from the upper horizons. However, the higher DTPA-Fe in surface horizons of all the pedons might be due to accumulation of organic carbon in the surface horizons. The organic carbon due to its affinity to influence the suitability and

Table 4. Depth wise distribution of available micronutrients in major cashew growing soils of Dakshina Kannada district, coastal Karnataka

Depth (cm)	Horizon	Available micronutrients (mg kg^{-1}) Fe	Mn	Zn	Cu
Pedon-1 (Pala hillock)					
0-21	A1	48.40	6.60	0.96	0.56
21-41	Bw/BA	17.80	1.72	0.38	0.28
41-68	Bt 1	10.60	4.20	0.40	0.30
68-95	Bt 2	7.00	4.00	0.40	0.28
95-123	BC	6.60	3.56	0.20	0.28
Pedon-2 (NRCC-Shanthigodu)					
0-19	Ap	21.74	12.60	0.60	0.76
19-42	Bw	13.08	7.74	0.22	0.74
42-71	CB	12.00	9.36	0.28	0.78
71-90	Cr 1	8.50	8.38	0.30	0.76
Pedon-3 (Muchipadavu)					
0-25	Ap	11.00	4.36	0.26	1.08
25-50	Bt 1	7.00	2.86	0.24	0.88
50-84	Bt 2	2.46	1.60	0.16	0.64
84-128	Bt 3	3.48	1.84	0.10	0.68
128-160	Bt 4	2.26	1.60	0.04	0.62
160-206	Bt 5	2.30	1.48	0.04	0.56
206-210	BC	2.20	0.92	0.04	0.60
Pedon-4 (Mulia)					
0-17	A	24.2	5.78	0.48	1.02
17-41	AB/BA	21.6	7.76	0.16	0.90
41-60	Bt 1	14.8	10.12	0.46	0.86
60-90	Bt 2	8.76	9.25	0.22	0.66
90-215	BC	3.60	8.04	0.34	0.66
Pedon-5 (ARS-Ullal)					
0-20	Ap	37.40	4.80	0.30	1.34
20-40	BA	23.60	3.98	0.28	0.84
40-70	Bt 1	13.06	6.72	0.40	0.82
70-99	Bt 2	11.08	5.04	0.38	0.80
99-127	Bt 3	7.64	2.30	0.42	0.76
127-165	Bt 4	7.92	2.02	0.42	0.80
165-191	Bt 5	6.40	2.36	0.36	0.78
191-210	BC	6.40	2.20	0.24	0.76
210-220	Cc	6.78	2.16	0.12	0.74
Pedon-6 (Palikudel)					
0-28	A	50.00	13.3	0.54	1.52
28-55	Bw	26.80	8.80	0.44	1.26
55-90	Bt 1	16.00	7.00	0.42	1.04
90-130	Bt 2	10.20	4.00	0.30	0.88
130-180	Bt 3	7.40	3.36	0.24	0.80
180-210	BC	7.30	3.02	0.16	0.86
210-235	C 1	7.14	3.20	0.14	0.82

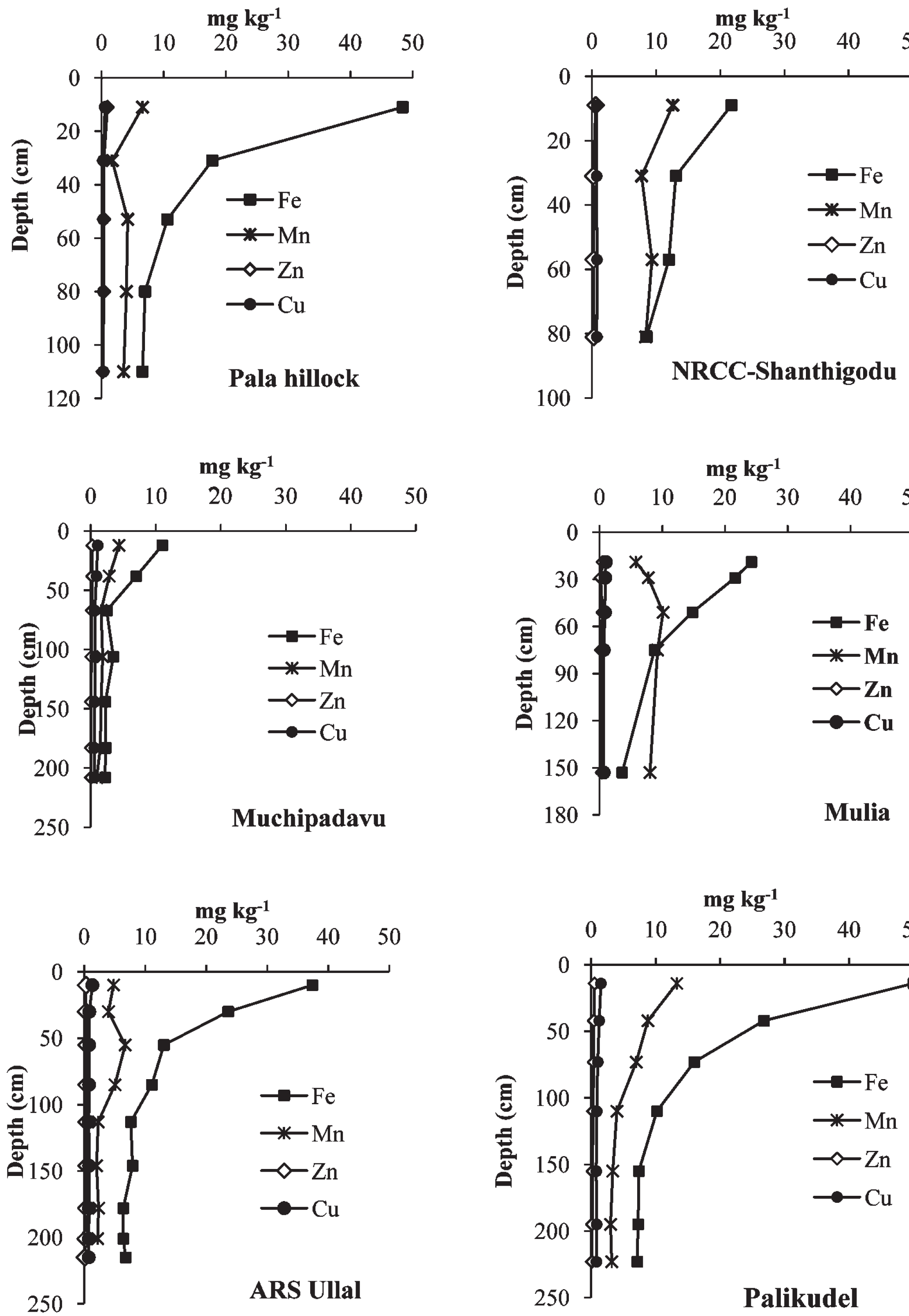

Fig. 3. Depth-wise distribution of available micronutrients in study areas

availability of iron by chelating action might have protected the iron from oxidation and precipitation, which consequently increased the availability of iron in the surface horizons (Prasad and Sakal, 1991).

Available Mn varied from 0.92 to 13.3 mg kg^{-1} soil and decreased with depth which might be due to higher biological activity and organic carbon in the surface horizons. The higher content of available Mn in surface soils was attributed to its chelation by organic compounds. These observations are in accordance with the findings of Verma *et al*. (2005). The micronutrient analysis of cashew growing soils of Dakshina Kannada district of coastal Karnataka indicated that the surface soils and subsurface soils are sufficient in DTPA extractable Fe and Mn except the subsurface soils of Pedon 3. Available copper content in surface and subsurface soils of all the pedons was in sufficient range. Surface and subsurface soils of all the pedons were deficient in available zinc content except A1 and Ap horizons of pedon 1 and pedon 2, respectively.

Conclusions

Fertility status of cashew growing soils of Dakshina Kannada district of coastal Karnataka indicated that soils are low to medium in available N and available K and low in available P in surface and subsurface horizons. Available sulphur remained low to medium in most soils. Among the exchangeable bases, exchangeable calcium was found to be high in most soils, followed by magnesium. With respect to micronutrients, iron and manganese contents were high, available copper was in sufficient range and available zinc was deficient in surface and subsurface soils of all the pedons. The deficient nutrients have to be restored through chemical fertilizers and/or organic manures to maintain soil health for efficient and sustainable cashew production in these soils.

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