Original Research Article

Soil fertility status of major coconut growing soils of Tumkur district, Karnataka

Abstract: Soil fertility status of two pedons of major coconut growing soils of Tumkur district of Karnatakaie.Turuvekere and Gubbiweredetermined. The soils were slightly to moderately alkaline 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 17.83 to 60.37 per cent, 8.71 to 28.86cmol (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 from low tohigh in different soil horizons. Analysis of secondary nutrients showed that exchangeable calcium and available sulphur was varying from deficient to sufficient levels and exchangeable magnesium was found to be deficient in both the soil pedons. Among the DTPA extractable micronutrients, iron,manganese and zincwere found to be adequate in soil horizons of both pedons~~where as~~whereas available copper and boron were found to be varying from deficient to adequate levels in these soilpedons.

Comment [w1]: Your soils pH ranges from 7.71 to 8.31.How these micronutrients are optimal in these soils?

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” (Reginald child, 1974). 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 (CDB, 2016-17) 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 (DES, 2009-10). 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 fertility. 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. 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.

Comment [w2]: Because you are concerning on soil fertility, it is better if you rewrite this sentence as: *One of the reasons for depletion of soil fertility is the extraction of nutrients by continuous cropping with low external nutrient supply, resulting in declining soil productivity*.

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 (Shivaprasad *et al.*, 1998). The present study was undertaken at Turuvekere and Gubbi in Tumkur district of Karnataka. Soils and climatic conditions of major coconut-growing areas were studied for their suitability to identify potential areas. Therefore, ~~E~~extensive field traversing was done to identify these areas. Based on the suitability assessment, Hosadurga in Chitradurga, Gubbi and Turuvekere inTumkur, 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~~.Figure 1 shows ~~the traditional~~the traditionalcoconut-growing soils of Karnataka.~~The present study was undertaken at Turuvekere and Gubbi in Tumkur district of Karnataka.~~~~Gubbi and Turuvekere~~The study areas 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 Turuvekereare classified asfine, mixed, semi-active, isohyperthermic, RhodicPaleustalfs and Gubbi asfine-loamy, mixed, semi-active, isohyperthermic, TypicRhodustalfs. Soil profiles (Pedons)of ~~these location~~these locations were studied. The soil samples were collected horizon-wise, air-dried, powdered and sieved using 2 mm sieve. Particle~~-size~~ distribution 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 (Jackson 1973). Available nitrogen was estimated by alkaline permanganate method (Subbaiah and

Formatted: Strikethrough

Formatted: Strikethrough

Comment [w3]: Fine what? It is not clear what you want to mean here. Please rewrite it again because the way you describe the soil type is somewhat not clear.

Formatted: Strikethrough

Asija, 1956). For available phosphorus determination, extraction was done using Braysextractant and then subsequent estimation by Jackson, (1973) method.

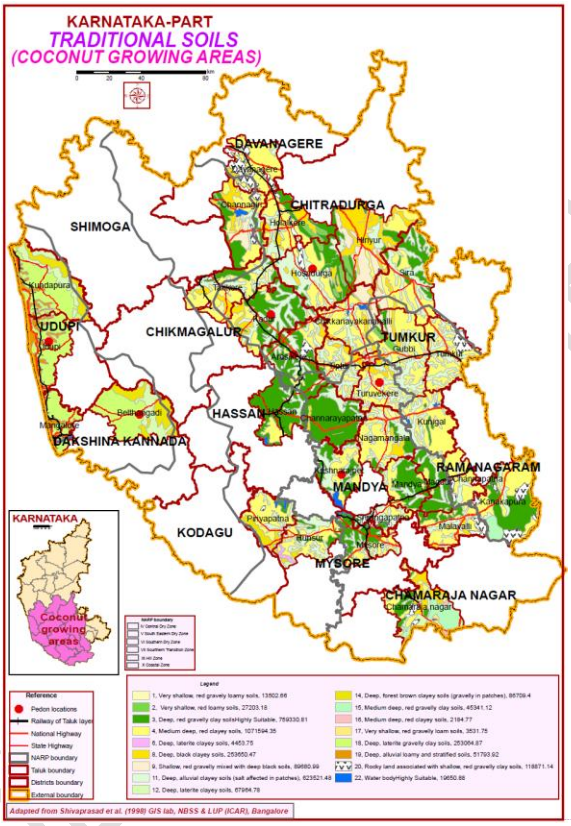

Fig. 1: Traditional coconut-growing soils of Karnataka

Comment [w4]: It is better if you add coordinates on you map.

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 extractant at pH 7.3 and the concentration was measured using atomic absorption spectrophotometer (Lindsay and Norvell, 1978).

Results and discussion

Physical and chemical properties of profile soil samples

Ranges and means of physical and chemical properties of soilpedonsof Turuvekere and Gubbi are given in table 1. Soil reaction was slightly alkaline to moderately alkalinewith pH ranging from 7.71 to 8.31 which is due to accumulation of basic salts from weathered parent materialand the soils were non-saline in nature (free of soluble salts). The organic carbon (OC) content of the soils varied from 0.16 to 0.78per cent.~~and~~It was found to be ~~high in surface soils and low in~~ low both in surface and sub-surface soils, and decreasing with increasing depth (Fig. 2). However the OC contents of the surface soils were relatively higher than sub-surface soils. This is attributed to the addition of plant residues and farmyard manure to surface horizons. The clay distribution indifferent soilhorizonsvaried from 17.83 to 60.37 per cent (Fig 3). The cation exchange capacity (CEC)estimated varied from 8.71 to 28.86cmol (~~p~~+) kg^{-1} soils 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 in different soil horizons whichindicated 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.

Comment [w5]: Not clear, are these soils acidic? This sentence is contradicting the first one. Please develop it again.

Comment [w6]: According to this percentage your study OC content is low.

Comment [w7]: Discuss each parameter accordingly by comparing and contrasting you results with others studies.

Table 1: 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 (NH_4OAc, pH 7.0)	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	17.2
Av. potassium (kg ha^{-1})	67.2-369.6	132.14
Av. sulphur (mg kg^{-1})	8.43-20.24	14.88
Ex. calcium (mg kg^{-1})	124.08-597.63	277.71
Ex. magnesium (mg kg^{-1})	17.86-105.2	47.04
DTPA extractable micronutrients		
Fe (mg kg^{-1})	4.6-10.28	7.32
Mn (mg kg^{-1})	8.6-35	16.1
Zn (mg kg^{-1})	1.04-1.96	1.42
Cu (mg kg^{-1})	0.08-2.26	0.48
B(mg kg^{-1})	0.09-0.76	0.40

Available macronutrients

Depthwise distribution of plant available nutrients in Turuvekere and Gubbisoil pedons are represented in table 2 and 3, respectively. Theavailable nitrogen (N) content in two soil pedonsvaried from 75.26 to 294.78 kg ha^{-1}throughout the depth and was rated as low to medium. Available N content was relatively found to be high 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). The available phosphorus (P_2O_5) content in the pedons varied from 3.36 to 32.48 kg $ha^{-1}$and was rated as low to medium. This is because of reaction of soilphosphorus (P) with calcium to form a sequence of products of low solubility (Mahdi *et al*, 2012). However, comparatively higher 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. 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 due 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} are low, 168 to 337 kg ha^{-1} as medium and more than 337 kg ha^{-1} as high (Srinivasamurthy*et al*., 1999). According toSrinivasamurthy*et al*., 1999, available K of this study was ranged from low to high.The available sulphur in these soils varied from 8.43 to 20.24 mg kg^{-1}. Exchangeable calcium (Ca) and magnesium (Mg)in differentof the studied soils' horizons were ranging from 124.08 to 597.63mg kg^{-1} soil and 17.86 to 105.2mg kg^{-1}soil, respectively. Some of the horizons had adequate calcium (> 300 mg kg^{-1}) due to release of calcium 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 (1993) and Alur (1994). The clay complex was dominated by exchangeable Ca in surface and sub-surface horizons of both soil profiles followed by Mg.

Comment [w8]: Is this rating is correct?

Comment [w9]: The same to N-rating

Comment [w10]: What is the rating of sulphur? The trend (is it increase with depth or decrease) you didn't discuss.

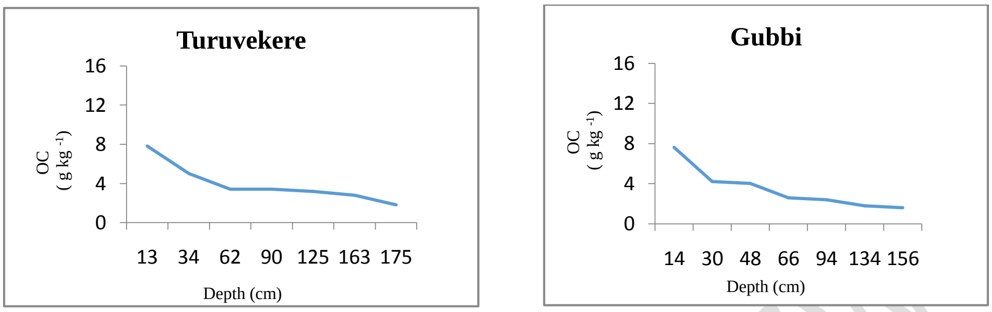

Fig. 2: Depth wise distribution of Organic carbon in two different pedons

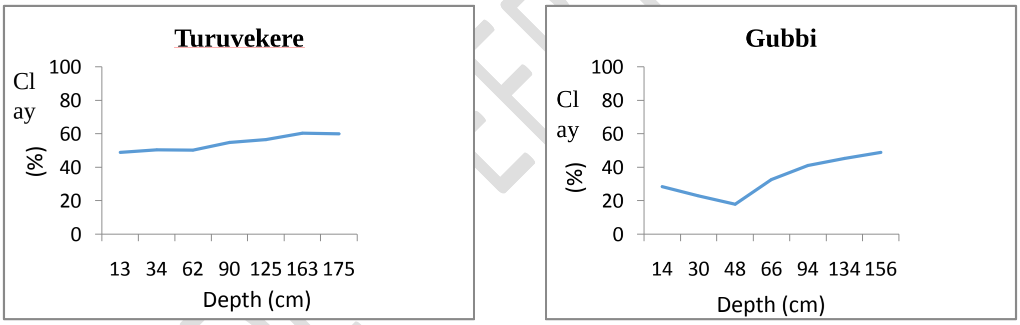

Fig. 3: Depth wise distribution of Clay in two different pedons

Table 2: Depthwise distribution of plant available nutrients insoil 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	105.20	20.24	9.66	27.26	0.80	1.96	0.54
13-34	5.03	275.97	14.56	124.99	281.60	45.25	12.65	7.28	14.90	0.32	1.70	0.76
34-62	3.42	244.61	8.40	102.14	264.00	48.77	8.43	5.86	16.20	0.08	1.36	0.37
62-90	3.42	243.18	11.20	123.65	271.37	48.11	12.65	5.78	15.14	0.08	1.32	0.28
90-125	3.20	213.25	14.00	216.38	336.38	61.20	17.71	5.42	10.24	0.12	1.48	0.09
125-163	2.81	206.98	16.80	114.24	301.62	55.59	20.24	5.18	8.60	0.46	1.44	0.65
163-175	1.81	188.16	12.32	146.49	320.87	55.15	15.18	4.60	18.36	0.12	1.26	0.33

Table 3: 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	7.64	200.70	23.52	103.48	152.35	24.46	19.40	9.98	14.02	2.26	1.38	0.65
14-30	4.22	175.62	32.48	111.00	191.95	31.61	18.55	8.78	15.06	1.32	1.38	0.45
30-48	4.02	156.80	23.52	67.20	167.09	24.46	16.87	10.28	12.24	0.74	1.28	0.26
48-66	2.61	150.53	21.84	73.90	124.08	17.86	9.28	8.96	15.58	0.14	1.26	0.30
66-94	2.41	137.98	21.28	96.76	232.32	35.90	13.49	8.42	13.00	0.10	1.78	0.26
94-134	1.81	112.90	10.64	102.14	324.17	52.51	11.81	5.70	10.08	0.08	1.18	0.37
134-156	1.61	75.26	3.36	98.11	322.63	52.51	11.81	6.62	35.00	0.12	1.04	0.32

Available micronutrients

The data on plant available micronutrients of Turuvekere and Gubbisoil profiles are presented in table 2 and 3 accordingly, respectively.The DTPA extractable Zinc (Zn)and Copper (Cu) ranged from 1.04 to 1.96 mg kg^{-1} and 0.08 to 2.26 mg2.26 mg kg^{-1} soil, respectively. The available Cu content was more in surface layers and decreased with depthin both soilprofiles, which might be due to its association with organic carbon. The DTPA extractable iron (Fe) content varied from 4.6 to 10.28 mg kg^{-1} soil. As per the critical limit given byLindsay and Norvell, 1978 i.e. 4.5 mg kg^{-1}soil,soil,both soilpedons were sufficient in available iron and it followed decreasing trend with depth in Turuvekeresoil pedon. 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). Available Manganese (Mn)was found to be adequate in both soil pedons which varied from 8.6 to 35 mg kg^{-1} soil and it followed irregular trend with depth of the soil profile. Available Boron (B) varied from 0.09 to0.76mg kg^{-1} soil and was rated as deficient to sufficient in these soils.

Comment [w11]: Poorly discussed and develop it and discuss it again.

Properties of Composite Surface Soil Samples

The pH in soil water suspension and 0.01M $CaCl_2$ ranged from 4.84 to 9.43 and 4.20 to 8.28, respectively. Electrical conductivity ranged from 0.04 to 1.45dS m^{-1}. Organic carbon ranged from 0.19 to 1.10per cent. Available N,P_2O_5andK_2Oranged from 85.12 to 492.80kg ha^{-1}, 3.36 to 48.18kg ha^{-1} and 63.17 to 325.23 kg ha^{-1} soil, respectively. Available Ca, Mg and S ranged from 78.21 to 401.19, 26.78 to 154.28 and 6.77 to 20 mg kg^{-1} soil, respectively. Available Fe, Mn, Zn, Cu and B in the soil varied from 6.12 to 71.90, 16.76 to 36.06, 0.20 to 6.16, 0.64 to 7.18 and 0.11 to 0.74 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 4.66 to 9.98 and 4.11 to 8.80, respectively. Electrical conductivity ranged from 0.04 to 1.52dS m^{-1}. Organic carbon ranged from 0.19 to 1.02 per cent. Available N,P_2O_5andK_2Oranged from 99.40 to 398.24 kg ha^{-1}, 2.74 to 54.16 kg $ha^{-1}$and 56.45 to 311.23 kg ha^{-1} soil, respectively. Available Ca, Mg and S ranged from 80.25 to 398.06, 27.48 to 149.24 and 2.98 to 17.56 mg kg^{-1} soil, respectively. Available Fe, Mn, Zn, Cu and B in the soil varied from 4.66 to 76.74, 11.26 to 36.30, 0.14 to 6.38 ,0.72 to 6.82 and 0.11 to 0.88mg kg^{-1} soil, respectively (table 5a & 5b, 7a & 7b).

Comment [w12]: Are the soils of the study areas were acidic or alkaline? Because I confused with these sentences and in abstractpart you stated that (slightly to moderately alkaline in reaction), thus which one is true?Also, what you try to discuss here on this part was somewhat vague.

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

Crop	pH	0.01 M $CaCl_2$ pH	EC (dSm^{-1})	OC (%)	N	P_2O_5	K_2O	S	Ca	Mg
					$kgha^{-1}$			$mg\ kg^{-1}$		
Arecanut	7.91	7.03	0.15	0.60	268.80	5.39	302.21	20.00	359.05	112.29
Coconut	8.08	7.38	0.30	0.88	394.24	12.80	325.23	15.69	365.29	102.23
Paddy	7.87	7.37	0.59	0.89	398.72	4.71	239.98	14.45	344.25	96.89
Maize	8.08	7.22	0.18	1.10	492.80	16.17	223.10	15.98	312.21	93.24
Chickpea	8.23	7.59	0.43	0.58	259.84	5.05	287.12	13.46	280.93	108.18
Coriander	8.07	7.30	0.42	0.19	85.12	42.59	270.89	12.89	362.51	123.17
Banana	8.81	7.67	0.21	0.46	206.08	14.82	312.36	6.98	401.19	154.28
Salt affected barren land	9.43	8.28	1.45	0.36	161.28	19.54	235.23	15.77	377.61	114.20
Coconut	8.13	7.52	0.22	0.27	120.96	20.89	317.26	12.64	341.19	123.37
Arecanut	8.65	7.67	0.17	0.46	206.08	6.42	211.08	15.64	311.18	120.15
Mean	**8.32**	**7.50**	**0.41**	**0.58**	**259.39**	**14.84**	**272.45**	**14.35**	**345.54**	**114.80**
Range	**7.87-9.43**	**7.03-8.28**	**0.15-1.45**	**0.19-1.10**	**85.12-492.80**	**4.71-42.59**	**211.08-325.23**	**6.98-20.00**	**280.93-401.19**	**93.24-154.28**

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

Crop	Fe	Mn	Zn	Cu	B
	mg kg^{-1}				
Arecanut	14.06	23.68	0.50	2.02	0.23
Coconut	10.40	16.76	0.38	1.54	0.17
Paddy	35.32	21.70	0.56	5.90	0.33
Maize	11.34	19.38	0.34	1.94	0.56
Chickpea	29.94	18.96	0.32	7.18	0.22
Coriander	71.90	29.48	0.38	5.34	0.13
Banana	13.52	23.60	0.30	1.98	0.74
Salt affected barren land	9.90	20.98	0.24	1.96	0.61
Coconut	18.36	21.34	0.28	2.70	0.51
Arecanut	8.56	19.66	0.36	1.44	0.56
Mean	**22.33**	**21.55**	**0.37**	**3.20**	**0.41**
Range	**8.56-71.90**	**16.76-29.48**	**0.24-0.56**	**1.44-7.18**	**0.13-0.74**

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

Crop	pH	0.01 M $CaCl_2$ pH	EC (dSm^{-1})	OC (%)	N	P_2O_5	K_2O	S	Ca	Mg
					kg ha^{-1}			mg kg^{-1}		
Arecanut	7.86	7.02	0.15	0.25	130.80	6.06	268.96	16.58	344.12	95.98
Coconut	8.25	7.36	0.22	1.02	398.24	8.42	268.80	17.23	377.82	140.78
Maize	8.03	7.27	0.21	0.94	377.58	8.76	306.43	17.56	299.24	115.02
Chickpea	8.42	7.66	0.32	0.23	120.33	6.73	311.23	16.24	322.54	89.57
Coriander	8.12	7.34	0.39	0.24	125.56	38.41	310.46	11.86	347.09	94.49
Banana	8.50	7.32	0.24	0.38	198.81	7.41	248.64	7.23	398.06	149.24
Salt affected barren land	9.98	8.80	1.52	0.29	151.72	14.15	217.73	14.54	368.52	119.64
Coconut	8.03	7.24	0.17	0.22	115.10	12.85	293.20	13.11	346.43	133.69
Arecanut	8.51	7.59	0.20	0.38	198.81	5.39	168.23	17.56	317.29	119.27
Mean	**8.41**	**7.51**	**0.38**	**0.44**	**201.88**	**12.02**	**265.96**	**14.66**	**346.79**	**117.52**
Range	**7.86-9.98**	**7.02-8.80**	**0.15-1.52**	**0.22-1.02**	**115.10-398.24**	**5.39-38.41**	**168.23-311.23**	**7.23-17.56**	**299.24-398.06**	**89.57-149.24**

Table5b: Plant available micro-nutrients in sub-surface soils of agricultural lands in Turuvekere

Crop	Fe	Mn	Zn	Cu	B
	mg kg^{-1}				
Arecanut	16.56	27.16	0.44	2.46	0.28
Coconut	10.90	15.78	0.34	1.54	0.11
Maize	4.66	15.74	0.18	1.02	0.45
Chickpea	46.76	26.60	0.66	6.82	0.17
Coriander	76.74	31.88	0.40	5.40	0.66
Banana	12.36	18.00	0.28	1.90	0.49
Salt affected barren land	10.62	20.36	0.22	2.02	0.34
Coconut	18.20	18.36	0.30	2.72	0.42
Arecanut	6.82	11.26	0.14	1.58	0.33
Mean	**22.62**	**20.57**	**0.33**	**2.83**	**0.36**
Range	**4.66-76.74**	**11.26-31.88**	**0.14-0.66**	**1.02-6.82**	**0.11-0.66**

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

Crop	pH	0.01 M $CaCl_2$ pH	EC (dSm^{-1})	OC (%)	N	P_2O_5	K_2O	S	Ca	Mg
					$kgha^{-1}$			$mg\ kg^{-1}$		
Coconut	8.17	7.14	0.06	0.27	157.25	35.04	294.34	18.42	260.78	89.31
Mango	5.43	4.60	0.04	0.33	192.19	3.52	63.17	7.50	102.89	35.24
Coconut	7.03	6.19	0.08	0.26	151.42	47.17	153.22	19.63	177.96	60.95
Coconut	6.05	5.45	0.05	0.35	203.84	3.36	83.33	12.57	160.12	54.84
Coconut	7.12	6.28	0.05	0.45	262.08	11.79	223.38	13.95	211.52	72.44
Mango	4.84	4.20	0.04	0.31	180.54	5.05	245.95	7.50	78.21	26.78
Arecanut	7.14	6.60	0.10	0.28	163.07	5.72	311.56	16.77	185.38	63.49
Arecanut	7.72	7.03	0.16	0.26	151.42	23.92	124.99	9.79	290.25	99.40
Arecanut	7.51	6.90	0.12	0.55	320.32	48.18	312.35	10.28	215.05	73.65
Coconut	8.22	7.36	0.18	0.44	256.26	35.04	323.48	6.77	277.82	95.14
Mean	**6.92**	**6.17**	**0.09**	**0.35**	**203.84**	**21.88**	**213.58**	**12.32**	**196.00**	**67.12**
Range	**4.84-8.22**	**4.20-7.36**	**0.04-0.18**	**0.26-0.55**	**151.42-320.32**	**3.36-48.18**	**63.17-323.48**	**6.77-19.63**	**78.21-290.25**	**26.78-99.40**

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

Crop	Fe	Mn	Zn	Cu	B
	mg kg^{-1}				
Coconut	6.12	24.46	0.84	1.40	0.28
Mango	27.86	33.00	0.44	1.10	0.53
Coconut	18.92	27.08	0.38	1.30	0.74
Coconut	11.98	31.34	0.54	1.26	0.48
Coconut	19.24	27.32	0.36	1.10	0.39
Mango	16.84	29.22	0.20	0.64	0.28
Arecanut	13.70	33.54	3.52	1.18	0.41
Arecanut	14.52	28.94	6.16	1.16	0.22
Arecanut	13.60	36.06	2.20	1.14	0.11
Coconut	11.60	25.86	0.52	1.18	0.22
Mean	**15.44**	**29.68**	**1.52**	**1.15**	**0.37**
Range	**6.12-27.86**	**24.46-36.06**	**0.20-6.16**	**0.64-1.40**	**0.11-0.74**

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

Crop	pH	0.01 M $CaCl_2$ pH	EC (dSm^{-1})	OC (%)	N	P_2O_5	K_2O	S	Ca	Mg
					kg ha^{-1}			mg kg^{-1}		
Coconut	8.16	7.16	0.07	0.21	109.87	41.11	243.26	15.33	272.26	93.24
Mango	5.04	4.30	0.05	0.38	198.81	2.74	56.45	5.30	96.52	33.05
Coconut	6.30	5.54	0.07	0.24	125.56	11.12	81.98	15.69	159.98	54.79
Coconut	6.27	5.58	0.04	0.32	167.42	4.14	102.12	7.85	179.87	61.60
Coconut	7.23	6.40	0.05	0.42	219.74	4.38	188.65	14.22	219.67	75.23
Mango	4.66	4.11	0.04	0.19	99.40	6.40	165.34	2.98	80.25	27.48
Arecanut	7.67	6.74	0.10	0.28	146.49	6.26	220.21	15.69	225.87	77.35
Arecanut	7.72	7.07	0.16	0.23	120.33	37.45	91.39	10.23	288.69	98.87
Arecanut	7.43	6.84	0.12	0.31	162.19	54.16	276.52	11.86	220.91	75.65
Coconut	7.60	6.83	0.15	0.37	193.58	44.49	289.37	5.86	265.19	90.82
Mean	**6.80**	**6.05**	**0.08**	**0.30**	**154.34**	**21.23**	**171.53**	**10.50**	**200.92**	**68.81**
Range	**4.66-8.16**	**4.11-7.16**	**0.04-0.16**	**0.19-0.42**	**99.40-219.74**	**2.74-54.16**	**56.45-289.37**	**2.98-15.69**	**80.25-288.69**	**27.48-98.87**

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

Crop	Fe	Mn	Zn	Cu	B
	mg kg^{-1}				
Coconut	6.00	24.74	0.86	1.34	0.49
Mango	26.22	32.76	0.48	1.06	0.88
Coconut	15.94	36.30	1.14	1.06	0.69
Coconut	13.16	34.76	0.82	1.10	0.55
Coconut	16.96	29.24	0.46	1.04	0.23
Mango	17.38	31.36	0.30	0.72	0.46
Arecanut	14.90	35.10	4.66	1.22	0.23
Arecanut	14.62	32.66	6.38	1.06	0.13
Arecanut	13.78	29.38	2.64	1.08	0.18
Coconut	8.60	13.00	0.48	0.92	0.29
Mean	**14.76**	**29.93**	**1.82**	**1.06**	**0.41**
Range	**6.0-26.22**	**13.0-36.30**	**0.30-6.38**	**0.72-1.34**	**0.13-0.88**

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 lowto high in available K in surface and subsurface soil horizons. Exchangeable magnesium remained low whereas exchangeable calcium and available sulphur were varying from deficient to adequate levels throughout the soil horizons. With respect to micronutrients, iron, manganese and zinc were found to be adequate in different soil horizons whereas available copper and boron were found to be varying from deficient to adequate levels.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.

References:

Alur, A. S., 1994, Properties of red soils of agro-climatic zone-3 (region-II) of north Karnataka. *M. Sc. (Agri.) Thesis*, Univ. Agric. Sci., Dharwad, Karnataka (India) and black soils in north Karnataka. *J. Indian Soc. Soil Sci.*, **49** (2): 301-309.

Coconut Development Board (CDB) 2016-17. Coconut Development Board coconutboard.nic.in/Statistics.aspx.

Department of Economics and Statistics (DES) 2009-10. Department of Economics and Statistics-Coconut Statistics, Bengaluru, Karnataka, India. https:// eands.dacnet.nic.in/.

Jackson, M. L. 1973. *Soil Chemical Analysis.* Prentice Hall, Inc. Eagle Wood Cliffs, N.J., USA. 498p.

Krishnamurthy, K. G., 1993, Properties genesis and classification of red soil of north Karnataka. *M. Sc. (Agri.) Thesis*, Univ. Agric. Sci., Dharwad, Karnataka (India).

Lindsay, W.L. and Norvell, W.A. 1978. Development of a DTPA soil test for zinc, iron, manganese and copper. *SoilScience Society of America Journal* **42**: 474-481.

Mahdi, S. S. Talat, M. A., Dar, M. H., Hamid, A. and Ahmad, L. 2012, Soil Phosphorus fixation chemistry and role of phosphate solubilizing bacteria in enhancing its efficiency for sustainable cropping- A review, *Journal of pure and applied microbiology*,**6** (4):1905-1911.

Prasad, R. and Sakal, R. 1991. Availability of Fe in calcareous soils in relation to soil properties. *Journal of the IndianSociety of Soil Science* **39**: 658-661.

Reginald Child, 1974, *Coconuts*, Longman publication, London, Britain. pp. 62-91.

Shivaprasad, C. R., Reddy, R.S., Seghal, J. and Velayutham, M. 1998. Soils of Karnataka for optimizing land use. ICAR-National Bureau of Soil Survey and Land Use Planning, Nagpur, *NBSS publication* **47**b**.** p. 15.

Srinivasamurthy, C.A., Chidanandappa, H.M. and Nagaraja, M.S. 1999. *Laboratory Manual for Methods of Soil Analysis*. Department of Soil Science and Agricultural. Chemistry, College of Agriculture, UAS, GKVK, Bangalore -65

Srinivasan,R., Natarajan,A.,Kalaivanan, D. andAnil kumar, K.S., Soil fertility status of cashew growing soils of dakshinakannada district of coastal karnataka *Journal of Plantation Crops*, 2013, **41** (3) : 373-379

Subbaiah, B.V. and Asija, G.L. 1956. A rapid procedure for estimation of available nitrogen in soils. *CurrentScience* **25**: 259-260.