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Soil fertility status of coconut growing soils of Dakshina Kannada and Udupi district, Karnataka

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Abstract
Soil fertility status of two pedons of coconut growing soils of coastal Karnataka ie. Beltangadi and Brahmavara of Dakshina Kannada and Udupi district, respectively were determined. The soils were acidic in reaction, non-saline in nature 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 28.89 to 42.20 percent, 3.86 to 7.85 cmol (p+) kg^{-1} and 47.19 to 83.22 percent, respectively. The macronutrient status of the soil samples indicated that available nitrogen and potassium contents varied from low to medium and available phosphorus was found to be very low in both soil pedons. Available sulphur was deficient in Beltangadi soil pedon and it was varying from deficient to sufficient levels in different soil horizons of Brahmavara soil pedon. The exchangeable calcium and magnesium contents were low in both pedon locations. Among the DTPA extractable micronutrients, iron, manganese and zinc were adequate in most soil horizons. Copper was found to be sufficient in entire study area where as boron was found to be highly deficient.

Keywords: Soil fertility status, coconut growing soils, DTPA

Introduction

In India, coconut is the most significant plantation crop. It is cultivated in seventeen states and three union territories, primarily around coastal parts. In Karnataka, it is being grown in an area of 5.15 lakh ha with production and productivity of 6773.05 million nuts and 13181 nuts ha^{-1}, respectively, hence making a significant contribution to the nation's coconut industry (CDB, 2016-17) [2] ranking next to Kerala and Tamil Nadu in area and production, respectively. Almost the whole state of Karnataka is home to coconut plantations with the seven main districts being Tumkur, Hassan, Chikmagalur, Mandya, Mysore, Udupi, and Dakshina Kannada (DES, 2009-10) [3]. The components of soil quality are erodibility, compactability, and fertility. Warren and Agnew (1988) [13] described that of all the threats to sustainability, the threat due to soil fertility depletion is the most serious. Among these, the problem of decline in soil fertility endangers maximum productivity (Katyal, 2003) [5]. The productivity of the coconut palm differs in various agro-climatic zones (ACZs) as a result of variations in environmental conditions and management practices. The inherent ability of the soil to supply nutrients is a key aspect that determines the fertility of the soil, which in turn determines the productivity of the crops. Understanding the ability of soils to provide nutrients is a crucial pre-requisite for crop nutrition in order to determine the amount of organic residues needed *i.e.*, the manures and fertilizers to be applied per palm to obtain a good yield. In coastal areas, coconut palms are typically planted on relatively poor fertile soils, which results in limited yields unless the palms receive regular fertilizer applications. The laterite soils of Dakshina Kannada and Udupi district vary considerably in depth, texture and other physical and chemical properties. Determining the soil's capacity to supply nutrients for crop growth is aided by the status of available macro and micronutrients in the soil profile. Hence with this background information a study has been conducted to evaluate the soil fertility status of coastal regions of Karnataka and its impact on palm health and productivity.

Materials and Methods

With the help of SRM data and report (Scale-1:2,50,000) of Karnataka, the major coconut-growing soils were studied (Shivaprasad *et al*., 1998) [8].

Climatic and soil-site conditions of major coconut-growing areas were analysed for their suitability to identify potential areas. Extensive field traversing was done to select these areas. Based on the suitability evaluation, Hosadurga in Chitradurga (Central dry zone), Gubbi and Turuvekere in Tumkur (Eastern dry zone), Arasikere in Hassan (Southern transition zone), Krishnarajapete in Mandya (Southern dry zone), Brahmavara in Udupi and Beltangadi in Dakshina Kannada districts (Coastal zone) were identified as the most potential areas for coconut cultivation. Figure 1 shows the traditional coconut-growing soils of Karnataka. The present study was undertaken at Beltangadi (Dakshina Kannada) and Brahmavara (Udupi), Karnataka. Beltangadi representing foothills of western ghats has a humid climate with 3950 to 4850 mm of annual rainfall and 210 to 240 days of LGP. Dominant soils are very deep and well-drained gravelly clay soils with low AWC on granite gneissic midland hills, with slight erosion and surface crusting. The coastal plain of Brahmavara has a hot and humid climate with annual rainfall of 3200 to 3900 mm and LGP of 180 to 210 days. The dominant soils are very deep and well-drained gravelly clay soils with surface crusting and compaction on undulating uplands. Soil profiles of Beltangadi and Brahmavara were studied. The soil samples were collected horizon-wise, air-dried, powdered and sieved using 2 mm sieve. International pipette method was used to carry out particle size analysis. Standard procedures were used to measure electrical conductivity (EC), pH, organic carbon (OC), cation exchange capacity (CEC), and base saturation (BS), (Jackson, 1973) [4].

Alkaline permanganate method was used to assess the amount of available nitrogen (N) in soil (Subbaiah and Asija, 1956) [11]. Available phosphorus (P) was extracted using Brays extractant and then subsequent estimation by Jackson, (1973) [4] method.

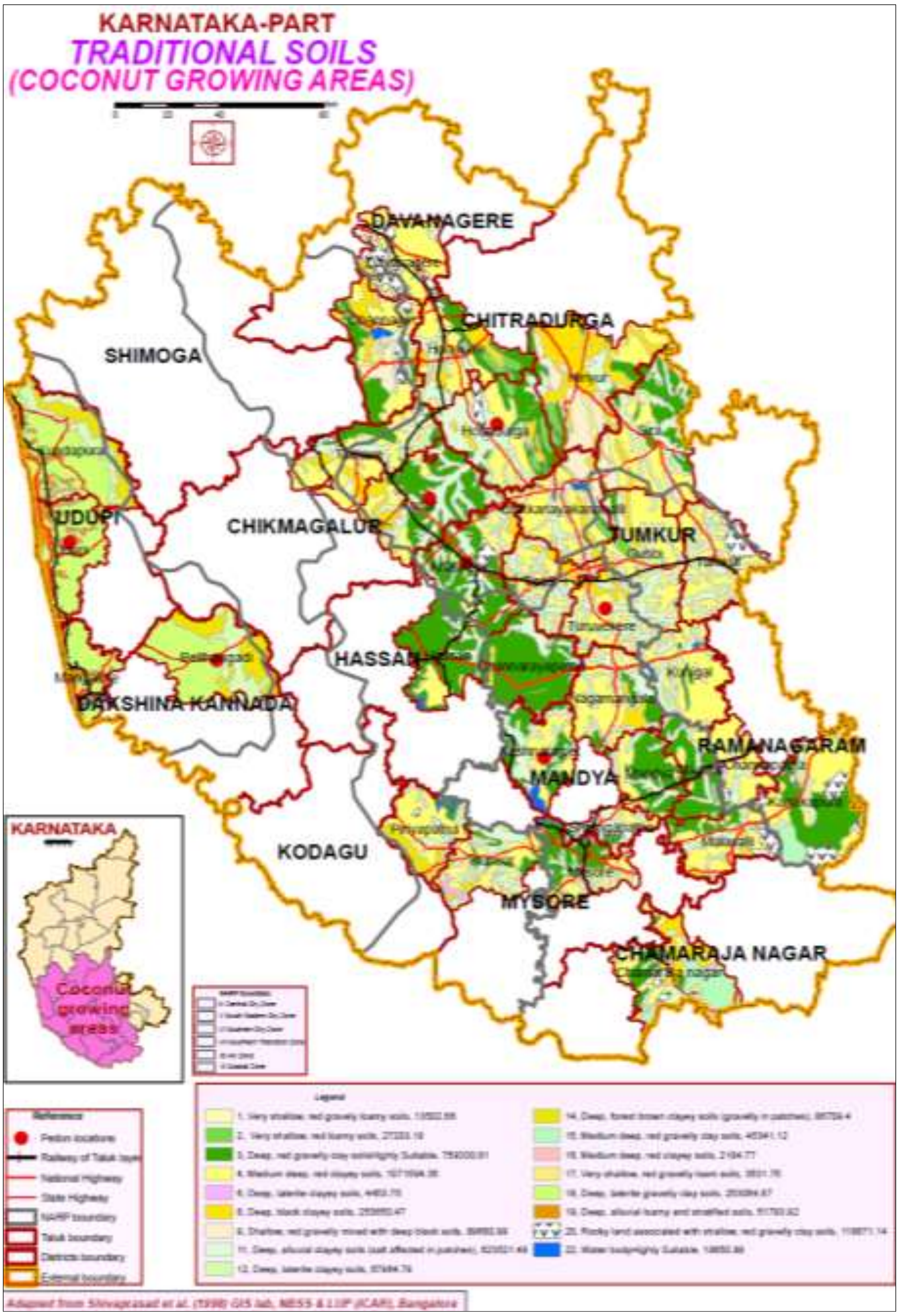

Fig 1: Traditional coconut-growing soils of Karnataka

Neutral normal ammonium acetate was used to extract the available potassium (K) and its content was measured using flame photometer (Jackson, 1973) [4]. Sulphur (S) was extracted using 0.15 percent $CaCl_2$ 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) [4]. Exchangeable calcium (Ca) and magnesium (Mg) were determined using versenate (EDTA) titration method. Available micronutrients such as iron (Fe), copper (Cu), manganese (Mn) and zinc (Zn) were extracted using standard DTPA extractant at pH 7.3 and the concentration was measured using an atomic absorption spectrophotometer (Lindsay and Norvell, 1978) [6]. The soils of Beltangadi and Brahmavara were classified as fine, kaolinitic, sub-active, isohyperthermic Typic Kandiustalfs and clayey-skeletal, acid, kaolinitic, sub-active, isohyperthermic Ustic Kanhaplohumults, respectively.

Results and Discussion

Properties of profile soil samples

Ranges and means of physical and chemical properties of Beltangadi and Brahmavara soil pedons are given in table 1. Both the soil pedons were moderate to very strongly acidic with pH ranging from 4.99 to 5.71 and non-saline in nature (free of soluble salts). The acidic pH of the soil might be attributed mainly to 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 0.12 to 1.49 percent 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 among both soil pedons varied from 28.89 to 42.20 percent (Fig 3). The CEC in soil pedons estimated varied from 3.86 to 7.85 cmol (p+) kg^{-1} soil which correspond to clay content in the horizons, low organic carbon content and also type of clay mineral present in the soil. Base saturation values varied from 47.19 to 83.22 percent among both soil pedons. Low base saturation might be attributed to the occurrence of high leaching conditions due to heavy rainfall in the study area.

Table 1: Ranges and means of physical and chemical properties of soils collected from pedons of Beltangadi and Brahmavara

Properties	Range	Mean
pH (1: 2.5)	4.99-5.71	5.37
EC (dSm^{-1})	0.01-0.04	0.02
Organic carbon (%)	0.12-1.49	0.79
Clay (%)	28.89-42.20	35.27
CEC (NH_4OAc, pH 7.0)	3.86-7.85	5.11
Base saturation (%)	47.19-83.22	64.36
Available (Av.) and exchangeable (Ex.) macronutrients		
Av. nitrogen (kg ha^{-1})	163.07-351.23	271.62
Av. phosphorus (kg ha^{-1})	2.80-8.40	5.26
Av. potassium (kg ha^{-1})	43-272.83	103.38
Av. sulphur (mg kg^{-1})	1.69-17.71	7.14
Ex. Calcium (mg kg^{-1})	21.56-108.02	53.58
Ex. Magnesium (mg kg^{-1})	5.10-29.19	17.27
DTPA extractable micronutrients		
Fe (mg kg^{-1})	1.58-77.63	19.44
Mn (mg kg^{-1})	1.62-55.28	10.62
Zn (mg kg^{-1})	0.45-2.86	0.91
Cu (mg kg^{-1})	1.03-4.23	2.75
B(mg kg^{-1})	0.09-0.47	0.28

Available macronutrients

Depthwise distribution of plant available nutrients in soil profiles of Beltangadi and Brahmavara are represented in table 2 and 3, respectively. The available nitrogen content in both soil pedons was rated as low to medium and it varied from 163.07 to 351.23 kg ha^{-1}, throughout the soil depth. Available N content was found to be maximum in surface horizons and decreased with soil depth, which might possibly be due to the accumulation of plant residues, debris and rhizosphere (Srinivasan *et al*, 2013) [10]. The available phosphorus content in the soil pedons varied from 2.80 to 8.40 kg ha^{-1} and was rated as low. However, comparatively higher available P was observed in the surface horizons and it decreased with soil 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. Lower P availability is due to fixation of soil P into insoluble form by iron and aluminum present in these acid soils. Available potassium ranged from 43 to 272.83 kg ha^{-1}. Comparatively higher available K content was noticed in the surface horizons and it showed decreasing trend with depth.

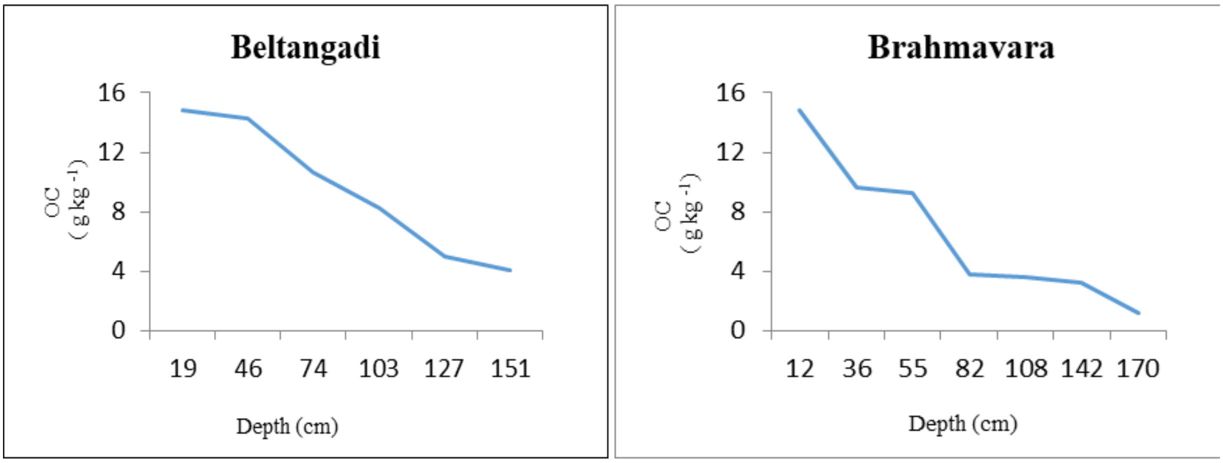

Fig 2: Depth wise distribution of Organic carbon (OC) in two different pedons

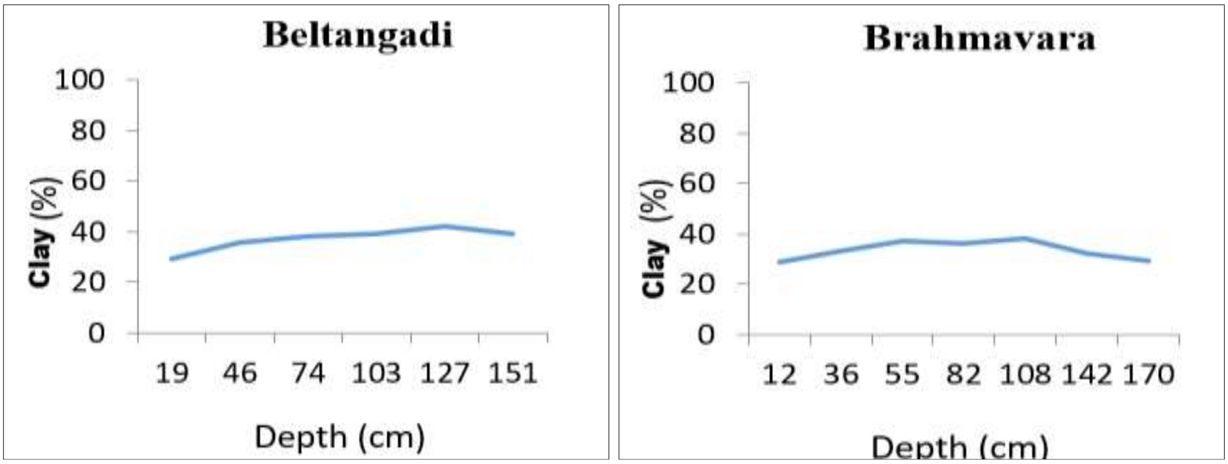

Fig 3: Depth wise distribution of Clay in two different pedons

Table 2: Depthwise distribution of plant available nutrients in Beltangadi soil profile

Depth (cm)	Available nutrients											
	OC	N	P_2O_5	K_2O	Ca	Mg	S	Fe	Mn	Cu	Zn	B
	(g kg^{-1})	kg ha^{-1}			mg kg^{-1} soil							
0-19	14.87	351.23	8.40	233.85	76.34	26.88	9.28	24.63	12.93	4.12	0.65	0.47
19-46	14.27	344.96	5.04	68.54	50.93	21.71	3.37	36.35	2.63	3.07	1.23	0.28
46-74	10.65	288.51	3.36	67.20	48.07	23.03	2.53	23.78	8.93	2.33	0.66	0.30
74-103	8.24	282.24	5.04	75.26	21.56	13.35	1.69	12.86	10.27	2.46	0.93	0.45
103-127	5.03	275.97	5.60	91.39	63.58	18.08	6.75	9.89	1.88	2.23	0.86	0.37
127-151	4.02	275.97	4.48	77.95	108.02	27.43	3.37	3.11	1.62	1.96	0.97	0.17

Table 3: Depthwise distribution of plant available nutrients in Brahmavara soil profile

Depth (cm)	Available nutrients											
	OC	N	P_2O_5	K_2O	Ca	Mg	S	Fe	Mn	Cu	Zn	B
	(g kg^{-1})	kg ha^{-1}			mg kg^{-1} soil							
0-12	14.87	294.78	7.28	272.83	68.53	29.19	17.71	77.63	55.28	2.06	2.86	0.35
12-36	9.65	263.42	6.72	142.46	55.22	15.21	14.34	41.36	9.87	3.56	0.45	0.17
36-55	9.25	263.42	6.72	94.08	37.84	7.69	8.43	8.93	12.78	3.95	0.77	0.30
55-82	3.82	257.15	3.92	72.57	23.65	5.10	5.90	6.21	10.88	4.23	0.72	0.19
82-108	3.60	250.88	5.04	61.82	31.79	15.00	10.96	3.55	4.58	3.12	0.51	0.17
108-142	3.20	219.52	2.80	43.00	22.33	15.11	3.37	2.78	3.89	1.69	0.69	0.09
142-170	1.21	163.07	3.92	43.00	88.66	6.75	5.06	1.58	2.49	1.03	0.58	0.39

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 showed 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) [1]. Ratings for available potassium indicated that values less than 168 kg ha^{-1} as low, 168 to 337 kg ha^{-1} as medium and more than 337 kg ha^{-1} as high (Srinivasamurthy *et al.*, 1999) [9]. The available sulphur in these soils varied from 1.69 to 17.71 mg kg^{-1} and most of the soil horizons were very low in ratings. 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 both soil profiles were low and ranged from 21.56 to 108.02 mg kg^{-1} soil and 5.10 to 29.19 mg kg^{-1}soil, 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 both soil profiles followed by Mg.

Available micronutrients

The data on depth wise distribution of plant available micronutrients in Beltangadi and Brahmavara soil profiles are presented in table 2 and 3, respectively. The DTPA extractable Zn ranged from 0.45 to 2.86 mg kg^{-1} soil. Vertical distribution of Zn exhibited little variation with depth. 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. Both the soil pedons were found to be sufficient in available copper (1.03 to 4.23 mg kg^{-1}) as all the values were well above the critical limit proposed (0.12 mg kg^{-1}) by Lindsay and Norvell (1978) [6]. The available Cu content was more in surface layers and decreased with depth in Beltangadi soil pedon, which might be due to its association with organic carbon. The DTPA extractable Fe content varied from 1.58 to 77.63 mg kg^{-1} soil. As per the critical limit given by Lindsay and Norvell, 1978 [6] ie. 4.5 mg kg^{-1}, the soils were generally rich in available iron and its vertical distribution followed decreasing trend with depth in both soil pedons. This is due to accumulation of organic carbon in the surface horizons. The organic carbon due to its affinity to influence the solubility and 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) [7]. Available Mn varied from 1.62 to 55.28 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) [12]. Available copper content in surface and subsurface horizons of both soil pedons was in sufficient range. Available boron varied from 0.09 to 0.47 mg kg^{-1} soil and it was found to be deficient in both soil pedons.

Properties of composite surface soil samples

The pH in soil water suspension and 0.01M $CaCl_2$ ranged from 4.94 to 6.46 and 4.11 to 5.76, respectively. Electrical conductivity ranged from 0.03 to 0.06 dS m^{-1}. Organic carbon ranged from 3.80 to 15.0 g kg^{-1} soil. Available N, P_2O_5 and K_2O ranged from 92.06 to 363.38 kg ha^{-1}, 3.12 to 17.53 kg ha^{-1} and 72.57 to 290.30 kg ha^{-1} soil, respectively. Available Ca, Mg and S ranged from 48.26 to 98.23, 21.29 to 35.08 and 1.67 to 25.83 mg kg^{-1} soil, respectively. Available Fe, Mn, Zn, Cu and B in the soil varied from 8.40 to 88.30, 9.80 to 77.80, 0.40 to 4.10, 1.0 to 16.70 and 0.11 to 0.59 mg kg^{-1} soil, respectively (table 4a & 4b, 6a & 6b).

Properties of composite sub-surface soil samples

The pH in soil water suspension and 0.01M $CaCl_2$ ranged from 5.17 to 6.21 and 4.24 to 5.16, respectively. Electrical conductivity ranged from 0.02 to 0.04 dS m^{-1}. Organic carbon ranged from 7.80 to 16.0 g kg^{-1} soil. Available N, P_2O_5 and K_2O ranged from 228.06 to 467.82 kg ha^{-1}, 2.73 to 11.34 kg ha^{-1} and 52.42 to 287.62 kg ha^{-1} soil, respectively. Available Ca, Mg and S ranged from 43.49 to 91.54, 19.86 to 33.41 and 2.52 to 18.70 mg kg^{-1} soil, respectively. Available Fe, Mn, Zn, Cu and B in the soil varied from 6.60 to 74.80, 7.60 to 75.90, 0.40 to 6.0, 1.10 to 7.30 and 0.11 to 0.45 mg kg^{-1} soil, respectively (table 5a & 5b, 7a & 7b).

Table 4a: Plant available primary and secondary nutrients in surface soils of agricultural lands in Beltangadi

Crop	pH	0.01 M $CaCl_2$ pH	EC (dSm^{-1})	OC (%)	N	P_2O_5	K_2O	S	Ca	Mg
					$Kgha^{-1}$			mg kg^{-1}		
Rubber	6.46	5.76	0.06	1.39	336.73	3.12	290.30	3.32	98.23	35.08
Arecanut	5.52	4.75	0.05	1.32	319.77	7.04	254.01	4.15	88.25	31.52
Cocoa	5.90	4.79	0.03	1.04	251.94	8.21	126.33	2.57	68.54	24.48
Coconut	5.03	4.60	0.03	0.82	198.65	6.65	244.62	1.67	62.24	22.23
Arecanut	4.94	5.12	0.03	0.88	213.18	3.91	76.63	4.13	59.61	21.29
Arecanut + Cocoa	5.52	4.84	0.04	0.38	92.06	10.71	72.57	5.26	71.29	25.46
Coconut	5.74	4.86	0.03	0.68	164.73	5.08	75.26	4.13	79.87	28.53
Coconut	5.57	4.53	0.03	1.24	300.39	6.65	185.47	2.56	83.28	29.74
Forest land	5.39	4.46	0.05	1.32	319.77	5.09	202.94	2.36	84.62	30.22
Mean	5.56	4.86	0.04	1.01	244.13	6.27	169.79	3.35	77.33	27.62
Range	4.94-6.46	4.46-5.76	0.03-0.06	0.38-1.39	92.06-336.73	3.12-10.71	72.57-290.30	1.67-5.26	59.61-98.23	21.29-35.08

Table 4b: Plant available micro-nutrients in surface soils of agricultural lands in Beltangadi

Crop	Fe	Mn	Zn	Cu	B
	mg kg^{-1}				
Rubber	24.20	10.30	1.50	4.70	0.18
Arecanut	22.90	19.50	0.70	11.70	0.50
Cocoa	18.40	18.00	1.00	3.10	0.28
Coconut	29.90	18.10	0.60	1.80	0.59
Arecanut	22.10	16.90	1.60	7.30	0.48
Arecanut + Cocoa	8.40	10.80	1.40	12.00	0.19
Coconut	12.60	12.20	1.60	16.70	0.28
Coconut	13.90	9.80	0.90	1.60	0.11
Forest land	29.40	23.30	1.00	1.30	0.46
Mean	20.20	15.43	1.14	6.69	0.34
Range	8.40-29.90	9.80-23.30	0.60-1.60	1.30-16.70	0.11-0.59

Table 5a: Plant available primary and secondary nutrients in sub-surface soils of agricultural lands in Beltangadi

Crop	pH	0.01 M CaCl₂ pH	EC (dSm⁻¹)	OC (%)	N	P₂O₅	K₂O	S	Ca	Mg
					Kg ha⁻¹			mg kg⁻¹		
Rubber	5.69	4.96	0.04	1.14	333.32	3.52	287.62	2.54	90.12	32.19
Arecanut	5.31	4.26	0.03	1.28	374.26	3.56	188.16	5.38	91.54	32.69
Cocoa	5.17	4.81	0.03	1.02	298.24	2.73	77.95	5.23	66.28	23.67
Coconut	5.65	4.52	0.02	0.94	274.85	8.60	176.06	2.52	70.08	25.03
Arecanut	5.58	5.06	0.02	0.78	228.06	6.65	75.26	3.32	69.27	24.74
Arecanut + Cocoa	5.72	5.05	0.02	1.12	327.48	3.91	53.76	5.21	78.64	28.09
Coconut	5.79	5.16	0.02	1.22	356.72	5.06	52.42	5.28	80.21	28.65
Coconut	5.42	4.45	0.04	1.18	345.02	2.73	194.88	7.58	89.62	32.01
Forest land	5.29	4.24	0.03	1.54	450.28	3.12	134.40	3.39	87.19	31.14
Mean	5.51	4.72	0.03	1.14	332.03	4.43	137.83	4.49	80.33	28.69
Range	5.17-5.79	4.24-5.16	0.02-0.04	0.78-1.54	228.06-450.28	2.730-8.60	52.42-287.62	2.52-7.58	66.28-91.54	23.67-32.69

Table 5b: Plant available micro-nutrients in sub-surface soils of agricultural lands in Beltangadi

Crop	Fe	Mn	Zn	Cu	B
	mg kg⁻¹				
Rubber	28.40	23.80	1.10	7.30	0.11
Arecanut	19.20	12.90	0.50	3.00	0.42
Cocoa	18.00	10.90	0.50	2.10	0.17
Coconut	14.10	14.30	0.40	1.40	0.37
Arecanut	11.40	11.00	0.70	2.80	0.37
Arecanut + Cocoa	6.60	9.00	0.60	4.00	0.15
Coconut	9.40	10.80	6.00	3.80	0.36
Coconut	15.40	7.60	0.60	1.40	0.18
Forest land	28.60	9.80	0.50	1.20	0.42
Mean	16.79	12.23	1.21	3.00	0.28
Range	6.60-28.60	7.60-23.80	0.40-6.0	1.20-7.30	0.11-0.42

Table 6a: Plant available primary and secondary nutrients in surface soils of agricultural lands in Brahmavara

Crop	pH	0.01 M CaCl₂ pH	EC (dSm⁻¹)	OC (%)	N	P₂O₅	K₂O	S	Ca	Mg
					Kgha⁻¹			mg kg⁻¹		
Coconut+Cocoa	5.78	4.92	0.04	1.36	329.46	6.25	189.50	18.93	55.69	25.43
Arecanut	5.08	4.11	0.03	0.98	237.41	9.38	262.08	25.83	52.19	23.83
Cashew	5.71	4.68	0.04	1.50	363.38	11.61	190.84	12.33	59.27	27.06
Jamun	5.89	4.88	0.06	1.12	271.32	11.23	188.16	15.95	71.29	32.55
Mango	5.86	4.58	0.04	1.36	329.46	17.53	153.22	12.58	48.26	22.04
Mean	5.66	4.63	0.04	1.26	306.20	11.20	196.76	17.12	57.34	26.18
Range	5.08-5.89	4.11-4.92	0.03-0.06	0.98-1.50	237.41-363.38	6.25-17.53	153.22-262.08	12.33-25.83	48.26-71.29	22.04-32.55

Table 6b: Plant available micro-nutrients in surface soils of agricultural lands in Brahmavara

Crop	Fe	Mn	Zn	Cu	B
	mg kg⁻¹				
Coconut+Cocoa	73.00	53.60	0.70	1.00	0.13
Arecanut	88.30	77.80	0.40	2.00	0.32
Cashew	32.90	25.60	4.10	2.90	0.24
Jamun	30.90	43.80	3.20	2.90	0.48
Mango	51.40	36.00	0.70	1.80	0.33
Mean	55.3	47.36	1.82	2.12	0.30
Range	30.9-88.3	25.6-77.8	0.40-4.10	1.0-2.90	0.13-0.48

Table 7a: Plant available primary and secondary nutrients in sub-surface soils of agricultural lands in Brahmavara

Crop	pH	0.01 M CaCl₂ pH	EC (dSm⁻¹)	OC (%)	N	P₂O₅	K₂O	S	Ca	Mg
					Kg ha⁻¹			mg kg⁻¹		
Coconut+Cocoa	5.67	4.76	0.03	1.34	391.80	11.34	126.33	16.65	54.19	24.74
Arecanut	5.21	4.26	0.02	1.60	467.82	9.69	244.60	18.70	56.14	25.63
Cashew	5.95	4.97	0.02	1.52	444.43	7.43	120.96	14.12	60.27	27.52
Jamun	6.21	5.03	0.03	1.48	432.74	10.86	118.27	16.11	73.17	33.41
Mango	5.59	4.46	0.04	1.02	298.24	9.97	134.41	13.23	43.49	19.86
Mean	5.73	4.70	0.03	1.39	407.01	9.86	148.91	15.76	57.45	26.23
Range	5.21-6.21	4.26-5.03	0.02-0.04	1.02-1.60	298.24-467.82	7.43-11.34	118.27-244.60	13.23-18.70	43.49-73.17	19.86-33.41

Table 7b: Plant available micro-nutrients in sub-surface soils of agricultural lands in Brahmavara

Crop	Fe	Mn	Zn	Cu	B
	mg kg^{-1}				
Coconut+Cocoa	68.60	54.00	0.50	1.10	0.26
Arecanut	74.80	75.90	0.40	1.70	0.23
Cashew	26.10	51.30	1.50	2.50	0.27
Jamun	46.70	32.90	1.00	1.70	0.45
Mango	64.90	33.00	0.60	1.80	0.38
Mean	56.22	49.42	0.80	1.76	0.32
Range	26.1-74.8	32.9-75.9	0.40-1.50	1.10-2.50	0.23-0.45

Conclusions

Fertility status of coconut growing soils of Dakshina kannada and Udupi districts indicated that the soils have low to medium levels of available N and K, and low levels of available P in surface and subsurface horizons. Exchangeable calcium and magnesium contents remained low in both soil profile locations. With respect to micronutrients, iron, manganese, copper and zinc contents were found to be adequate in most of the soil horizons. Boron was low in entire study region. The study shows that the coconut growing soils of Dakshina Kannada and Udupi districts are generally low in fertility and proper management practices are necessary to enhance the nutrient supply capacity of these soils which involves application of chemical fertilizers and/or organic manures to maintain soil health for efficient and sustainable coconut production in these soils. Liming has to be done in coconut gardens of these soils to correct soil acidity and to ensure adequate supply of Ca and Mg.

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