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Soil Fertility Status of Major Coconut Growing Soils of Tumkur District, Karnataka, India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A study was conducted to assess the soil fertility status of major coconut growing soils of Tumkur district of Karnataka with soil pedon locations being Turuvekere and Gubbi. The results revealed that soils of the study area were slightly to strongly alkaline in reaction and non-saline in nature. The organic carbon content was varying from low to high and it followed decreasing trend with soil depth in both soil profiles (Turuvekere and Gubbi). The clay distribution, cation exchange capacity and base saturation of the soils varied from 17.83 to 60.37 per cent, 8.71 to 28.86 cmol (p+) kg^{-1} and 75.53 to 93.42 per cent, respectively. The macronutrient status of the soil samples indicated that the available nitrogen and phosphorus varied from low to medium, and available potassium content was varying from low to high. Analysis of secondary nutrients showed that exchangeable calcium and magnesium were found to be sufficient but available sulphur was varying from deficient to sufficient level in these soils. The DTPA extractable micronutrients *viz*., iron, manganese, zinc and boron were found to be deficient in entire study area where as copper was varying from deficient to adequate level with surface soil having relatively high copper content than subsurface soil.

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Keywords: Soil fertility; Pedon; coconut growing soils.

1. INTRODUCTION

The Coconut palm (*Cocos nucifera* L.) is one of the most fascinating and beautiful palms in the world. Epigraphical, literary and sculptural evidences provide proof that coconut has served humanity for more than three millennia. The palm is looked upon with reverence and affection and is referred to by such eulogistic epithets as “Kalpavriksha”, “Tree of heaven”, “The tree of abundance”, “Nature’s super market”, “King of palms” and “The tree of life” [1]. “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, thus contributing a major share in coconut industry in the country [2] ranking next to Kerala and Tamil Nadu in area and production, respectively. Coconut is majorly grown in southern parts of Karnataka, and the major seven districts are Tumkur, Hassan, Chikmagalur, Mandya, Mysore, Udupi and Dakshina Kannada [3]”. Srinivasan et al. [4] “Soil plays a major role in determining the sustainable productivity of an agro-ecosystem. The productivity of a soil mainly depends upon its ability to supply essential nutrients to the growing plants. Soil fertility is one of the important factors which control the availability of plant nutrients there by the crop yields. Soil fertility management issues are at the centre of debates on the sustainability of agricultural production systems in our country, where farmers are concerned with soil fatigue. The decline in soil fertility markedly accounts for the low crop productivity. One of the reasons for this low productivity is the extraction of nutrients by continuous cropping with low external nutrient supply, resulting in declining soil productivity. Soil fertility is a function of many soil properties which are interrelated. Knowing the fertility status of the soils is an important crop nutrient prerequisite to decide the extent of organic residues required, *i.e.,* the manures and fertilizers to be applied per palm to obtain a better yield”. Srinivasan et al. [4] The present study was undertaken at Tumkur district, Karnataka to assess the fertility status of major coconut growing soils and identification of soil related constraints to palm health and productivity.

2. MATERIALS AND METHODS

Major coconut-growing soils of Karnataka were studied by taking the help of SRM data and report (Scale-1:2,50,000) of Karnataka [5]. “Soils and climatic conditions of major coconut-growing areas were studied for their suitability to identify potential areas. Extensive field traversing was done to identify these areas. Based on the suitability assessment, Hosadurga in Chitradurga, Gubbi and Turuvekere in Tumkur, Arasikere in Hassan, Krishnarajapete in Mandya, Brahmavara in Udupi and Beltangadi in Dakshina Kannada districts were identified as the most potential areas for coconut cultivation. Fig. 1 shows the traditional coconut-growing soils of Karnataka”. Srinivasan et al. [4] The present study was undertaken at Turuvekere and Gubbi in Tumkur district of Karnataka. Gubbi and Turuvekere possess semi-arid climate with an annual rainfall of 560 to 866 mm and 810 to 925 mm and LGP of 120 to 150 and 150 to 180, days respectively. Soils of these areas are generally deep and moderately well-drained, clayey soils of valleys with problems of drainage and slight salinity in patches. “The soils of Turuvekere are classified as fine, mixed, semi-active, isohyperthermic, Rhodic Paleustalfs and Gubbi as fine-loamy, mixed, semi-active, isohyperthermic, Typic Rhodustalfs. Soil profiles (Pedons) of these locations were studied. 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 using international pipette method. Electrical conductivity, pH, organic carbon, cation exchange capacity and base saturation were determined by standard methods” [6]. “Available nitrogen (N) was estimated by alkaline permanganate method” [7]. For available phosphorus (P) determination, extraction was done using Brays extractant and then subsequent estimation by Jackson method [6].

“Available potassium (K) was extracted using neutral normal ammonium acetate and measured with flame photometer [6]. Sulphur (S) 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 [6]. 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 atomic absorption spectrophotometer” [8]. Soil fertility ratings for different parameters are given in Table 1.

Table 1. Soil fertility ratings for different parameters

Classes	Ratings		
Soil reaction (pH) classes			
Ultra acidic	<3.5		
Extremely acidic	3.5 - 4.5		
Very strongly acidic	4.5 - 5.0		
Strongly acidic	5.0 - 5.5		
Moderately acidic	5.5 - 6.0		
Slightly acidic	6.0 - 6.5		
Neutral	6.5 - 7.5		
Slightly alkaline	7.5 - 7.8		
Moderately alkaline	7.8 - 8.4		
Strongly alkaline	8.4 - 9.0		
Very strongly alkaline	>9.0		
Soil salinity classes (EC) (dS m^{-1})			
Non saline	<2		
Low	2 - 4		
Medium	4 - 8		
High	8 - 12		
Very high	12 - 16		
Extremely high	>16		
Available macronutrient classes	**Low**	**Medium**	**High**
Organic carbon (%)	<0.5	0.5 - 0.75	>0.75
Nitrogen (kg ha^{-1})	<280	280 – 560	>560
Phosphorus (kg P_2O_5 ha^{-1})	<23	23 - 56	>56
Potassium (kg K_2O ha^{-1})	<140	140 - 330	>330
Available secondary nutrient classes	**Deficient**		**Sufficient**
Exchangeable Calcium (mg kg^{-1})	<400		>400
Exchangeable Magnesium (mg kg^{-1})	<60		>60
Sulphur (mg kg^{-1})	<10		>10
Available micronutrient classes	**Deficient**		**Sufficient**
Copper (mg kg^{-1})	<0.2		>0.2
Iron (mg kg^{-1})	<4.5		>4.5
Manganese (mg kg^{-1})	<2.5		>2.5
Zinc (mg kg^{-1})	<0.6		>0.6
Boron (mg kg^{-1})	<0.5		>0.5

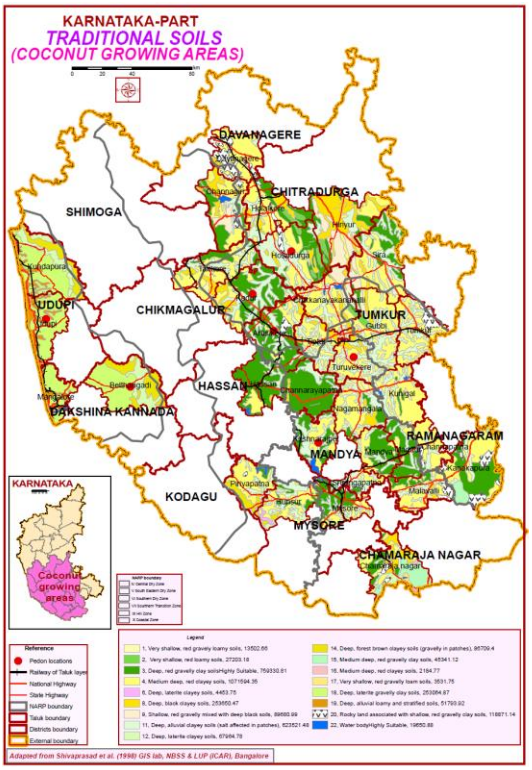

Fig. 1. Traditional coconut-growing soils of Karnataka

3. RESULTS AND DISCUSSION

3.1 Physical and Chemical Properties of Profile Soil Samples

Ranges and means of physical and chemical properties of soils of Turuvekere and Gubbi are given in Table 2. Soil reaction was slightly to moderately alkaline with pH ranging from 7.71 to 8.31 which is due to accumulation of basic salts from weathered parent material. The soils were non-saline in nature (free of soluble salts) with EC values ranging from 0.06 to 0.12 dSm^{-1}. The organic carbon (OC) content of the soils varied from 0.16 to 0.78 per cent and was found to be high in surface soils and low in sub-surface soils, decreasing with increasing soil depth (Fig. 2). This is attributed to the addition of plant residues and farmyard manure to surface horizons. The clay distribution in study area varied from 17.83 to 60.37 per cent which followed increasing trend with soil depth in both soil profiles (Fig 3). The cation exchange capacity (CEC) estimated varied from 8.71 to 28.86 cmol (p+) kg^{-1} soil which correspond to nature and amount of clay and organic carbon content present in the soil horizons. Base saturation values varied from 75.53 to 93.42 per cent which indicated low degree of leaching in these soils. The influence of exchangeable calcium (Ca^{2+}) and magnesium (Mg^{2+}) contributed for higher base saturation in these soils.

3.2 Available Macronutrients

Depthwise distribution of plant available nutrients in Turuvekere and Gubbi soil profiles are represented in Tables 3 and 4, respectively. “The available nitrogen (N) content was ranging from 75.26 to 294.78 kg ha^{-1} and was rated as low to medium. Available N content was found to be relatively high in surface soil horizons and it decreased with increasing soil depth, which might be possibly due to the accumulation of plant residues, debris and rhizosphere” [9]. “The available phosphorus (P_2O_5) content in the soils varied from 3.36 to 32.48 kg ha^{-1} and was rated as low to medium. This is because of reaction of soil phosphorus (P) with calcium to form a sequence of products of low solubility” [10]. “However, comparatively higher available P was observed in the surface horizons and it decreased regularly 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. Available potassium (K_2O) ranged from 67.2 to 369.6 kg ha^{-1}. Comparatively higher K_2O content was noticed in the surface horizons than subsurface horizons. This could be attributed to more intensive weathering, release of labile K from organic residues and application of K fertilizers. 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” [11]. The available sulphur in these soils was varying from deficient to adequate levels with values ranging from 7.51 to 14.39 mg kg^{-1}. The surface soil horizons had relatively more sulphur content due to application of S containing fertilizers and high organic matter content. Exchangeable calcium (Ca) and magnesium (Mg) of studied soil horizons were ranging from 459.82 to 623.46 mg kg^{-1} and 157.18 to 205.20 mg kg^{-1} soil, respectively. The soils had adequate calcium and magnesium due to their release from weathered basic parent material. The quantity of exchangeable Ca and Mg are also attributed to the type and amount of clay present in these soils. These results were in confirmation with the findings of Krishnamurthy [12] and Alur [13]. The clay complex was dominated by exchangeable Ca in surface and sub-surface horizons of both soil profiles followed by Mg.

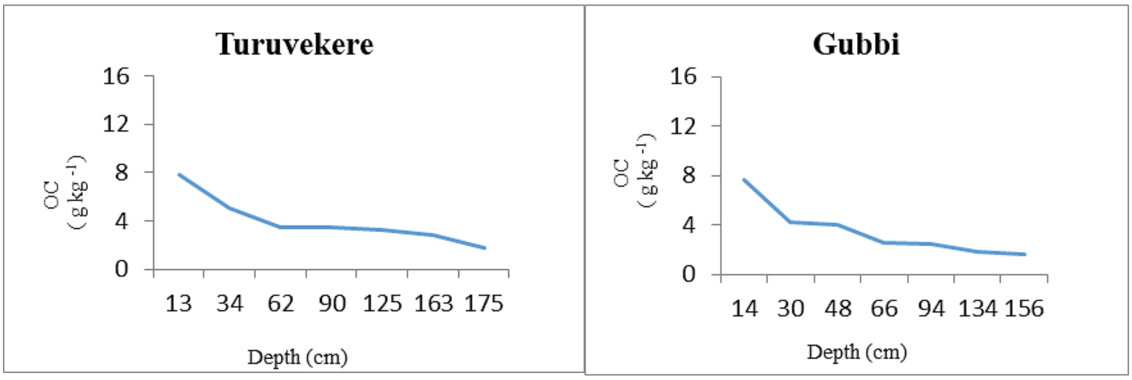

Fig. 2. Depth wise distribution of Organic carbon (OC) in two different pedons

Table 2. Ranges and means of physical and chemical properties of soils collected from pedons of Turuvekere and Gubbi

Properties	Range	Mean
pH (1: 2.5)	7.71-8.31	7.92
EC (dSm^{-1})	0.06-0.12	0.092
Organic carbon (%)	0.16-0.78	0.37
Clay (%)	17.83-60.37	44.16
CEC (cmol (p+) kg^{-1})	8.71-28.86	15.07
Base saturation (%)	75.53-93.42	85.95
Available (Av.) and exchangeable (Ex.) macronutrients		
Av. nitrogen (kg ha^{-1})	75.26-294.78	191.19
Av. phosphorus (kg ha^{-1})	3.36-32.48	17.20
Av. potassium (kg ha^{-1})	67.2-369.6	132.14
Av. sulphur (mg kg^{-1})	7.51-14.39	10.02
Ex. calcium (mg kg^{-1})	459.82-623.46	520.19
Ex. magnesium (mg kg^{-1})	157.18-205.20	173.34
DTPA extractable micronutrients		
Fe (mg kg^{-1})	3.45-4.46	4.10
Mn (mg kg^{-1})	1.86-2.43	2.28
Zn (mg kg^{-1})	0.22-0.51	0.34
Cu (mg kg^{-1})	0.06-0.28	0.16
B (mg kg^{-1})	0.26-0.49	0.36

3.3 Available Micronutrients

The data on plant available micronutrients of Turuvekere and Gubbi soil profiles are presented in Tables 3 and 4, respectively. The DTPA extractable Fe and Mn content varied from 3.45 to 4.46 mg kg^{-1} and 1.86 to 2.43 mg kg^{-1} soil, respectively. The DTPA extractable Zn and Cu ranged from 0.22 to 0.51 mg kg^{-1} and 0.06 to 0.28 mg kg^{-1} soil, respectively. The available Cu content was more in surface layers which might be due to its association with organic matter and it followed decreasing trend with depth in both soil profiles. Available B varied from 0.26 to 0.49 mg kg^{-1} soil and was rated as deficient. As per the critical limit given by Lindsay and Norvell [8] for micronutrients in soil, the entire study area was found to be deficient for micronutrients. The deficiency of Fe, Mn and Zn in study area was attributed to their decreased solubility and mobility due to alkaline soil reaction. These results are in conformity with the findings of Vijayashekhar et al. [14]. It may also be due to non-application of micronutrient fertilizers [15].

3.4 Properties of Composite Surface Soil Samples

The soils of the study area were slightly to very strongly alkaline in reaction where pH values ranged from 7.6 to 9.43. Electrical conductivity ranged from 0.04 to 1.45 dS m^{-1} which indicates non-saline nature of these soils. Organic carbon ranged from 0.19 to 1.10 per cent. Available N, P_2O_5 and K_2O ranged from 120.96 to 492.80 kg ha^{-1}, 19.54 to 48.18 kg ha^{-1} and 94.34 to 345.23 kg ha^{-1} soil, respectively. Available Ca, Mg and S ranged from 411.08 to 577.36 mg kg^{-1}, 154.28 to 223.37 mg kg^{-1} and 6.98 to 15.98 mg kg^{-1} soil, respectively. Available Fe, Mn, Zn, Cu and B in the soil varied from 2.98 to 4.45, 1.67 to 2.43, 0.24 to 0.56, 0.11 to 0.38 and 0.13 to 0.46 mg kg^{-1} soil, respectively (Tables 5a & 5b, 6a & 6b).

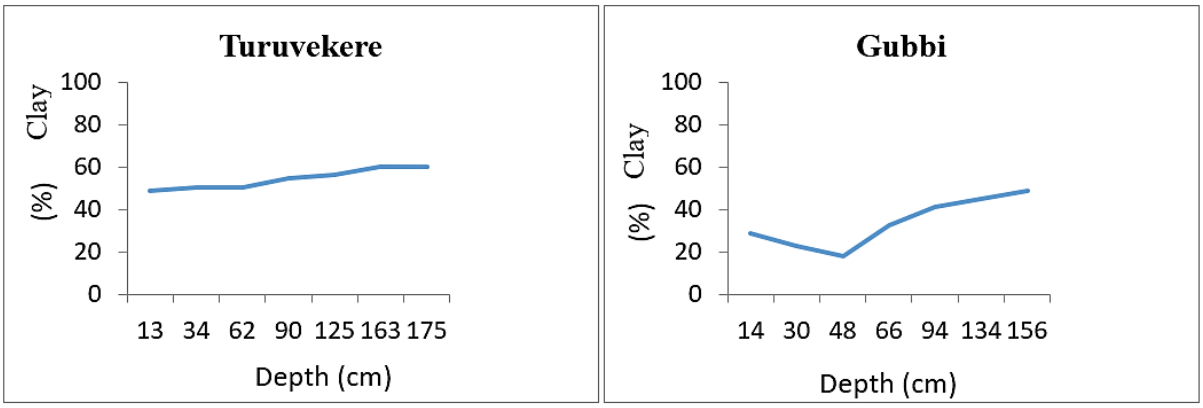

Fig. 3. Depth wise distribution of Clay in two different pedons

Table 3. Depthwise distribution of plant available nutrients in soil profile of Turuvekere

Depth (cm)	Available nutrients											
	OC (g kg^{-1})	N	P_2O_5	K_2O	Ca	Mg	S	Fe	Mn	Cu	Zn	B
		kg ha^{-1}			mg kg^{-1} soil							
0-13	7.84	294.78	26.88	369.60	597.63	205.20	12.86	4.09	2.17	0.28	0.49	0.44
13-34	5.03	275.97	16.80	216.38	541.28	191.77	10.39	4.13	1.86	0.23	0.51	0.37
34-62	3.42	244.61	14.56	146.49	541.77	193.49	7.51	3.88	2.31	0.16	0.37	0.41
62-90	3.42	243.18	14.00	124.99	489.68	182.08	8.96	4.23	2.23	0.11	0.28	0.29
90-125	3.20	213.25	12.32	123.65	481.97	185.17	8.13	4.46	2.39	0.08	0.36	0.32
125-163	2.81	206.98	11.20	114.24	496.08	167.25	9.09	3.96	2.27	0.12	0.22	0.35
163-175	1.85	188.16	8.40	102.14	492.65	170.19	7.66	4.15	2.41	0.17	0.25	0.39

Table 4. Depthwise distribution of plant available nutrients in soil profile of Gubbi

Depth (cm)	Available nutrients											
	OC (g kg^{-1})	N	P_2O_5	K_2O	Ca	Mg	S	Fe	Mn	Cu	Zn	B
		kg ha^{-1}			mg kg^{-1} soil							
0-14	7.67	200.70	32.48	111.00	623.46	162.51	14.39	3.86	2.43	0.25	0.36	0.49
14-30	4.21	175.62	23.52	103.48	566.84	166.25	12.58	3.97	2.36	0.19	0.41	0.45
30-48	4.02	156.80	23.52	102.14	499.17	158.12	11.65	3.45	2.24	0.14	0.28	0.26
48-66	2.61	150.53	21.84	98.11	500.37	165.98	12.16	4.11	2.31	0.17	0.31	0.30
66-94	2.39	137.98	21.28	96.76	518.31	161.26	8.22	4.42	2.43	0.13	0.34	0.26
94-134	1.81	112.90	10.64	73.90	473.69	160.24	7.66	4.39	2.38	0.06	0.28	0.37
134-156	1.68	75.26	3.36	67.20	459.82	157.18	9.07	4.26	2.12	0.09	0.31	0.32

Table 5a. Plant available primary and secondary nutrients in surface soils of agricultural lands in Turuvekere

Crop	pH	EC (dSm^{-1})	OC (%)	N	P_2O_5	K_2O	S	Ca	Mg
				kg ha^{-1}			mg kg^{-1}		
Arecanut	7.91	0.15	0.60	268.80	25.39	302.21	14.88	459.05	212.29
Coconut	8.08	0.30	0.88	394.24	32.80	345.23	15.69	465.29	202.23
Paddy	7.87	0.59	0.89	398.72	24.71	239.98	14.45	411.08	196.89
Maize	8.08	0.18	1.10	492.80	36.17	223.10	15.98	430.89	193.24
Chickpea	8.23	0.43	0.58	259.84	45.05	287.12	13.46	449.16	208.18
Coriander	8.07	0.42	0.19	185.12	42.59	270.89	12.89	496.78	223.17
Banana	8.81	0.21	0.46	206.08	34.82	312.36	6.98	482.18	154.28
Salt affected barren land	9.43	1.45	0.36	161.28	19.54	235.23	15.77	577.36	214.20
Coconut	8.13	0.22	0.27	120.96	20.89	317.26	12.64	543.63	223.37
Arecanut	8.65	0.17	0.46	206.08	36.42	211.08	15.64	498.07	220.15
Mean	8.33	0.41	0.58	269.39	31.84	274.45	13.84	481.35	204.80
Range	7.87-9.43	0.15-1.45	0.19-1.1	120.96-492.8	19.54-45.05	211.08-345.23	6.98-15.98	411.08-577.36	154.28-223.37

Table 5b. Plant available micro-nutrients in surface soils of agricultural lands in Turuvekere

Crop	Fe	Mn	Zn	Cu	B
	mg kg^{-1}				
Arecanut	4.06	2.11	0.42	0.26	0.23
Coconut	4.23	2.06	0.38	0.29	0.17
Paddy	3.65	1.98	0.56	0.33	0.33
Maize	4.18	2.23	0.34	0.17	0.46
Chickpea	3.96	2.36	0.32	0.21	0.22
Coriander	3.57	2.18	0.38	0.27	0.13
Banana	4.29	2.01	0.30	0.16	0.42
Salt affected barren land	3.23	1.67	0.24	0.11	0.39
Coconut	4.45	2.21	0.28	0.22	0.38
Arecanut	4.19	2.27	0.36	0.24	0.43
Mean	3.98	2.11	0.36	0.23	0.32
Range	3.23-4.45	1.67-2.36	0.24-0.56	0.11-0.33	0.13-0.46

Table 6a. Plant available primary and secondary nutrients in surface soils of agricultural lands in Gubbi

Crop	pH	EC(dSm^{-1})	OC (%)	N	P_2O_5	K_2O	S	Ca	Mg
				kg ha^{-1}				mg kg^{-1}	
Coconut	8.16	0.07	0.21	257.25	35.04	94.34	15.33	576.17	159.23
Mango	8.11	0.05	0.38	192.19	23.52	163.17	11.17	555.25	168.41
Coconut	7.96	0.07	0.24	251.42	47.17	153.22	13.69	469.31	160.91
Coconut	7.73	0.04	0.32	203.84	31.36	103.33	7.85	472.35	162.39
Coconut	8.20	0.05	0.42	262.08	21.79	123.38	14.22	512.18	170.23
Mango	8.17	0.04	0.19	280.54	35.05	245.95	12.98	477.64	169.34
Arecanut	7.89	0.10	0.28	263.07	25.72	311.56	15.88	492.08	158.83
Arecanut	7.72	0.16	0.23	270.89	23.92	124.99	10.23	500.61	160.38
Arecanut	7.69	0.12	0.31	320.32	48.18	312.35	11.86	459.12	161.27
Coconut	7.60	0.15	0.37	256.26	35.04	223.48	10.27	444.28	164.97
Mean	7.92	0.09	0.30	255.79	32.68	185.58	12.35	495.90	163.60
Range	7.6-8.2	0.04-0.16	0.19-0.42	192.19-320.32	21.79-48.18	94.34-312.35	7.85-15.88	444.28-576.17	158.83-170.23

Table 6b. Plant available micro-nutrients in surface soils of agricultural lands in Gubbi

Crop	Fe	Mn	Zn	Cu	B
	mg kg^{-1}				
Coconut	4.35	2.39	0.27	0.23	0.34
Mango	4.11	2.12	0.31	0.28	0.41
Coconut	4.09	1.97	0.45	0.22	0.28
Coconut	3.93	2.06	0.39	0.18	0.31
Coconut	3.79	1.68	0.26	0.26	0.43
Mango	2.98	2.39	0.34	0.21	0.45
Arecanut	3.16	2.18	0.42	0.31	0.38
Arecanut	3.77	2.24	0.36	0.38	0.27
Arecanut	4.29	2.03	0.44	0.25	0.31
Coconut	4.31	2.43	0.37	0.29	0.46
Mean	3.88	2.15	0.36	0.26	0.36
Range	2.98-4.35	1.68-2.43	0.26-0.45	0.18-0.38	0.27-0.46

4. CONCLUSION

Fertility status of major coconut growing soils of Tumkur district indicated that the soils are low to medium in available N and P, and low to high in available K content. Exchangeable calcium and magnesium were found to be sufficient but available sulphur was varying from deficient to sufficient level in these soils. The DTPA extractable micronutrients *viz*., iron, manganese, zinc and boron were found to be deficient in entire study area where as copper was varying from deficient to adequate level with surface soil having comparatively more copper content than subsurface soil. The study shows that the coconut growing soils of Tumkur district are low in fertility and proper management practices are required 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. Application of suitable soil amendments has to be ensured to correct soil alkalinity. Practice of zero tillage and return of all palm residues to its base has to be done to maintain high levels of organic matter in soil. Increasing productivity of coconut has to be done by way of promoting coconut cultivation in areas which show high and moderate suitability, and restricting at marginally suitable locations.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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