

CHARACTERISTICS OF COCONUT SOILS OF INDIA

1. MORPHOLOGY, SOME PHYSICO-CHEMICAL CHARACTERISTICS AND TAXONOMY

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ABSTRACT

On the West Coast of India, coconut is grown on laterites, coastal sand and red sandy loam, on the East Coast on deltaic alluvium, coastal sandy areas, and on localised patches of red and black soils in the interior areas. The morphological and some of the physico-chemical characteristics of typical coconut growing soils from different agro-climatic regions of India have been discussed. The soils studied can be classified under Alfisols, Entisols, Ultisols and Vertisols and a classification upto sub-group level has been attempted under 'Soil Taxonomy'.

INTRODUCTION

Coconut, though essentially a tree crop of the humid tropics, is versatile in its adaptability to a wide range of soil and climatic conditions. Currently, it is grown in an area of 1.1 million ha in the country, of which the West Coast accounts for nearly 87%. It is grown under highly heterogenous conditions of soil, ranging from littoral sand to clay, in situations from poorly drained low lying marshes to well drained uplands and hillslopes and in strongly acid to highly calcareous coral soils. Earlier, Sankarasubramoney *et al.* (1954), Pandalai (1953), Menon and Pandalai (1958), and Sankaranarayanan and Velayudham (1976) had dealt with some aspects of coconut soils of a few selected or problem areas. The information available on a country wide basis on these soils is very scanty. So far no systematic study on the characteristics of the various coconut soils of our country has been made. As a first step, the morphological and some of the physico-chemical characteristics of these soils are discussed in this paper. An attempt has also been made to study their taxonomy.

MATERIAL AND METHODS

Twelve typical soil profiles, representing the major coconut growing tracts of Kerala, Karnataka, Tamil Nadu, Andhra Pradesh, Maharashtra, Orissa, West Bengal, Assam, Andaman and Nicobar Islands and Lakshadweep were studied for their morphological and some physico-chemical characteristics by the accepted standard procedures (A.O.A.C., 1950; Jackson, 1958; Dewis and Freitas, 1970).

The morphological features of the soils are presented below. (field data like location, physiography, drainage, etc. are presented in Table 1).

KERALA

I(a). NENMANDA (NENMANDA SERIES) KOZHIKODE, KERALA

Horizon	Depth (cm)	Description
Ap	0-12	Yellowish red (5 YR 4/6) dry; reddish brown (5 YR 4/4) moist; gravelly clay; weak medium granular; moist friable; slightly sticky when wet; pH 5.0; moderately rapid permeability; abundant roots; diffuse smooth boundary.
B ₂₁	12-50	Yellowish red (5 YR 4/6) dry; Red (2.5 YR 4/6) moist; gravelly clay; medium moderate sub angular blocky, breaking to granular; moist friable, wet slightly sticky and slightly plastic; plenty of ferruginous concretions; pH 5.2; moderate permeability; few roots; clear smooth boundary.
I ₂	50-91	Red (2.5 YR 4/6) dry; dark red (2.5 YR 3/6) moist; gravelly clay; medium moderate subangular blocky, breaking to granular; plenty of ferruginous concretions; pH 5.3; moderate permeability; clear smooth boundary.
C	91-180+	Plinthite

Table 1. Field data of the soils studied

No.	Location	Physiography	Topography	Drainage	Parent material	Ground water	Rainfall (mm)	Vegetation
Kerala								
1.	Kozhikode Nenmanda	Upland	Undulating	Well drained	Gneissic rock	10 m	3200	Coconut (RF)*
2.	Trivandrum Tiruvallam Pachalur Vellayani	Upland	Gently sloping to flat	Well drained	Colluvial	8 m	3200	Coconut (RF)
3.	Quilon Karunagapally Onattukara	Low land	Very gently sloping	Excessively drained	Marine alluvium	3 m	2800	Coconut (RF)
Tamil Nadu								
4.	Thanjavur Thiruthurai- poondi Muthupet	Coastal plain upland	Flat	Imperfectly drained	Coastal alluvium	6 m	1298	Coconut (RF)
Karnataka								
5.	South Kanara Vittal	Upland	Undulating	Well drained	Granite gneisses	5 to 20 m	3820	Coconut (RF)
Andhra Pradesh								
6.	West Godavari Narasapur Madhavapalam	Coastal plain upland	Flat	Somewhat poorly drained	Alluvium	1 to 3 m	1081	Coconut (RF)
Maharashtra								
7.	Ratnagiri Dapoli	Upland	Flat to undulating	Well drained	Basalt	8 m	2508	Coconut (RF)

PLACROSYM-1

Orissa								
8.	Ganjam Prayagi	Coastal plain	Flat to undulating	Excessively drained	Aeolean and marine deposits	1 m	1100-1350	Coconut (RF)
West Bengal								
9.	24 Parganas Mathurapur	Flood plains	Flat	Moderately well drained	Alluvium	1.5 to 3m	1164	Coconut (RF)
Assam								
10.	N. bank of Brahmaputra Korara	Flood plains of Brahmaputra	Flat	Well drained	Alluvium	2981	Coconut (RF)
Andaman Island								
11.	Carbyn's cove valley	Coastal plain	Flat	Excessively drained	Marine alluvium	3 to 4 m	3250	Coconut (RF)
Lakshadweep								
12.	Minicoy	Coastal upland	Flat	Well drained	Coral formations	1.6 m low tide; 0.82 m high tide	1742	Coconut (RF)

* RF—Rainfed

COCONUT SOILS OF INDIA

I(b). KARUNAGAPALLY (ONATTUKARA SERIES)
QUILON, KERALA

Horizon	Depth (cm)	Description
	0-10	Dark grey (10 YR 4/1) dry; dark greyish brown (10 YR 3/2) moist; sand; weak medium granular; dry loose, moist very friable, non calcareous; pH 4.3; very rapid permeability; abundant fine and coarse roots; clear smooth boundary.
	10-63	Dark brown (10 YR 6/3) dry; yellowish brown (10 YR 5/4) moist; sand; weak medium granular; moist very friable; pH 4.4; very rapid permeability; abundant coarse roots; clear smooth boundary.
	63-116	Light yellowish brown (10 YR 6/4) moist; sand; structureless; moist very friable; pH 5.4; very rapid permeability; few coarse roots; clear smooth boundary.
	116-180	Brownish yellow (10 YR 6/6) dry; yellowish brown (10 YR 5/6) moist; sand; structureless; moist friable; pH 5.2; very rapid permeability.

I(c). PACHALUR (VELLAYANI SERIES), KERALA

Horizon	Depth (cm)	Description
Ap	0-22	Weak red (10 R 4/4) dry; sandy loam; weak medium granular; dry slightly hard, moist friable, wet slightly sticky and non plastic; pH 5.6; non calcareous; rapid permeability; many fine roots; clear smooth boundary.
B ₁₁	22-55	Red (10 R 4/8) dry; sandy loam; massive; moist very friable; pH 4.2; rapid permeability; few fine roots; diffuse smooth boundary.

B ₁₂	55-180	Red (10 YR 4/6) dry; sandy loam; massive; moist very friable; pH 3.7; rapid permeability; diffuse boundary.
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KARNATAKA

II. VITTAL, SOUTH KANARA, KARNATAKA

Horizon	Depth (cm)	Description
A _c	0-8	Strong brown (7.5 YR 5/8) dry; gravelly sandy clay loam; weak medium granular; dry slightly hard, moist friable; pH 5.4; rapid permeability; many fine roots; clear smooth boundary.
B ₂₁	8-26	Reddish yellow (7.5 YR 6/6) dry; gravelly sandy clay loam; weak medium subangular blocky; dry hard, moist firm, wet slightly sticky and non plastic; ferruginous concretions; pH 5.4; moderate permeability; many roots; diffuse boundary.
B ₂₂	26-75	Reddish yellow (7.5 YR 6/6) dry; gravelly clay; moderate medium subangular blocky; dry hard, moist firm, plenty of ferruginous concretions; pH 5.9; moderate permeability; clear smooth boundary.
B ₂₃	75-180	Reddish yellow (5 YR 7/8) dry; gravelly clay; dry hard; moist firm; plenty of ferruginous concretions; pH 5.3; no roots; slow permeability.

TAMILNADU

III MUTHUPET, THANJAVUR (KALLIVAYAL SERIES),
TAMILNADU

Horizon	Depth (cm)	Description
Ap	0-15	Greyish brown (10 YR 5/2) moist; loamy sand; dry slightly hard, moist firm; pH 8.6; moderate permeability; non calcareous; abundant roots; clear smooth boundary.

- B₁** 15-55 Greyish brown (10 YR 5/2) moist; sandy clay loam; medium moderate sub angular blocky; faint few grey and yellow mottlings; dry slightly hard, moist friable, wet slightly sticky and slightly plastic; pH 8.0; moderate permeability; few roots; localised effervescence; gradual smooth boundary.
- B₂₂** 55-103 Dark grey (10 YR 4/7) moist; sandy clay loam; coarse sub angular blocky; distinct common yellow and grey mottles; dry hard, moist firm, wet sticky and plastic; localised effervescence; pH 6.5; moderately slow permeability; clear smooth boundary.
- BC** 103-135 Light brownish grey (10 YR 6/2) moist; sandy clay loam; moderate medium sub angular blocky; distinct few yellow and red mottles; dry hard, moist firm, wet sticky and plastic; moderately slow permeability; pH 6.0; clear smooth boundary.

ANDHRA PRADESH

IV. MADHAVAPALAM, WEST GODAVARI, ANDHRA PRADESH

Horizon	Depth (cm)	Description
Ap	0-20	Dark grey brown (10 YR 3/2) moist; sandy clay; strong medium granular structure; dry slightly hard, moist firm, wet sticky and plastic; pH 7.0; many fine roots; clear smooth boundary.
As	20-60	Dark grey (10 YR 4/1) dry; very dark greyish brown (10 YR 3/2) moist; clay; strong angular blocky; dry hard, moist very firm, wet sticky and plastic; pH 7.6; slickensides non intersecting; slow permeability; calcium carbonate shells; many roots; clear smooth boundary.

- C₁** 60-93 Dark grey brown, (10 YR 4/2) dry; very dark greyish brown (10 YR 3/2) moist; sandy clay; coarse many yellowish brown (5 YR 5/8) mottles; strong angular blocky; pressure faces; dry very hard, moist firm, wet sticky and plastic; pH 7.8; sand pockets; slow permeability; calcium carbonate shells; diffuse boundary.
- C₂** 93-130+ Dark greyish brown (10 YR 4/2) dry; very dark greyish brown (10 YR 3/2) moist; clay; angular blocky; dry very hard, moist firm, wet sticky and plastic; pH 7.7; slow permeability; many fine roots.

MAHARASTRA

V. DAPOLI, RATNAGIRI, MAHARASHTRA

Horizon	Depth (cm)	Description
Ap	0-30	Dark reddish brown (2.5 YR 3/4) dry; clay; moderate coarse sub angular blocky; dry hard, moist firm, wet sticky; non calcareous; pH 5.8; moderately rapid permeability; many coarse roots; clear smooth boundary.
B ₂	30-75	Dark red (2.5 YR 3/6) moist; clay; medium moderate sub angular blocky; dry slightly hard, moist friable; wet sticky and plastic; pH 5.9; rapid permeability; diffuse to wavy boundary.
B ₃	75-180	Red (2.5 YR 4/6) moist; gravelly clay; moderate medium sub angular blocky, breaking to granular; moist friable, wet slightly sticky and non plastic; 80 per cent ferruginous concretions; pH 5.9; rapid permeability; diffuse boundary.

ORISSA

VI. PRAYAGI, GANJAM, ORISSA

Horizon	Depth (cm)	Description
	0-30	Light yellowish brown (10 YR 6/4) dry; sand; structureless; dry loose; pH 5.9; rapid permeability; few fine roots; abrupt smooth boundary.
	30-95	Brownish yellow (10 YR 6/6) moist; sand; structureless; moist loose; pH 6.4; very rapid permeability; no roots; clear smooth boundary.
	95-145	Brownish yellow (10 YR 6/6) moist; sand; structureless; moist loose; pH 6.4; very rapid permeability; no roots; clear smooth boundary.
	145-180+	Brownish yellow (10 YR 6/8) moist; coarse sand; structureless; loose consistency; pH 6.7; very rapid permeability.

WEST BENGAL

VII. MATHURAPUR, 24 PARAGANAS, WEST BENGAL

Horizon	Depth (cm)	Description
	0-12	Olive grey (5 Y 5/2) dry; very dark greyish brown (2.5 Y 3/2) moist; sandy loam; medium sub angular blocky, breaking to crumbs; dry slightly hard; slight effervescence; pH 7.9; moderately rapid permeability; many roots; clear smooth boundary.
	12-60	Pale olive (5 Y 6/3) dry; dark greyish brown (2.5 Y 3/2) moist; sandy clay; weak medium sub angular blocky; dry slightly hard; slight effervescence; pH 7.8; few roots; diffuse boundary.

60-180+ Pale olive (5 Y 6/3) dry; dark greyish brown (2.5 Y 4/2) moist; sandy clay; moderate medium sub angular blocky; dry slightly hard, moist firm; few CaCO₃ concretions; pH 8.0; diffuse boundary.

ASSAM

VIII. KORARA (NORTH BANK OF BRAHMAPUTRA), ASSAM

Horizon	Depth (cm)	Description
	0-16	Light grey (10 YR 7/2) dry; sandy loam; weak moderate sub angular blocky; wet non sticky and non plastic; pH 5.8; non calcareous; common fibrous roots; diffuse boundary.
	16-45	Light grey (10 YR 7/2) dry; sandy clay loam; moderate sub angular blocky; wet non sticky and non plastic; pH 5.7; moderately rapid permeability; few fine roots; diffuse boundary.
	45-100	Very pale brown (10 YR 7/3) dry; yellowish moderate sub angular blocky; clay; wet non sticky and non plastic; pH 6.1; moderately rapid permeability; diffuse boundary.
	100-150	Very pale brown (10 YR 7/3) dry; yellowish brown (10 YR 5/4) moist; clay loam; weak medium angular blocky; wet non sticky and non plastic; few ferromagnesium concretions; pH 6.4; clear wavy boundary.

ANDAMAN AND NICOBAR ISLANDS

IX. CARBYN'S COVE, ANDAMAN DISTRICT, ANDAMAN ISLANDS

Horizon	Depth (cm)	Description
A	0-20	Dark greyish brown (10 YR 4/2) dry; dark yellowish brown (10 YR 4/4) moist;

sand; structureless; dry loose; slight localised effervescence; few fine shells; pH 8.7; rapid permeability; many roots; clear boundary.

II	20-55	Light yellowish brown (10 YR 6/4) dry; dark yellowish brown (10 YR 4/4) moist; sand; structureless; dry and moist loose; no carbonate; pH 7.1; rapid permeability; clear smooth boundary.
III C ₁	55-93	Light yellowish brown (10 YR 6/4) dry; yellowish brown (10 YR 5/4) moist; sand; structureless; loose; coarse calcium carbonate shells; pH 8.9; rapid permeability; clear smooth boundary.
III C ₂	93-115	Light grey (10 YR 7/2) dry; light brownish grey (10 YR 6/2) moist; sand; structureless; loose; localised violent effervescence; pH 8.5; rapid permeability.

LAKSHADWEEP ISLANDS

X. CPCRI REGIONAL STATION, MINICOY, LAKSHADWEEP ISLANDS

Horizon	Depth (cm)	Description
A ₁	0-13	Greyish brown (10 YR 5/2); sandy (comprises entirely of fine pieces of coral); loose; structureless; violent effervescence; rich in organic matter; many coarse fibrous roots; pH 7.9; rapid permeability; clear smooth boundary.
A ₂₁	13-20	Light grey (10 YR 7/2) dry; sand (entirely of fine pieces of coral); strong effervescence; lumps of coral embedded; pH 8.3; few roots; rapid permeability; clear smooth boundary.

A ₂₂	20-50	Light grey (10 YR 7/1) dry; sand (entirely of fine pieces of coral); dry and moist loose; weak coarse crumbs; violent effervescence; pH 8.3; rapid permeability; clear smooth boundary.
A ₂₃	50-70	Light grey (10 YR 7/2) dry; sand (entirely of fine pieces of coral); coral nodules; weak coarse crumbs with organic matter streaks; rapid permeability; violent effervescence; pH 8.3; abrupt smooth boundary.
C ₁	70-90	Light grey (10 YR 7/2) dry; hard pan of weathered coral; slow permeability; pH 8.2; clear smooth boundary.
C ₂	90-103	White (10 YR 8/1) dry; sand (entirely of fine pieces of coral) structureless; loose; very rapid permeability; pH 8.7; violent effervescence.

RESULTS AND DISCUSSION

The analytical data are presented in Tables 2 and 3.

In Kerala, coconut is cultivated in almost all soil types viz., laterites, red sandy loams, coastal sandy soils, 'kari soils' and on the made up soils of low lying areas. The laterite soil is gravelly clay in texture, very deep, strongly acidic, well drained with abundant ferruginous concretions in subsoil which grades to a plinthite. These soils are derived from the archaic gneiss.

The next major tract on which coconut is cultivated, is the coastal belt which is sedimentary formation, known as Varkalai series, extending from Varkalai in the south to Kasaragod in the north. It is littoral sand, very deep, excessively drained with little stratification and profile development.

The red sandy loams, said to be transported soils which have undergone a process of imperfect laterization (Koshy and Thomas Varghese, 1972), occupy the area next to coastal sandy.

Table 2. Analytical data of the profiles studied

No.	Location	Horizon depth (cm)	pH (1:2.5)	EC micro-mhos/cm	Org. C%	CaCO ₃ %	Mechanical fractions				Available nutrient (ppm)		K fixation me/100g
							Clay %	Silt %	C. sand %	F. sand %	P	K	
I. Kerala													
1.	Nenmanda	0-12	5.0	50	0.99	—	52.20	13.3	9.1	14.1	16.1	63	0.103
2.		12-50	5.2	37	1.61	—	61.30	12.4	4.4	16.7	4.9	50	
3.		50-91	5.5	37	0.81	—	75.69	—	3.8	13.2	—	30	
4.		—	—	—	—	—	—	—	—	—	—	—	
5.	Vellayani	0-22	5.6	164	0.93	—	18.32	0.8	10.1	67.8	—	30	0.803
6.		22-55	4.2	388	0.42	—	17.24	0.3	11.9	66.4	—	25	
7.		55-180	3.7	777	0.34	—	18.53	1.0	11.1	66.3	—	98	
8.	Onattukara	0-10	4.3	547	0.44	—	2.60	1.6	—	95.8	59.4	30	0.059
9.		10-63	4.4	460	0.31	—	0.60	—	—	99.4	57.8	8	
10.		63-116	5.4	27	0.23	—	1.70	2.6	—	95.7	27.4	7	
11.		116-180	5.2	19	0.14	—	—	—	—	99.4	29.9	8	
II. Karnataka													
12.	Vittal	0-8	5.4	50	2.82	—	23.56	13.7	8.1	44.4	—	58	0.143
13.		8-26	5.4	43	1.11	—	32.06	9.5	7.4	40.6	0.8	44	
14.		26-75	5.9	22	0.89	—	51.58	10.6	5.9	25.8	—	34	
15.		75-180	5.3	34	0.61	—	50.75	14.3	5.2	24.9	—	25	

Table 2. (contd.)

III. Tamil Nadu													
16.	Muthupet	0-15	8.6	90	0.24	0.01	9.32	2.4	17.0	67.7	3.32	115	0.075
17.		15-55	8.0	128	0.25	..	30.98	6.0	7.9	52.9	1.10	115	
18.		55-103	6.5	252	0.12	..	33.32	3.8	8.5	50.9	—	115	
19.		103-135	6.2	280	0.14	..	31.58	3.6	10.2	48.0	1.40	98	
IV. Andhra Pradesh													
20.	Madhavapalam	0-20	7.0	202	0.67	0.08	39.74	9.0	15.4	24.4	1.05	200	0.113
21.		20-60	7.6	230	0.41	1.34	63.60	0.1	12.0	11.8	6.65	150	
22.		60-93	7.8	547	0.25	1.18	42.45	6.4	19.4	14.2	0.70	183	
23.		93-150	7.7	331	0.31	0.57	53.32	8.7	22.3	8.9	1.01	128	
V. Maharashtra													
24.	Dapoli	0-30	5.8	62	2.67	—	52.26	17.1	0.8	8.5	—	98	0.120
25.		30-75	5.9	57	0.79	—	69.00	18.1	1.3	6.2	—	85	
26.		75-180	5.9	63	0.60	0.22	69.29	14.7	0.8	9.9	—	75	
VI. Orissa													
27.	Prayagi	0-30	5.9	20	0.09	—	—	—	—	—	15.40	30	0.080
28.		30-95	5.7	16	0.03	—	—	—	—	—	13.11	43	
29.		95-145	6.4	17	0.03	—	—	—	—	—	39.24	30	
30.		195-180	6.7	14	0.01	—	—	—	—	—	18.91	43	
VII. West Bengal													
31.	Mathurapur	0-12	7.9	547	0.88	0.36	14.18	14.7	11.5	52.5	9.97	130	
32.		12-60	7.8	489	0.47	0.40	36.63	12.0	8.2	34.8	3.50	183	
33.		60-180	8.0	633	0.27	0.42	40.39	3.3	10.3	36.7	3.67	260	

Table 2. (contd.)

No.	Location	Horizon depth (cm)	pH (1:2.5)	EC micro-mhos/cm	Org. C%	CaCO ₃ %	Mechanical fractions					Available nutrients (ppm)		K fixation me/100g
							Clay %	Silt %	C. Sand %	F. sand %	P	K		
VIII. Assam														
34.	Korara	0-16	5.8	86	0.62	0.04	6.6	14.0	—	79.4	9.97	63	0.112	
35.		16-45	5.9	86	0.73	0.02	15.6	29.0	—	55.4	2.10	68		
36.		45-110	6.1	50	0.50	0.06	31.2	36.8	—	32.0	2.30	50		
37.		110-150	6.4	52	0.36	—	11.2	26.8	—	62.0	5.10	—		
IX. Andaman Islands														
38.	Carbyn's cove	0-20	8.7	187	0.45	0.6	7.0	—	—	93.0	7.69	130	0.102	
39.		20-55	7.1	87	0.26	—	—	—	—	99.2	1.40	25		
40.		55-93	8.9	141	0.28	0.4	—	—	—	98.8	2.10	98		
41.		93-115	8.5	66	0.19	—	—	—	—	99.8	0.35	105		
X. Lakshadweep Islands														
42.	Minicoy	0-13	7.9	129	1.22	92.8	2.0	—	Coral	—	8.74	78	0.135	
43.		13-20	8.3	103	0.42	94.9	—	—	sand	—	1.75	8		
44.		20-50	8.3	84	0.19	96.6	2.1	0.4	like	—	1.40	13		
45.		50-70	8.3	172	0.76	95.8	—	—	parti-	—	2.50	8		
46.		70-90	8.2	144	1.65	92.2	—	—	cles	—	2.50	18		
47.		90-103	8.7	79	0.03	95.8	9.0	9.0	—	—	1.40	8		

Table 3. Analytical data of the profiles studied

Sl. No.	Location	Depth (cm)	Exchangeable cations me/100g				Exch. acidity me/100g	Exch. Al me/100g	Exch. H me/100g	CEC me/100g	Base saturation %	K saturation %	Ca saturation %	Mg saturation %	Ca/Mg
			Ca	Mg	K	Na									
I. Kerala															
1.	Nenmanda	0-12	—	—	0.89	—	0.625	0.0082	0.0543	11.9	26.27	7.47	22.22	—	—
2.	(laterite)	12-50	—	—	0.89	0.54	0.072	0.0082	0.0638	9.2	26.41	9.67	16.30	—	—
3.		50-91	—	—	0.89	0.11	0.028	0.0049	0.0226	6.1	49.18	14.59	32.78	—	—
4.	Vellayani	0-22	1.0	—	0.70	0.54	0.030	—	—	5.0	44.80	14.00	20.00	—	—
5.	(red sandy loam)	22-55	1.0	—	0.89	0.89	0.050	0.0003	0.0457	4.7	49.36	18.93	21.27	—	—
6.		55-180	—	—	0.70	0.70	0.053	0.0452	0.0073	3.8	18.42	18.42	—	—	—
7.	Onattukara	0-10	—	—	0.89	—	0.025	0.0048	0.0202	2.4	37.08	37.08	—	—	—
8.	(Coastal sandy)	10-63	—	—	0.76	—	0.028	0.0049	0.0226	1.9	40.00	76.19	—	—	—
9.		63-116	—	—	0.76	—	0.038	0.0063	0.0312	2.3	33.04	33.04	—	—	—
10.		116-180	—	—	0.96	—	0.023	0.0032	0.0193	1.5	78.00	64.00	—	—	—
II. Tamil Nadu															
11.	Muthupet	0-15	0.5	1.0	0.26	0.43	—	—	—	6.6	33.16	3.93	7.50	15.15	4.90
12.		15-55	7.0	3.0	0.26	1.19	—	—	—	16.9	61.83	1.53	41.42	17.75	2.33
13.		55-103	10.0	3.0	0.76	1.84	0.010	—	0.010	16.8	92.85	4.52	59.52	17.85	3.33
14.		103-135	10.0	1.5	0.89	1.52	0.005	—	0.005	15.7	88.59	5.67	63.69	9.55	6.66

Table 3. (contd.)

Sl. No.	Location	Depth (cm)	Exchangeable cations me/100g				Exch. acidity me/100g	Exch. Al me/100g	Exch. H me/100g	CEC me/100g	Base saturation %	K saturation %	Ca saturation %	Mg saturation %	Ca/Mg
			Ca	Mg	K	Na									
III. Karnataka															
15.	Vittal	0-8	1.00	—	0.58	0.11	0.015	0.0022	0.0128	5.9	33.13	16.94	9.83	—	—
16.		8-26	0.75	—	0.92	—	0.016	0.0017	0.0145	6.7	24.72	11.11	13.63	—	—
17.		26-75	1.00	0.5	0.92	0.11	0.025	0.0038	0.0212	7.1	33.84	13.98	12.86	6.90	2.02
18.		75-180	1.50	1.5	0.96	0.11	0.022	0.0004	0.0121	6.1	49.34	24.57	15.73	24.59	1.00
IV. Andhra Pradesh															
19.	Madhavapalam	0-20	20.5	7.0	0.50	0.43	—	—	—	31.5	90.25	1.50	65.07	22.22	2.92
20.		20-60	24.5	5.5	0.38	0.76	—	—	—	32.0	98.12	1.18	76.56	17.18	4.45
21.		60-93	20.5	6.0	0.45	1.08	—	—	—	30.2	92.81	1.50	67.88	19.86	3.41
22.		93-130	23.0	12.5	0.31	1.63	—	—	—	42.6	87.88	0.70	53.99	29.34	1.80
V. Maharashtra															
23.	Dapoli	0-30	4.5	2.0	0.26	0.11	0.005	—	0.005	14.3	48.04	1.81	31.46	13.98	2.25
24.		30-75	5.5	—	0.26	0.11	0.005	—	0.005	10.7	54.85	2.42	51.40	—	—
25.		75-180	6.0	—	0.26	0.11	0.005	—	0.005	10.7	59.53	2.42	56.07	—	—
VI. Orissa															
26.	Prayagi	0-30	1.0	—	0.06	0.22	0.005	—	0.005	4.8	26.66	1.25	20.83	—	—
27.		30-95	—	—	0.06	—	0.005	—	0.005	2.7	2.22	2.22	—	—	—
28.		95-145	—	—	0.06	—	0.005	—	0.005	1.4	4.28	4.28	—	—	—
29.		145-180	—	—	0.06	—	0.005	—	0.005	3.4	31.17	1.76	—	—	—

Table 3. (contd.)

VII. West Bengal															
30.	Mathurapur	0-12	6.0	1.0	0.26	0.43	—	—	—	15.0	51.25	1.73	40.00	6.60	6.06
31.		12-60	6.0	2.5	0.39	0.76	—	—	—	13.2	73.10	2.70	40.45	18.90	2.11
32.		60-180	4.5	2.5	0.64	1.52	—	—	—	13.5	90.07	4.70	33.33	40.70	0.82
VIII. Assam															
33.	Korara	0-16	3.0	—	0.19	0.11	0.005	—	0.005	7.6	43.42	2.50	39.47	—	—
34.		16-45	1.5	4.0	0.19	0.11	0.005	—	0.005	12.3	47.15	1.54	12.19	32.52	0.37
35.		45-110	5.5	3.5	0.13	0.11	0.005	—	0.005	12.3	72.86	1.00	42.63	27.13	1.57
36.		110-150	4.0	1.5	0.06	0.11	0.005	—	0.005	9.7	58.35	0.61	41.23	15.46	2.66
IX. Andaman Islands															
37.	Carbyn's cove	0-20	1.5	—	0.64	0.43	—	—	—	3.2	80.31	20.00	46.87	—	—
38.		20-55	1.5	—	0.89	0.32	—	—	—	3.2	84.68	27.81	46.87	—	—
39.		55-93	—	—	0.70	0.65	—	—	—	2.2	61.36	31.81	—	—	—
40.		93-115	1.0	—	0.70	0.43	—	—	—	2.2	96.81	31.81	45.45	—	—
X. Lakshadweep Islands															
41.	Minicoy	0-13	—	—	—	—	—	—	—	9.02	—	—	—	—	—
42.		13-20	—	—	—	—	—	—	—	4.34	—	—	—	—	—
43.		20-50	—	—	—	—	—	—	—	2.71	—	—	—	—	—
44.		50-70	—	—	—	—	—	—	—	5.00	—	—	—	—	—
45.		70-90	—	—	—	—	—	—	—	5.65	—	—	—	—	—
46.		90-103	—	—	—	—	—	—	—	1.41	—	—	—	—	—

While the laterite is fairly supplied with organic matter, the red sandy loam and coastal sandy soil are poor in it. The pH varies from 5.0 to 5.5 in the laterite, 4.3 to 5.2 in the coastal sandy and 5.6 to 6.7 in red sandy loam profiles. In general, these soils are low in available P and K. The CEC of laterite profile ranges from 11.9 on the surface to 6.1 m.e./100 g in the subsoil and similarly the CEC is low for red sandy loam (5.0–3.8 m.e./100 g) and for the coastal sandy soil it is as low as 2.4–1.5 m.e./100 g. These observations suggest kandite mineralogy of these soils. The laterite is low in exch. Ca and Na, higher in exch. K and low in exchange acidity. These contribute to the base saturation which is 26 to 49% in the profile. A similar trend is noticed in red sandy loam soils. In the coastal sandy soils potassium is the only exchangeable cation which contributes to the base saturation which is 35 to 28% in the profile studied. The average potassium fixation is 0.103 m.e./100 g. for laterite, 0.059 m.e./100 g. for coastal sandy and 0.083 m.e./100 g. for red sandy loam soils.

In Karnataka, coconut is mainly cultivated in the coastal belt of sandy and red sandy loam soils, in laterite and in the red soils of maidan area. The characteristics of the soils of maidan area are dealt with elsewhere (Murthy *et al.*, 1976). The laterite soil studied is gravelly sandy loam on the surface to gravelly clay in the subsoil, strongly acidic, very deep, moderately well drained with plenty of ferruginous concretions in the solum. It is low in potassium with traces of phosphorus and fairly rich in organic carbon. The CEC is low and varies from 5.1 to 7.3 m.e./100 g in the profile, with a mean base saturation of less than 35%. The average potassium fixation is estimated to be 0.143 m.e./100 g.

Coconut is grown in Tamilnadu in coastal and river alluviums and in the red and black soils. The major area is concentrated in Thanjavur, Tiruchirapally, Chengleput, North Arcot, Kanyakumari and Coimbatore Districts. A representative profile from the major coconut growing area of the Thanjavur is described. The soil is loamy sand to sandy clay loam in texture, moderately alkaline on the surface to neutral to slightly acidic in the subsoil. It is very deep, non calcareous and imperfectly drained. It is poor in organic carbon and available P with medium available

K status. Eventhough the CEC varies from 6.6 to 16.9 m.e./100 g, the base saturation ranges from 33 to 92 percent indicating that the soil is rich in bases. The average potassium fixing capacity is 0.075 m.e./100 g.

In Andhra Pradesh coconut is extensively cultivated in the Godavari deltaic alluvium. The soil is sandy clay to clayey in texture, neutral to alkaline in reaction, very deep, poorly drained, low in available P, high in available K and with medium organic matter status. The CEC is high and the base saturation ranges from 87 to 98%, with calcium as the dominant cation. The water table rises to about 1.3 m from surface during the rainy season resulting in water stagnation and impeded drainage. It is reported that (Tech. Bull. I, 1976, CPCRI, Kasaragod) Thattipaka disease of coconut in Andhra Pradesh is severe in black clayey soils, subject to water stagnation almost throughout the year. Soluble aluminium compounds and harmful organic acids accumulate under waterlogged conditions with serious deleterious effect on coconut palms. (Pandalai, 1953)

In Maharashtra coconut is largely grown in laterite soil in Ratnagiri district in addition to the coastal sandy tract. The laterite soil is clayey to gravelly clay, very deep, well drained and moderately acidic. It is formed over basaltic parent material of the Deccan trap. It is medium to high in organic carbon, medium in available K with traces of available P. The CEC varies from 10.7 to 14.3 m.e./100 g and the base saturation ranges from 31 to 56% with depth. Even though Ca, K, Na are present on the exchange complex, their concentration is low. The average potassium fixation is estimated to be 0.120 m.e./100 g.

In Orissa coconut is grown mainly on the coastal plains fringed with sand dunes and shallow lakes. The soil is formed here through a complicated set of geomorphological processes i.e. aeolean and marine combinations. Soil is sandy, very deep, excessively drained, moderately acidic, very poor in organic carbon, low in available K and medium to high in available P. As is common with sandy soils, the CEC is very low and varies from 1.4 to 4.8 m.e./100 g in the profile with low base saturation and traces of exchangeable cations. The average potassium fixation is 0.080 m.e./100 g.

Coconut cultivation is mainly confined to the alluvial plains in 24 Paraganas, Hoogly, Howrah and Midnapur districts. Changes in the main course of the Ganges, associated with choking up of deltaic branches and cutting up of head water supplies, contributed to the formation of these alluvial soils. The soil is sandy loam to sandy clay (and in some pockets sand embeded in the profile), very deep, moderately well drained, slightly calcareous and slightly alkaline and has no well developed genetic horizon. It is low in available P, medium in available K and fairly high in organic carbon at the surface. The CEC is medium ranging from 13.2 to 15.0 m.e./100 g and the base saturation from 51 to 91% increasing with depth in the profile. The exchange sites are dominated by the cations in the following order $Ca > Mg > Na > K$. The average potassium fixing capacity is 0.1 m.e./100 g.

In Assam, coconut is grown mainly on the flood plains formed by the alluvial deposits of the river Brahmaputra and its tributaries. The soil is sandy loam to sandy clay loam, very deep, well drained and moderate to slightly acidic in reaction. The CEC is low, ranging from 7.6 to 12.3 m.e./100 g and the average base saturation is 50% in the profile, with low contents of exch. cations, viz., Ca, Mg and K. The soil has an average potassium fixing capacity of 0.112 m.e./100 g. Soil acidity is a problem for other crops in Assam (Bora and Dass, 1972) and no adverse effect of this is reported on coconut.

The major coconut growing area in Andaman and Nicobar Islands is the coastal sandy plains. The soil is sandy, very deep, excessively drained, moderately alkaline, slightly calcareous on the surface with violent effervescence in the bottom horizon. It is poor in organic carbon, low in available P and low to medium in available K. The CEC is very low ranging from 2.2 to 3.2 m.e./100 g.

In Lakshadweep, coconut covers almost the entire cultivable land. The pedon is coral sandy, very deep, highly calcareous, well drained with fairly rich organic-surface horizons occurring on flat and very gently sloping terrains. The coral profile is greyish brown on the surface which grades to light grey with an organic matter rich layer at 50-60 cm depth and to a white substratum of partly weathered coral. The ground water fluctuates according to

the tide with the possibility of enriching the soil with nutrients and moisture. The soil is moderately alkaline with the $CaCO_3$ content varying from 92 to 96% in the profile and is low in available P and K. The CEC is 1.4 to 9.2 m.e./100 g which closely follows the trend of organic matter in the profile.

In Andhra, Tamil Nadu and parts of Orissa water logging in the coconut gardens during the rainy season is a problem. It may be due to the heavy clayey nature of the soil or the physiographic setting. In heavy clay soils periodical incorporation of river sand or addition of large amounts of organic matter can help in improving the drainage.

In many states, coconut is grown on littoral sandy tracts. Heavy rainfall, followed by moisture stress in summer and poor capacity of these soils to fix the applied nutrients, suggest a judicious application of organics, burial of cocnut husks or application of tank silt or red earth, to improve the structure and water retention of the soil. In coral soils of Lakshadweep and Nicobar islands, it is reasonable to expect that because of the strong alkaline conditions, Fe, Mn, Zn, B and Cu may become unavailable, resulting on lime induced chlorosis and other physiological disorders. Pomier (1964) suggested that by direct injection of Fe and Mn salts into adult trees the induced micronutrient deficiencies could be over come. In the East Coast, where strong gales and wind erosion are experienced, raising casuarina or eucalyptus as wind breaks will be helpful.

The coconut growing soils show poor fixation of potassium which is a very important nutrient for coconut. The dominance of kaolinite type of minerals and the preponderance of iron oxides are responsible for low potassium retention. In such soils, frequent replenishment of nutrients through fertilisers is necessary. The extent of cationic saturation of the exchange complex reveals that, the contribution of potassium to the exchange complex (K saturation) is almost negligible in all soils, except the red laterite soils of Kerala and Karnataka and the coastal sandy soils of Andhra and Andamans. While in the former (coconut soils of Andhra Pradesh, Assam, West Bengal, Maharashtra and Tamil Nadu) it is due to dominance of other cations like Ca and Mg, in the latter the comparatively high K saturation is also due to poor CEC

of these soils. It is also expected that in the soils of Andhra Pradesh, Assam, West Bengal, Maharashtra and Tamil Nadu antagonistic relationship between Ca, Mg and K is likely and K uptake from the soil may be restricted, unless replenishment with K through fertilisers is made. It is also possible that excess Ca in these soils will impair the uptake of Mg and K and particularly Mg in all the soils whenever, Ca/Mg ratio is low even though the Mg content may be high (Hesse, 1971).

The foregoing discussion suggests that coconut is grown on a variety of soils and almost all soils are medium to coarse textured with a poor buffering capacity and nutrient status except the black soils of Andhra Pradesh. It is interesting to note that coconut comes up well with luxuriant growth and heavy crop, under conditions which might appear to be not quite congenial for it. Hence, the ordinary norms of soil fertility employed for other crops may not hold good in understanding coconut nutrition. A correct understanding of the mineralogical make up of the soil, the release and fixation of nutrients, moisture retention and movement in the soil, soil-plant-root relationship and storage and mobility of nutrients in the crown may throw some light in judging the complexity of coconut nutrition. The soil ecology and the influence of climatic parameters should be properly understood, as they are possible catalysing forces of nutrient availability and enrichment of these soils.

Another aspect of nutrient availability which merits attention in coconut nutrition studies, is the possibility of direct assimilation of potassium, and possibly other nutrients, by root contact without the necessity of the nutrient getting into soil solution. This may explain the reasons for excellent crops raised in these soils which have relatively small amounts of exchangeable potassium. Yet another aspect in the study of nutrition of coconut is the understanding of the phosphate requirement of the crop with the evolutionary background of the crop (Sherman, 1971). Coconut has been growing on these soils which are comparatively low in available phosphorous and has adapted to low phosphorous requirements.

Soil Taxonomy

An attempt has been made in this paper to place coconut growing soils of India upto subgroup level in the soil taxonomy

(USDA, 1975). The guidelines proposed for Indian soils (Murthy *et al.*, 1977) has been carefully followed in attempting the classification.

Soil Studied	Taxonomy
I. Kerala	
Nenmanda (laterite)	—Oxic Haplustults
Vellayani (red sandy loam)	—Vermic Ustorthents
Onattukara (coastal sandy)	—Ustoxic Quartzipsamments
II. Karnataka	
Vittal (laterite)	—Oxic Haplustults
III. Tamil Nadu	
Muthupet (coastal alluvium)	—Typic Ochraqualfs
IV. Andhra Pradesh	
Madhavapalam (alluvium)	—Udic Chromusterts
V. Maharashtra	
Dapoli (laterite)	—Oxic Rhodustalfs
VI. Orissa	
Prayagi (sandy)	—Ustoxic Quartzipsamments
VII. West Bengal	
Mathurapur (alluvium)	—Fluentic Ustochrepts

VIII. Assam

Korara (alluvium) —Typic Ustorthents

IX. Andaman and Nicobar Islands

Carbyn's cove valley —Typic Ustipsamments

X. Lakshadweep Islands

Minicoy —Tentatively the profile can be classified as Calciustolls.

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REFERENCES

- A.O.A.C., 1950. Official and tentative methods of analysis.
- BORA, P. K. AND DAS, M. C. 1972. Soils of Assam. pp. 22-35. In *Soils of India*. The Fertiliser Association of India, New Delhi.
- DEWIS, J. AND FREITAS, F. 1970. Physical and chemical methods of soil and water analysis. *Tech. Bull. No. 10 F.A.O.*, Rome.
- HESSE, P. R. 1971. *A text book of soil chemical analysis*. John Murray, London.
- JACKSON, M. L. 1958. *Soil chemical analysis*. Prentice Hall Inc., USA.
- KOSHY M. M. AND THOMAS VARGHESE, 1972. Soils of Kerala. pp. 144-157. In *Soils of India*. The fertiliser Association of India, New Delhi.
- MURTHY, R. S., BARDE, N. K., NAGA BHUSHANA, S. R., VENUGOPAL, K. R., SHIVAPRASAD, C. R., AND HARINDRANATH, C. S. 1976. Soils of coconut garden areas in Maiden parts of Karnataka State, India, Abstract of papers—International Symposium on coconut Research and Development. Dec. 28-31, Kasaragod., S. India.
- MURTHY, R. S., SHANKARANARAYANA, H. S. AND HIREKERUR L. R. 1977. Approach to soil survey and soil classification. *J. Indian Soc. Soil Sci.* 25: 284-287.

- PANDALAI, K. M. 1953. Certain Aspects of soil suitability in relation to coconut cultivation. *Indian Cocon. J.* 6: 89-93.
- MENON, K.P.V. AND PANDALAI, K. M. 1958. *The coconut palm—A monograph* Indian Central Coconut Committee, Ernakulam.
- POMIER, M. 1964. Restoration and nutrition of coconut groves on coral soils. *Oleagineux* 19: 615-620.
- SANKARASUBRAMONEY, H., PANDALAI, K. M. AND MENON, K.P.V. 1954. Studies on soil conditions in relation to coconut soils. *Indian Cocon. J.* 5: 141-148.
- SANKARANARAYANAN, M. P. AND VELAYUTHAM, M. 1976. Coconut soils on the East Coast of India. *Cocon. Bull.* 7 (6 & 7): 13-14.
- SHERMAN, G. D. 1971. Phosphorous availability in tropical soils. *Agri. Digest* No. 23.
- U.S.D.A., 1975. *Soil Taxonomy. A basic system of soil classification for making and interpreting soil surveys*. Agril. Hand Book. No. 436. Soil Conservation Service, Washington.