a GLIMPSE to PROBLEM SOILS of Kerala

A GLIMPSE TO PROBLEM SOILS OF KERALA

Compiled by

P. Padmaja
V. L. Geetha Kumari
K. Harikrishnan Nair
N. P. Chinnamma
N. K. Sasidharan
K. C. Rajan

KERALA AGRICULTURAL UNIVERSITY
VELLANIKKARA, THRISSUR 680 654, KERALA, INDIA

English

A GLIMPSE TO PROBLEM SOILS OF KERALA

Editors :

Dr. N. MOHANAKUMARAN
Dr. N. MOHANDAS

Published by :

Dr. V. K. SASIDHAR
Director of Extension i/c
Kerala Agricultural University
Mannuthy 680 651, Thrissur, Kerala

Cover design :

V. CHANDRANANDAN
College of Agriculture, Vellayani

Typesetting & Layout :

P. SREEKUMAR
NARP (SR), Vellayani

Printed at :

SB PRESS,
College Lane, Statue,
Thiruvananthapuram 695 001
Telephone: (0471) 71904

FOREWORD

Soils of Kerala with features peculiar to them, pose several problems. Heavy rainfall and high temperature associated with humid tropical climate, poor drainage, organic matter accumulation resulting in acidity, salinity due to sea water ingress etc. are the conditions to which the soils are exposed to. Research works in such soils eventhough carried out for the last seventy years, have not yet been properly documented. This has handicapped the planning of research and developing of proper location specific agrotechniques for such soil types.

The scientists associated with this publication have shown keen interest to survey the literature and compile the same to the extent possible. It is hoped that this publication will serve as a reference book for research planning and proper utilization of the information for the management of these soils. Morphological, physical and chemical properties of each soil type have been well described and the management practices based on the research work carried out in these soils were thoroughly discussed.

I appreciate the good and dedicated work carried out by our scientists and hope that this piece of work is of immense use to persons engaged in research, teaching and extension activities in the field of agriculture.

Dr. A. M. Michael
Vice Chancellor
Kerala Agricultural University

PREFACE

Kerala with its humid tropical climate poses soil problems of various kinds. Better knowledge of these soils is highly warranted for the successful soil management. This work is attempted with a view to serve as a guide for research and extension workers for planning and execution of future agricultural programmes. Materials used for this publication had been collected from different post graduate theses and basic records of various research stations of KAU. Only local names of the soils are furnished since taxonomic classification of the soils mentioned in this publication is not yet complete and majority of the authors of the references cited have used only local names. Being the first attempt in this line, discrepancies might have crept in and all types of suggestions are welcome to improve this publication.

P. PADMAJA
(on behalf of co-authors)

ACKNOWLEDGEMENTS

The authors express their deep indebtedness to Dr. M. Aravindakshan, Director of Research, Kerala Agricultural University for the keen interest bestowed by him and providing all facilities for the preparation of this publication.

We place on record our gratitude to Dr. C. Sreedharan, Dean, Faculty of Agriculture for his constant and untiring encouragement. Valuable suggestions, help and guidance offered by Dr.N. Mohanakumaran, Associate Director, NARP (Southern Region) are gratefully acknowledged.

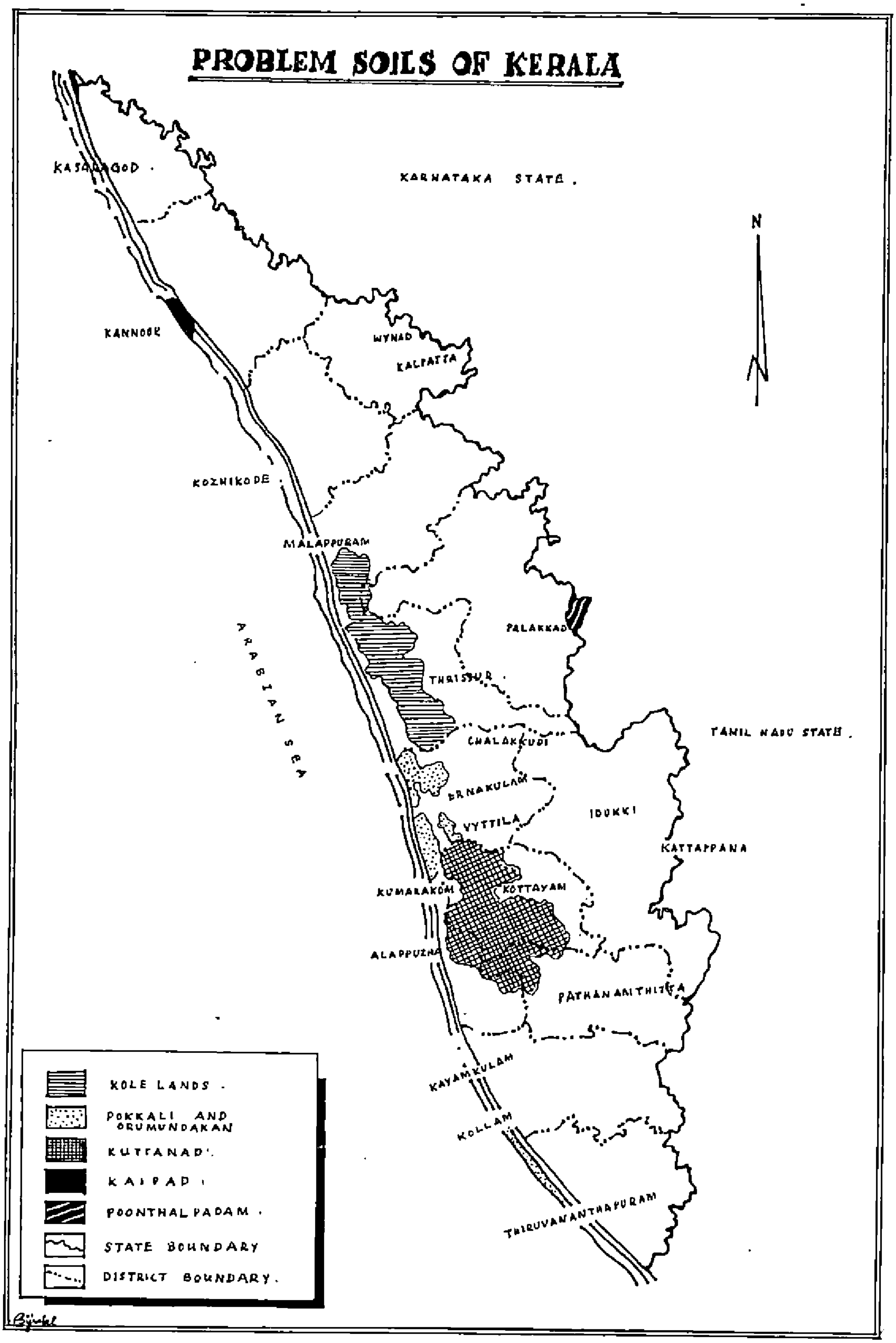
We express our sincere thanks to Dr. R.S. Aiyer, Professor and Head (Retd.) Soil Science and Agricultural Chemistry and heads of Rice Research Stations, Moncompu and Vyttila and Regional Agricultural Research Station, Kumarakom and AICRP on Agricultural Drainage, Karumady for providing the valuable research data.

It would be in appropriate, if authors do not acknowledge the numerous post graduate students and scientists who have worked in these soils and their priceless contribution. Since individual acknowledgement is not possible we profusely thank everyone of them who have helped us with the source information.

Our profound thanks are also due to Sri. P. Sreekumar, Assistant of NARP(SR), Sri. S. Raghavan, Selection Grade Typist, Sri. K. Chandrakumar, Typist Grade I, Sri. Chandranandan, Artist of the Extension Department and Sri. A. Sulaimankutty, Photographer, NARP(SR) for having accomplished their respective assignments sincerely and competently.

P. PADMAJA
(on behalf of co-authors)

CONTENTS


PROBLEM SOILS OF KERALA
KASARAGOD
KARNATAKA STATE
N
KANNOOR
WYNAD
KALPATTA
KOZHIKODE
MALAPPURAM
ARABIAN SEA
PALAKKAD
THRISSUR
TAMIL NADU STATE
CHALAKKUDI
ERNAKULAM
VYTTILA
IDUKKI
KATTAPPANA
KUMARAKOM
KOTTAYAM
ALAPPUZHA
PATHANAMTHITTA
KAYAMKULAM
KOLLAM
THIRUVANANTHAPURAM
KOLE LANDS.
POKKALI AND ORUMUNDAKAN
KUTTANAD.
KAIPAD.
POONTHAL PADAM.
STATE BOUNDARY
DISTRICT BOUNDARY.

INTRODUCTION

Kerala, endowed with a high ecological diversity, has the inherent problems associated with different soil types. Undulating terrain, odd toposequence, heavy rainfall and soil acidity as well as salinity caused by intrusion of séa water are the factors contributing to low productivity of the region. The soils which require special management practices for sustained agricultural production are termed as problem soils.

Major problem soils identified are 'Kuttanad soils' distributed in and around Vembanad lake in Alappuzha, Kottayam and Pathanamthitta districts; 'Pokkali', 'Orumundakan' and 'Kaipad soils' of Ernakulam, Thrissur, Alappuzha, Kollam and Kannur districts; 'Kole lands' of Thrissur and Malappuram districts and 'Poonthalpadom' of Palghat district.

Kuttanad, comprises an area of approximately 875 km^2. Millions of years ago,these were forest areas with abundant marshy vegetation. In succeeding geological ages, Arabian sea advanced and engulfed these lands. The areas remained submerged below the ground level and thereafter got silted up to varying heights. Soils in these areas had vast organic deposits along with fossils of timber and shell-fish at different depths. The Kuttanad soils have been posing major problems to the farming community who relies on paddy cultivation as the sole means of their livelihood.

The land area of Kuttanad is divided into a large number of padasekharams, each extending about one thousand hectares surrounded by broad man-made bunds of mud and in some places, rubbles. The different padasekharams are separated from one another by canals and rivers. Rice is grown in these padasekharams after pumping out water into the adjoining water ways. Coconut is grown on the earthern bunds in several places.

The mean temperature of the region varies from 21°C to 36°C and the annual rainfall averages about 325 cm. Most of the rainfall is received during June to December. In this period, the entire area is flooded and covered by a vast sheet of water, brought down by rivers flowing in these regions. When the monsoon subsides in September-October, the level of water drops and cultural operations for rice cultivation begin with strengthening of the bunds surrounding the padasekharams. After pumping out water from individual padasekharams, the land is prepared and sprouted rice seeds are sown or seedlings are transplanted during October and the harvest is done in November. Consequent to the construction of Thanneermukkam bund, an additional crop is being raised in an area of about 10,000 hectares during June-July to August-September.

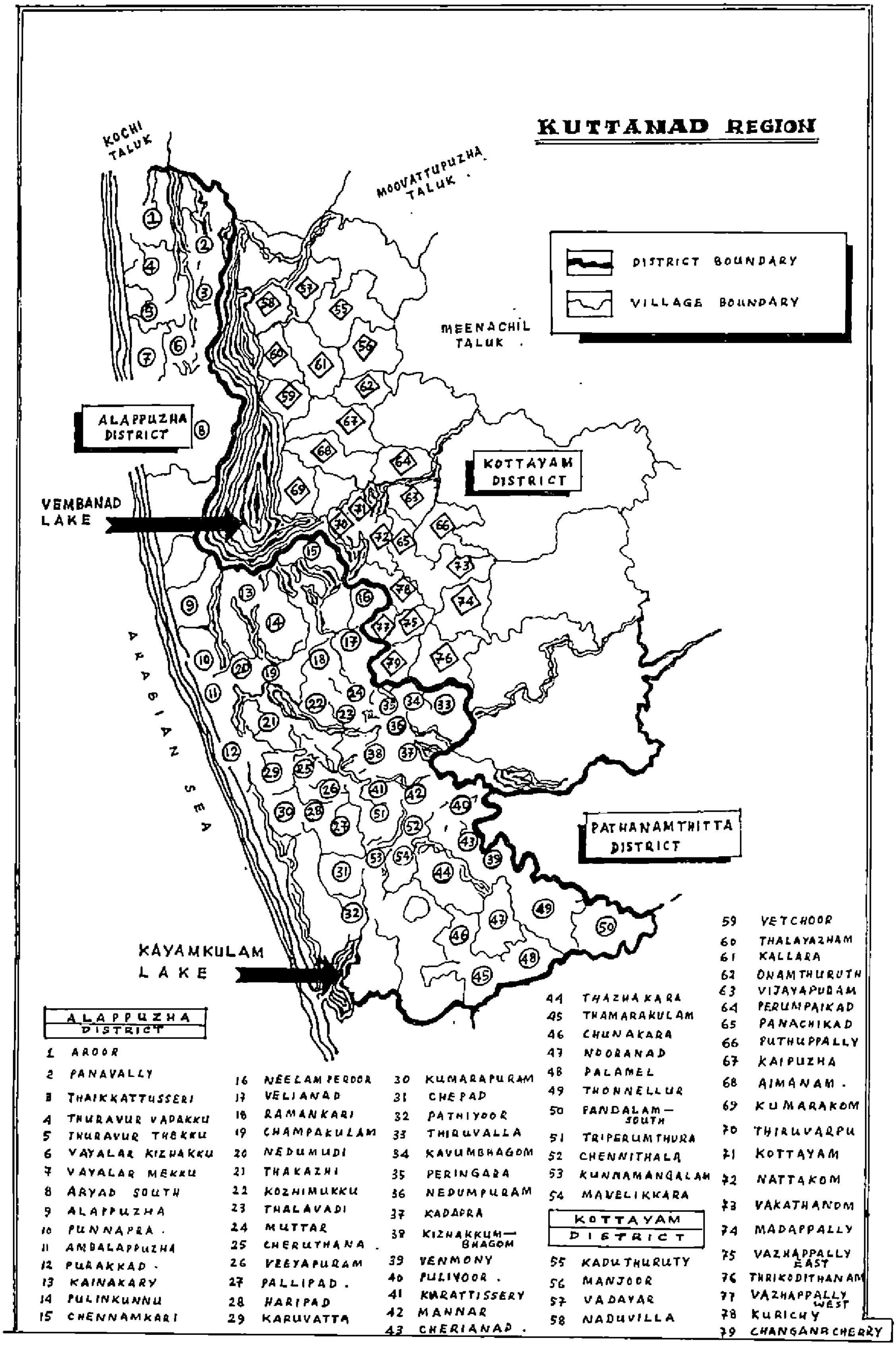
Soils of Kuttanad are grouped into three categories viz., Kari, Karappadom and Kayal soils. Kari soils are found in isolated patches in Alappuzha and Kottayam districts. Karappadom soils occur along the inland water ways and rivers which are spread over a large part of the upper Kuttanad. Kayal soils are found in the reclaimed lake beds in Kottayam and Alappuzha districts.

Kerala with its long coastal line of about 580 km, has sixteen lagoons or backwaters, covering an area of about 650 km^2 linked to the sea. Most of the coastal lands, deltaic areas at river mouths and reclaimed backwaters are either at sea level or 1.0 to 1.5 m below sea level. This leads to intrusion of sea water which makes the soil saline. Based on the location, extent and intensity of salinity, three types of saline soils are recognised in Kerala. They are the Orumundakan lands of Alappuzha and Kollam districts, known after the long duration variety of rice grown there. Pokkali lands, known after the pokkali type of cultivation, located between Thanneermukkam and Enamakkal bunds in Ernakulam and Thrissur districts and Kaipad lands of Kannur district situated in the low lying deltaic areas of river mouths. The different types of saline soils constitute an area of about 30,000 ha. These areas are cropped with paddy once in a year during June-July to October-November, when the salinity levels in the surface soils is brought below critical level of less than 4 dSm^{-1} for the saturation extract of the soil by monsoon showers.

Kole lands extending over an area of 11,000 ha are located in Thrissur, Chavakkad and Mukundapuram taluks of Thrissur district and Ponnani taluk of Malappuram district. The tract is bordered by hilly areas on the east, Kanoly canal on the west, Muriyad kayal on the south and Mulloor kayal on the north. They lie between 0.5 to 2.0 m below MSL and are under submerged condition for major part of the year. Judged by its proximity to sea and the climate of the region, it can be inferred that the Kole area might have been a marshy land in the recent past. This area is drained mainly by two rivers viz. Karuvannur and Kecheri. The Karuvannur river originates from the high lands and runs through narrow valleys and finally enters the plains, assumes a long and meandering course to the backwaters and then falls in Kanoly canal and finally reaches the sea at Chettuvai. Kecheri river has it's origin in Machad forest and flows north-west and enters Kole lands near Parappu and finally empties into Arabian sea at Chettuvai through Enamakkal regulator.

Poonthalpadom soils are located in patches in Chittoor taluk in the Palghat district and in some parts of Waynad district. These soils are locally known as Poonthalpadoms due to the deep slushy nature of soil during major part of the year. These soils spread over an area of 2000 ha in Chittoor taluk and is mainly located in the Palghat gap of Western Ghats.

Problems associated with each soil is situation specific and warrant suitable agrotechniques for increasing productivity. The main objective of this publication is to bring to light the results of research carried out by several scientists and to project available findings for planning future research programmes for these areas.


KUTTANAD REGION
KOCHI TALUK
MOOVATTUPUZHA TALUK
DISTRICT BOUNDARY
VILLAGE BOUNDARY
MEENACHIL TALUK
ALAPPUZHA DISTRICT
KOTTAYAM DISTRICT
VEMBANAD LAKE
ARABIAN SEA
PATHANAMTHITTA DISTRICT
KAYAMKULAM LAKE
ALAPPUZHA DISTRICT
1 AROOR
2 PANAVALLY
3 THAIKKATTUSSERI
4 THURAVUR VADAKKU
5 THURAVUR THEKKU
6 VAYALAR KIZHAKKU
7 VAYALAR MEKKU
8 ARYAD SOUTH
9 ALAPPUZHA
10 PUNNAPRA
11 AMBALAPPUZHA
12 PURAKKAD
13 KAINAKARY
14 PULINKUNNU
15 CHENNAMKARI
16 NEELAMPEROOR
17 VELIANAD
18 RAMANKARI
19 CHAMPAKULAM
20 NEDUMUDI
21 THAKAZHI
22 KOZHIMUKKU
23 THALAVADI
24 MUTTAR
25 CHERUTHANA
26 VEEYAPURAM
27 PALLIPAD
28 HARIPAD
29 KARUVATTA
30 KUMARAPURAM
31 CHEPAD
32 PATHIYOOR
33 THIRUVALLA
34 KAVUMBHAGOM
35 PERINGARA
36 NEDUMPURAM
37 KADAPRA
38 KIZHAKKUM-BHAGOM
39 VENMONY
40 PULIYOOR
41 KARATTISSERY
42 MANNAR
43 CHERIANAD
44 THAZHAKARA
45 THAMARAKULAM
46 CHUNAKARA
47 NOORANAD
48 PALAMEL
49 THONNELLUR
50 PANDALAM-SOUTH
51 TRIPERUMTHURA
52 CHENNITHALA
53 KUNNAMANGALAM
54 MAVELIKKARA
KOTTAYAM DISTRICT
55 KADUTHURUTY
56 MANJOOR
57 VADAYAR
58 NADUVILLA
59 VETCHOOR
60 THALAYAZHAM
61 KALLARA
62 ONAMTHURUTH
63 VIJAYAPURAM
64 PERUMPAIKAD
65 PANACHIKAD
66 PUTHUPPALLY
67 KAIPUZHA
68 AIMANAM
69 KUMARAKOM
70 THIRUVARPU
71 KOTTAYAM
72 NATTAKOM
73 VAKATHANAM
74 MADAPPALLY
75 VAZHAPPALLY EAST
76 THRIKODITHANAM
77 VAZHAPPALLY WEST
78 KURICHY
79 CHANGANACHERRY

1 KARI LAND

1.1 General characteristics

Kari lands are confined in pockets in a non-contiguous manner along the coastal plains adjoining the backwaters in Alappuzha and Kottayam districts. Occurrence of Kari soils in isolated patches can readily be distinguished by their deep black charcoal colour which is due to high organic matter content. Kari soil derived its name from the malayalam word "Kari" meaning black. The soil is heavy in texture, poorly aerated and ill-drained. Top soil is admixed with well decomposed organic matter in the range of 10-30 per cent. But very often, this layer is underlaid by partially decomposed fibrous plant residues containing less than 50 per cent mineral matter. Soils of some of the regions are called as muck or peat soils depending upon the organic matter content and its degree of decomposition. In some places, big logs of wood locally known as "kandamarams" occur embedded in the sub-soil which are sometimes excavated and used both as firewood or even as timber.

Several hypotheses have been put forward on the genesis of these soils. One of them holds that the soil arose by submergence of a pre-historic forest by a violent land slide. Another hypothesis is that the organic materials with the soil might have been washed down and deposited in this area from the forests of the Western Ghats by rivers. This view is supported by the fact that the Kari lands lie near the estuary of four major rivers, Meenachil, Pampa, Achen Coil and Manimala.

These soils are affected by severe acidity and periodic saline water inundation with consequent accumulation of soluble salts. In these soils, free sulphuric acid is formed by the oxidation of sulphur compounds of organic residues or that accumulated in the soil from sea water by repeated inundation. The soil is of low fertility status. Besides, they contain toxic concentrations of iron, aluminium and many unidentified toxic organic compounds. The presence of large quantities of organic matter that have resisted decomposition for long time and high acidity, inspite of large accumulation of calcareous lime shells, are some of the peculiar characteristics of Kari soils.

During the early years of rice cultivation in Kari lands, only one crop was taken in two or three years. Afterwards, these fields were cultivated annually with varying degrees of success. At present an additional crop is also being raised during May-June to August-September in some areas where better water management facilities exist.

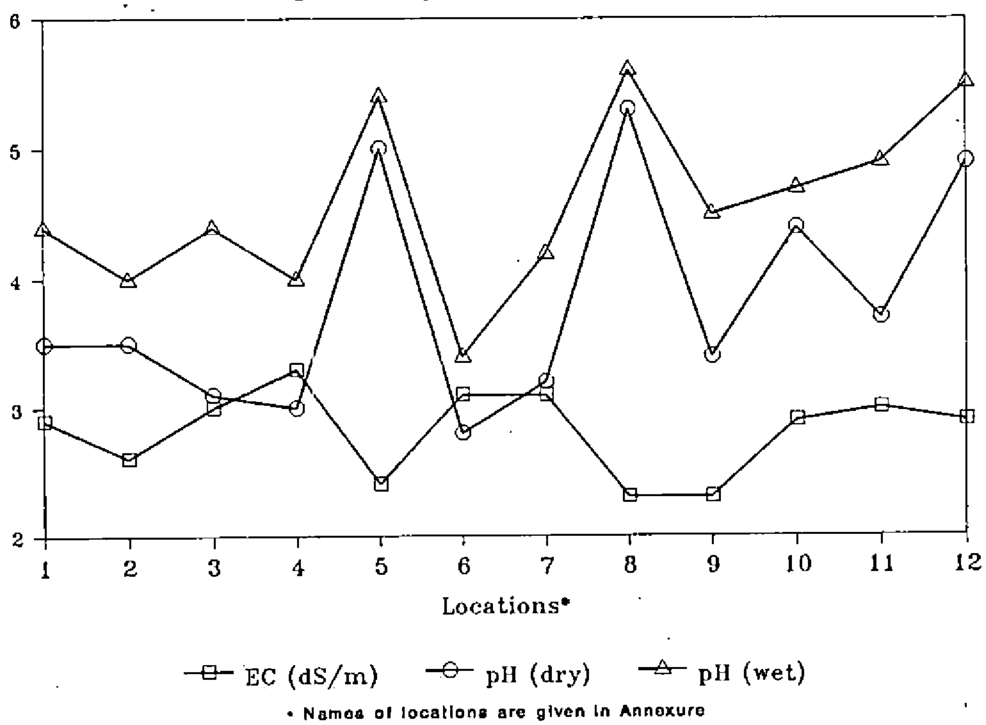
1.2 Physico-chemical properties of surface soil

Scientific studies on Kari soils of Kuttanad were started about fifty years back.

Texture of the surface soil was mostly clayey with a water holding capacity ranging from 65 to 70 per cent (Pillai, 1964). Saline water intrusion and seepage rendered these soils poorer in exchangeable calcium but enriched in sodium and as a result, these soils developed undesirable physical properties (Britomutunayagam and Nambiar, 1948).

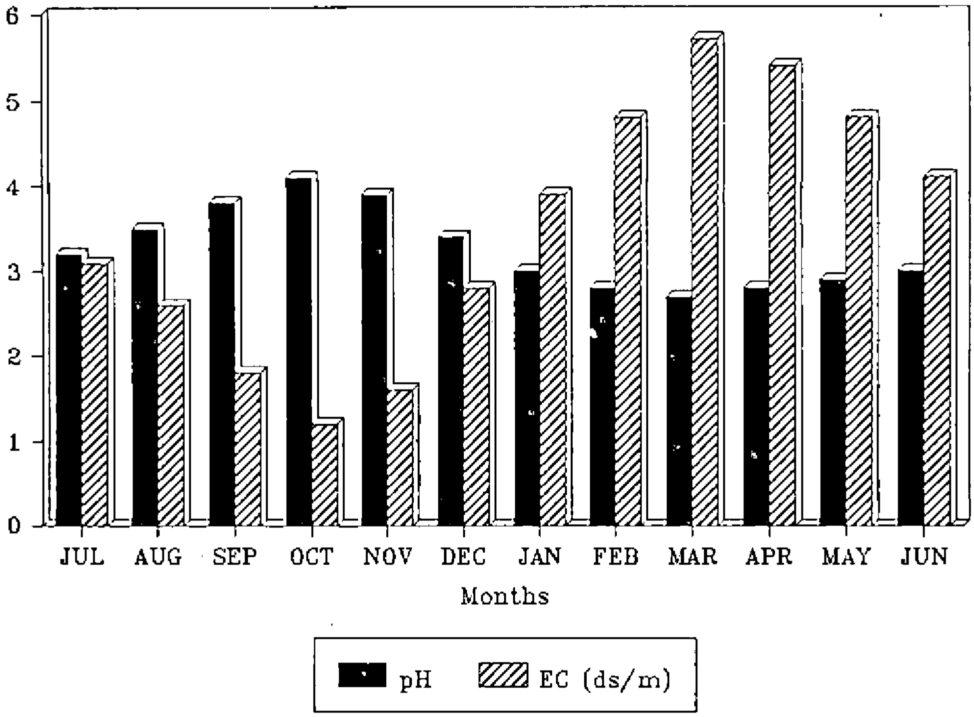
pH of air dried samples ranged from 2.8 to 5.3. Wet soil samples recorded pH values higher than that of dry samples by about one unit. Seventyfive per cent of Kari soils registered pH below 4.5. EC varied from 2.3 to 3.3 dSm^{-1} (Fig. 1.2.1). Maximum pH was noted in October-November while minimum in March-April (Fig. 1.2.2). Kuruvila and Patnaik (1973) studied specific conductance of Vadayar and Thottappally Kari and was found to range from 4.6 to 6.0 dSm^{-1}.

Organic carbon content of the soils of different locations varied widely and it ranged from 5.35 to 17.55 per cent (Fig. 1.2.3). Organic matter in Kari soils was largely of ligno-protein complex consisting of large quantitites of lignin, ether and alcohol soluble substances and other resistant fraction of organic matter. Koshy (1970) studied the chemical nature of organic complexes in Kari soils. According to him, organic



Source: Kurup, 1967.

Fig. 1.2.1 pH and electrical conductivity (EC) of Kari soils (surface samples)



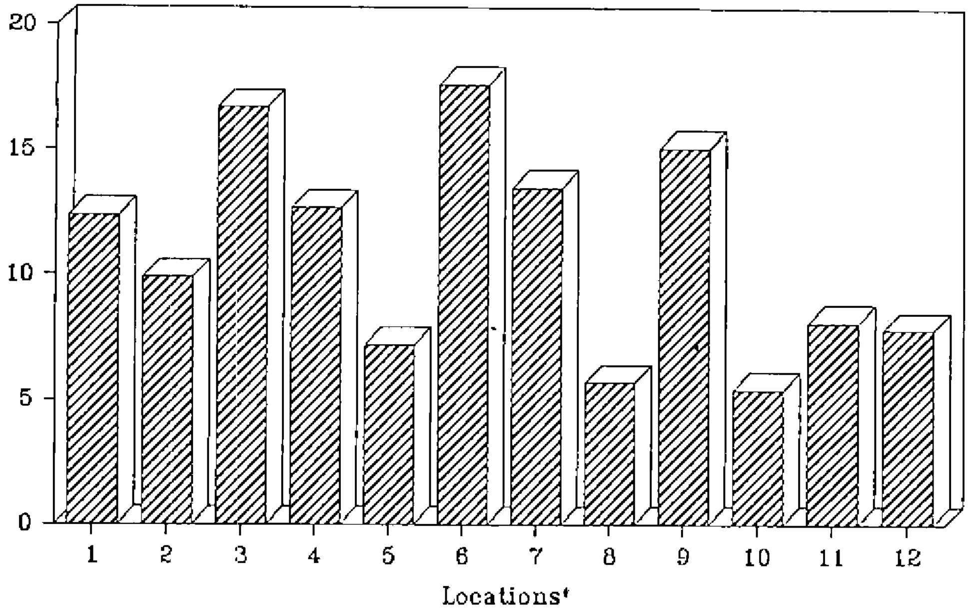
Source: Kurup, 1967.

Fig. 1.2.2 Seasonal variations in pH and EC in Kari soil (Purakkad kari)

matter of these soils was noteworthy in two respects viz. absence of hemicellulose and cellulose and preponderance of ether and alcohol extractable fractions.

CEC of surface soils varied from 24.1 to 42.5 cmol (P^+) kg $^{-1}$. Among exchangeable cations, hydrogen dominated and occupied about 75-80 per cent of the exchange complex (Fig. 1.2.4). Base saturation of most soils ranged from 15-25 per cent of the exchange complex. But surface soils of locations like Irandachira of Thottappally recorded more than 80 per cent base saturation (Kurup, 1967). A comparative study of the exchangeable bases in fallow rice soils with that of an adjacent cropped soils indicated that exchangeable hydrogen increased markedly due to cropping and pH decreased correspondingly. Continuous cropping without adding any inorganic fertilizers resulted in a drastic fall in total and exchangeable bases and a significant increase in exchangeable hydrogen (Britomutunayagam and Nambiar, 1948).

Effect of flooding on electro-chemical and chemical kinetics of these soils revealed a sharp increase in pH during the first ten days of submergence which levelled off subsequently. Eh values decreased markedly during the first ten days in the surface soils of both Thottappally and Vadayar Kari. There was an increase in the sodium chloride extractable organic matter during the first ten days and a steady increase in ammonium nitrogen throughout the period. A slight increase was noted in extractable phosphorus in 10-25 days period with a slight decrease thereafter in Thottappally kari



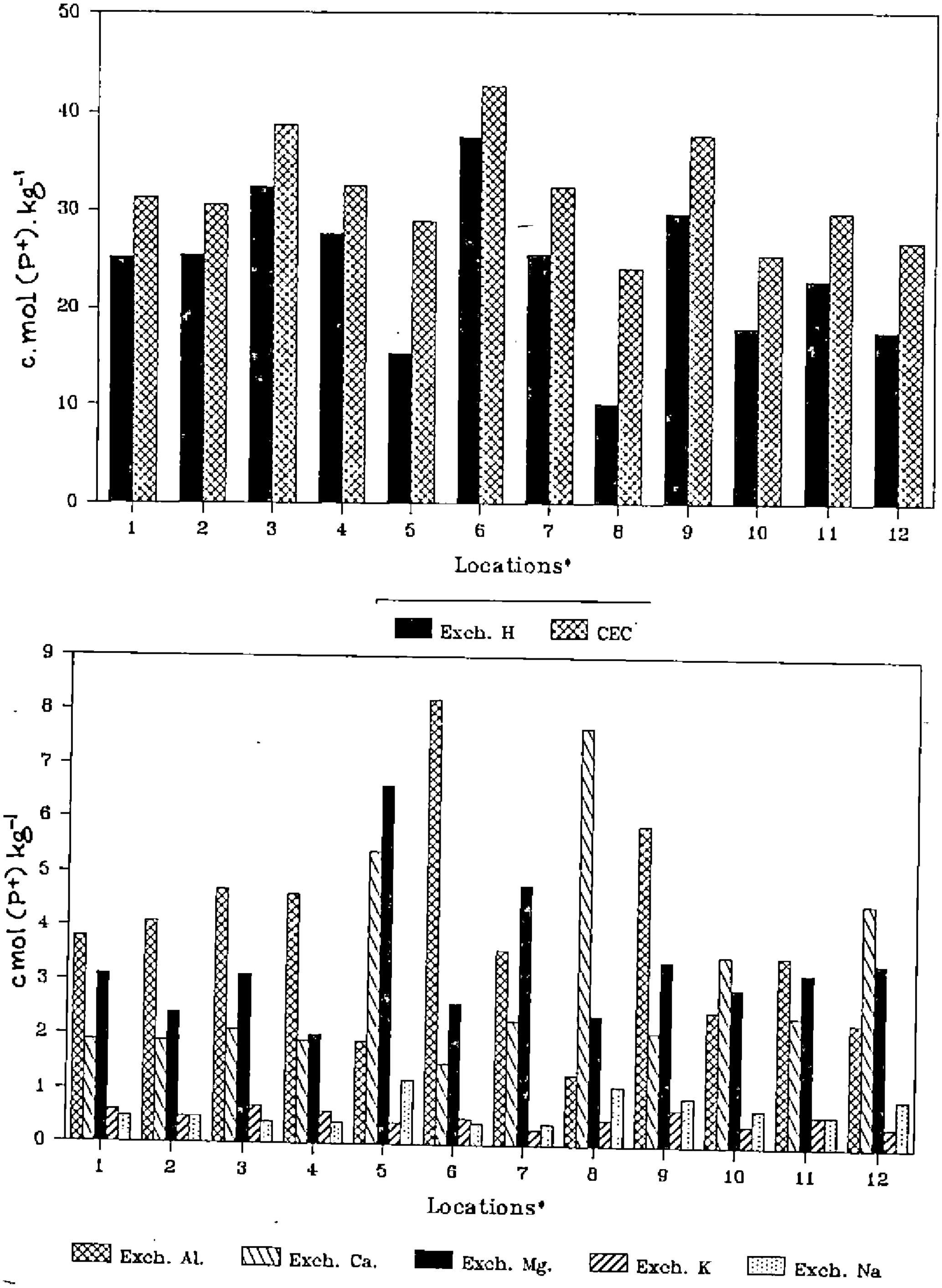
* Names of locations are given in Annexure

Source: Kurup, 1967.

Fig. 1.2.3 Organic carbon content of Kari soils (surface samples)

whereas in Vadayar kari, only traces of P could be noticed. There was a steady increase of potassium in both the soils as the period of submergence progressed. Calcium and magnesium increased only during the first 10 to 20 days and thereafter declined. Soluble iron content also increased sharply during the first thirty days and then decreased. Aluminium recorded an increase during the first ten days of submergence after which, it decreased to a level lower than the initial value (Table 1.2.1).

Low fertility status of Kari soil was attributed to low available plant nutrient status (Pillai, 1928). An investigation in Kari soil of different locations indicated that generally most of these soils are highly deficient in phosphorus and lime but were abnormally high in soluble salts (Iyer, 1928). According to Pillai and Subramaniyan (1931), low fertility of Kari soil was due to high contents of iron and aluminium phosphates. Soils though exhibited comparatively higher total nutrient status, plant availability was comparatively low. Contents of total N, P_2O_5 and K_2O varied from 0.284 to 0.713, 0.077 to 0.386 and 0.940 to 0.572 per cent respectively. Values for available N, P_2O_5 and K_2O varied from 173 to 282, trace to 22 and 89 to 130 kg ha^{-1} respectively. Carbon-nitrogen ratio of the soils showed higher values ranging from 12.7 to 32.8 (Fig. 1.2.5). Low pH values recorded by Kari soils indicated that plant growth might be seriously hindered by the direct effect of hydrogen ions. High concentration of iron and aluminium present in these soils intensified toxicity (Money and Sukumaran, 1973). Lime requirement of these soils ranged from 3.5 to 24.2 t $CaCO_3$ ha^{-1} (Fig. 1.2.6).



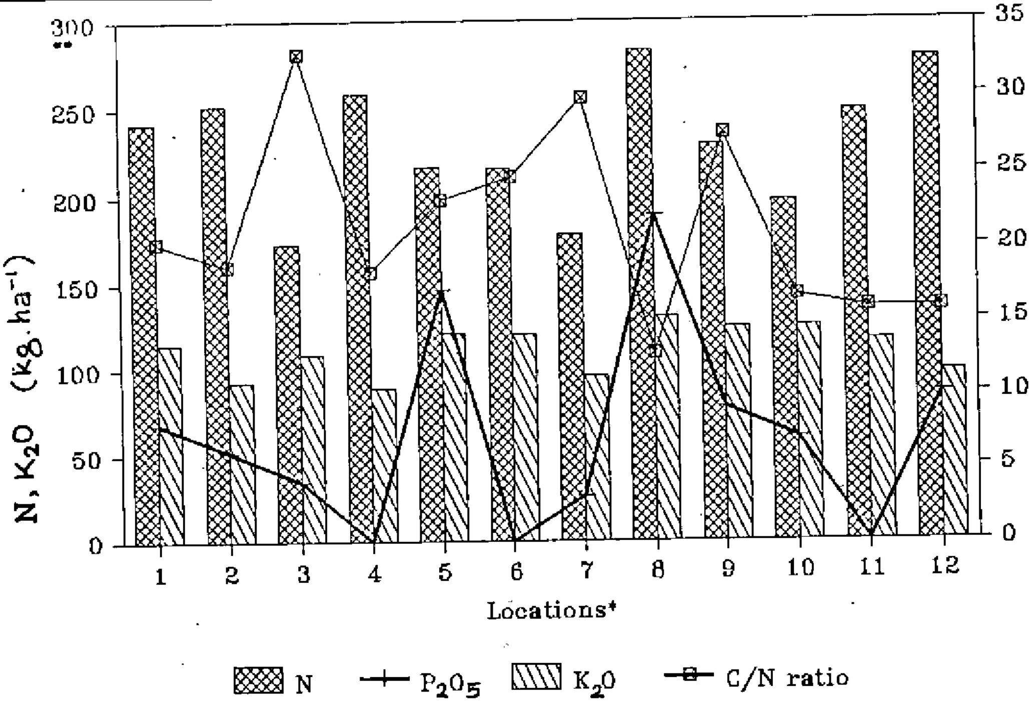
Source: Kurup, 1967. * Names of locations are given in Annexure

Fig. 1.2.4 Cation exchange capacity (CEC) and exchangeable cations of Kari soils

Table 1.2.1 Effect of submergence on electro-chemical and chemical properties

Properties	Thottappally kari						Vadayar kari					
	Days of flooding											
	0	10	20	30	50	Mean	0	10	20	30	50	Mean
pH	3.15	3.60	3.60	3.65	3.70	3.50	3.35	3.90	4.00	4.05	3.85	3.80
Eh (mV)	182.00	31.00	51.00	77.00	92.00	87.00	164.00	19.00	-7.00	-19.00	-11.00	29.00
Oxd-O.M. (%)	1.40	2.80	2.60	2.60	2.50	2.40	1.75	21.00	2.00	2.10	2.00	1.99
NH_4 - N (ppm)	75.00	107.00	117.00	125.00	150.00	115.00	71.00	94.00	123.00	134.00	134.00	118.00
P (ppm)	0.03	0.12	0.30	0.15	0.20	0.16	Traces	Traces	Traces	Traces	0.60	0.01
K (ppm)	31.00	46.00	57.10	59.00	86.00	56.00	36.00	42.00	50.00	63.00	101.00	58.00
Ca (ppm)	2456.00	1580.00	1580.00	1435.00	1352.00	1481.00	1206.00	1331.00	1414.00	1331.00	1331.00	1323.00
Mg (ppm)	760.00	1297.00	1272.00	1235.00	1200.00	1153.00	399.00	1260.00	1397.00	1223.00	1240.00	1104.00
Fe (ppm)	310.00	1980.00	2525.00	3010.00	1512.00	1867.00	285.00	1730.00	2380.00	2835.00	1320.00	1710.00
Al (ppm)	150.00	192.00	162.00	130.00	112.00	149.00	138.00	142.00	124.00	110.00	94.00	122.00
Mn (ppm)	9.00	20.00	14.00	14.00	15.00	14.00	17.00	28.00	22.00	25.00	23.00	23.00
SO_4-S (ppm)	2388.00	1995.00	1218.00	1536.00	1536.00	1747.00	2238.00	2073.00	1865.00	1948.00	1520.00	1929.00

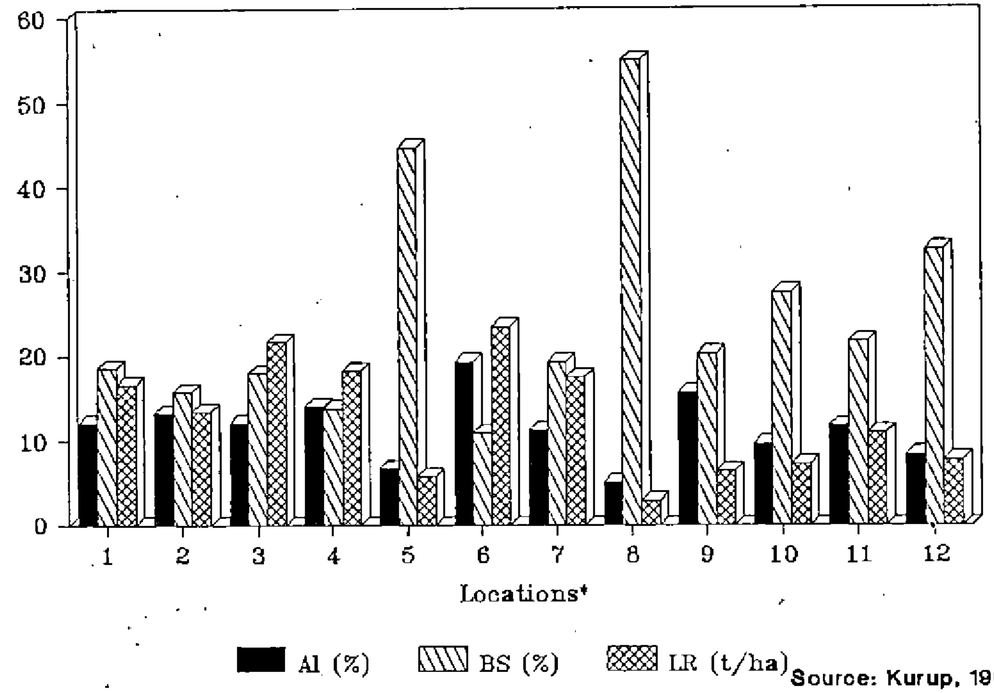
Source: Kabeerathumma and Patnaik, 1978.



* Names of locations are given in Annexure

Source: Kurup, 1967.

Fig. 1.2.5 Available major nutrient status of Kari soils



Source: Kurup, 1967.

* Names of locations are given in Annexure

Fig. 1.2.6 Aluminium (Al), base saturation (BS) and lime requirement (LR) of Kari soils (surface samples)

Properties of surface soils greatly determine the productivity of a soil. Surface soils of Kari are extremely acidic even on submergence. Lime requirement of the soils ranged from 3 to 25 t ha^{-1}. Soluble salt content of most of the soils is also high which include chlorides, sulphates, soluble iron and aluminium. High C/N ratio recorded in most of the soils indicate the presence of undecomposed plant residues rich in higher carbohydrates. Physical properties of most of the soils is also poor due to clayey texture and dominance of sodium in the exchange complex. Low fertility status of Kari soil is attributed to low plant available nutrients in these soils. Plant growth is also hindered by high acidity and conseqent direct effect of hydrogen ions as well as toxic concentration of iron and aluminium present in these soils.

1.3 Profile characteristics

1.3.1 Morphological properties

Detailed investigations were carried out on morphological, physical and chemical properties of the soil profiles of Kari soils occurring in Thottapally region of Shertalai taluk and Thuravoor region of Ambalappuzha taluk (Pillai, 1964; Varghese and Aiyer, 1973). Colour of the profile was darker in the lower layers of Thottapally profile whereas in Thuravoor profile, a decrease in intensity of colour was noticed with depth. Thottappally profile contained $CaCO_3$ deposits in the form of lime shells in the upper horizons and calcium carbonate nodules in the lower horizons. Wood fossils were seen in different horizons of most of the profiles. (Table 1.3.1.1).

1.3.2 Physical properties

Texture of the soils of different horizons showed remarkable variations ranging from clayey to sandy loam. Texture was clayey in Thottappally profile except in C_1 horizon (86-92 cm), where it was sandy loam. In both profiles, surface layers exhibited clayey texture. Apparent specific gravity ranged from 0.96 to 1.62 and absolute specific gravity varied from 2.08 to 2.76. In general, specific gravity increased with depth. Maximum water holding capacity ranged from 25.93 to 56.76 per cent (Table 1.3.2.1).

Table 1.3.1.1 Description of Thottappally and Thuravoor profiles

A. Thottappally (Alappuzha district)

I. General information of the site

a.	Elevation	:	0.5 m below sea level
b.	Land form		
	i. Physiographic position of the site	:	plain water-logged
	ii. Land form of surrounding	:	flat
	iii. Microtopography	:	flat
c.	Slope on which profile is situated	:	almost flat
d.	Vegetation and land use	:	single cropped paddy land
e.	Climate	:	tropical humid climate with alternately wet and dry periods
f.	Parent material	:	alluvial deposit of peat and sand
g.	Drainage	:	poorly drained
h.	Moisture condition	:	wet
i.	Depth of ground water table	:	highly fluctuating, 1 m during March and water-logged during off season
j.	Human influence, if any	:	cultivated area

II. Profile characteristics

Depth cm	Colour	Texture	Consistency	Pore space	Roots	$CaCO_3$ deposits	pH
0	Moist-10YR 3/4 dark yellowish brown. Dry-10 YRY/3 dark brown	Clay	Wet - very sticky Moist - extremely firm Dry-very hard	Common, very fine	Frequent root wood fossils	Lime shells	5.6
22	Moist-10YR 3/3 dark brown Dry-10YR 2/1 black	Clay	-do-	Few,very fine	Frequent	- do -	6.2
46	Moist-10YR 2/1 black Dry-10YR 3/2 very dark greyish brown	Clay	-do-	Nil	None	- do -	6.6
86	Moist-10YR 2/1 black Dry-7.5 YRY/0 dark grey	Sandy loam	Wet-slightly sticky Moist-friable Dry-slightly hard	Nil	None	$CaCO_3$ nodules	6.4
92	Moist-10YR 2/1 black Dry-10YR 5/1 grey	Clay	Wet - sticky Moist - firm Dry-hard	Nil	None	- do -	6.7

B. Thuravoor (Alappuzha district)

I. General information of the site

a.	Elevation	:	0.5 m below seal level
b.	Land form		
	i. Physiographic position of the site	:	plain water-logged
	ii. Land form of surrounding	:	flat
	iii. Microtopography	:	flat
c.	Slope on which profile is situated	:	almost flat
d.	Vegetation and land use	:	single crop paddy land
e.	Climate	:	tropical humid climate with alternately wet and dry periods
f.	Parent material	:	sedimentary arenaceous deposits
g.	Drainage	:	poorly drained
h.	Moisture condition	:	wet
i.	Depth of ground water table	:	highly fluctuating, 1 m during March and water-logged during off season
j.	Human influence, if any	:	cultivated area

II. Profile characteristics

Depth cm	Colour	Texture	Consistency	Features of biological origin	Roots	pH
0	Moist-7.5 YR 2/0 black Dry-10YR 3/1 very dark grey	Clay	Wet - Slighty sticky Moist - Very friable Hard - Dry	Wood fossils	Abundant	5.5
18	Moist-5YR 2/1 black Dry - 5 YR 2/2 reddish brown	Clay	Wet - Nonsticky Moist - Friable Dry - Slightly hard	Wood fossils	-do-	4.7
28	Moist-5YR2/1 black Dry-10YR3/1 very dark grey reddish brown	Sandy loam	Wet-Non sticky Moist-loose Dry-slightly hard	None	None	4.7
65	Moist-10YR3/1 very dark grey Dry-10YR3/2 dark grey	Sandy loam	Wet-non sticky Moist-loose Dry-soft	None	None	4.6
100	Moist-10YR3/1 very dark greyish Dry-10YR6/1 light grey	Sandy loam	Wet-non sticky Moist-loose Dry - Soft	None	None	4.5

Source: Varghese, 1973.

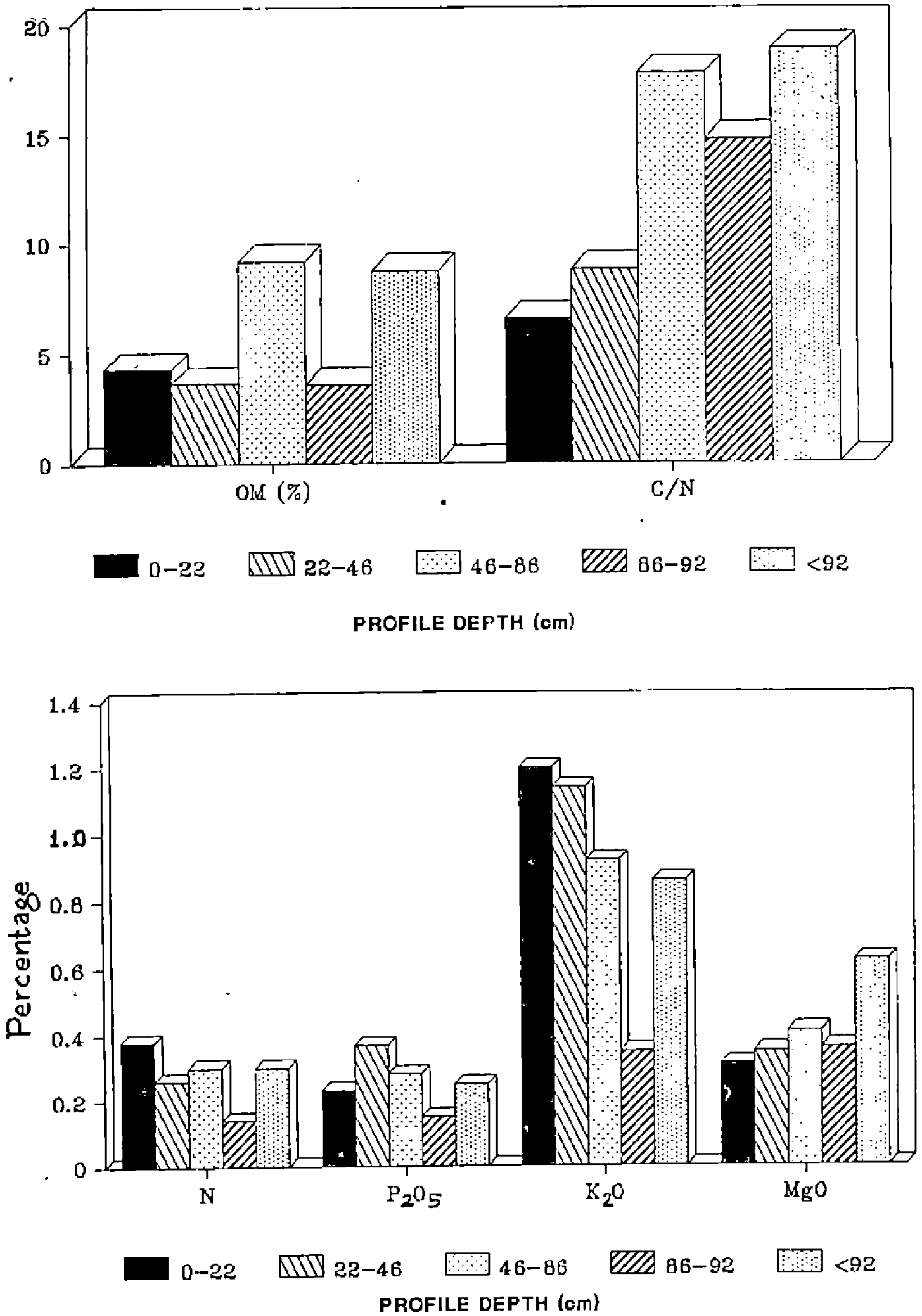
Table 1.3.2.1 Physical properties of Thuravoor and Thottappaly profiles

Sample no.	Location	Depth (cm)	Apparent specific gravity	Absolute specific gravity	Maximum water holding capacity (per cent)
1	Thuravoor	(0-18)	1.12	2.08	53.45
2	Thuravoor	(18-28)	1.14	2.18	55.35
3	Thuravoor	(28-65)	1.13	2.16	56.76
4	Thuravoor	(65-100)	1.24	2.35	32.34
5	Thuravoor	(> 100)	1.18	2.29	52.89
6	Thottappally	(0-22)	0.97	2.18	55.00
7	Thottappally	(22-46)	0.96	2.15	50.67
8	Thottappally	(46-86)	1.21	2.51	37.77
9	Thottappally	(86-92)	1.45	2.62	27.27
10	Thottappally	(> 92)	1.62	2.76	25.93

Source: Varghese and Aiyer, 1973

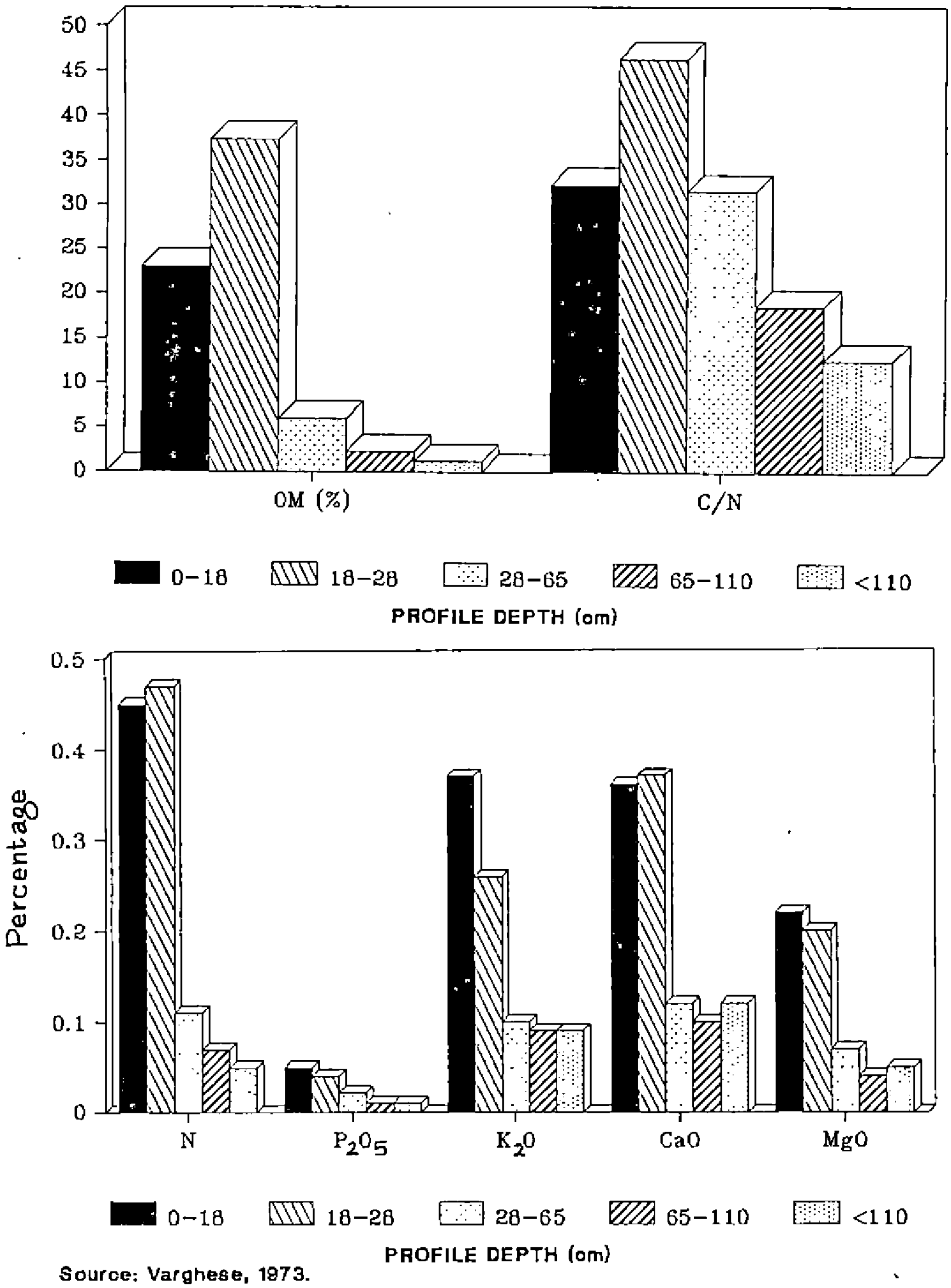
1.3.3 Chemical characteristics

Varghese and Aiyer (1973) studied chemical properties of the soils of different horizons of Thuravoor and Thottappally regions of Ambalappuzha and Sherthalai taluks respectively. The surface soils of both the profiles were slightly acidic. But pH and EC increased with depth in Thottappally profile, whereas the reverse trend in pH and no variation in electrical conductivity was observed in Thuravoor. Organic matter content was comparatively higher in Thottappally profile and was sufficient to designate it as peaty soil. Upper horizons of both the profiles showed higher contents of phosphorus and potassium. Magnesium content was higher in Thuravoor profile and showed a general increase with depth. A reverse trend was observed with Thottappally profile (Fig. 1.3.3.1 a & b). Soils of the two profiles recorded fairly high CEC. It decreased with depth in Thottappally profile whereas no definite pattern of distribution was observed in Thuravoor profile. Exchangeable base contents of the two profiles was in the order Ca > Mg > K. The maximum amount of exchangeable bases was observed in Thuravoor soil samples, (Fig. 1.3.3.2 a & b). Variations in pH of dry and wet samples of four different profiles are presented in Fig. 1.3.3.3. Air drying of the soils of surface horizons led to extreme acidity whereas that of lower horizons changed to neutral or even slightly alkaline (Pillai, 1964).



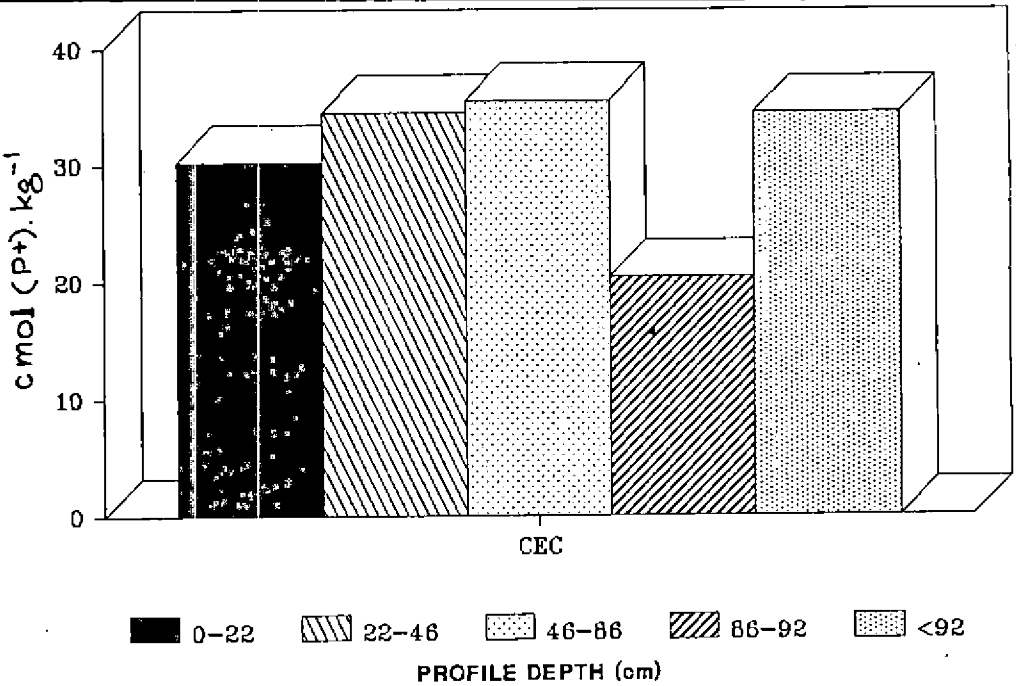
Source: Varghese, 1973

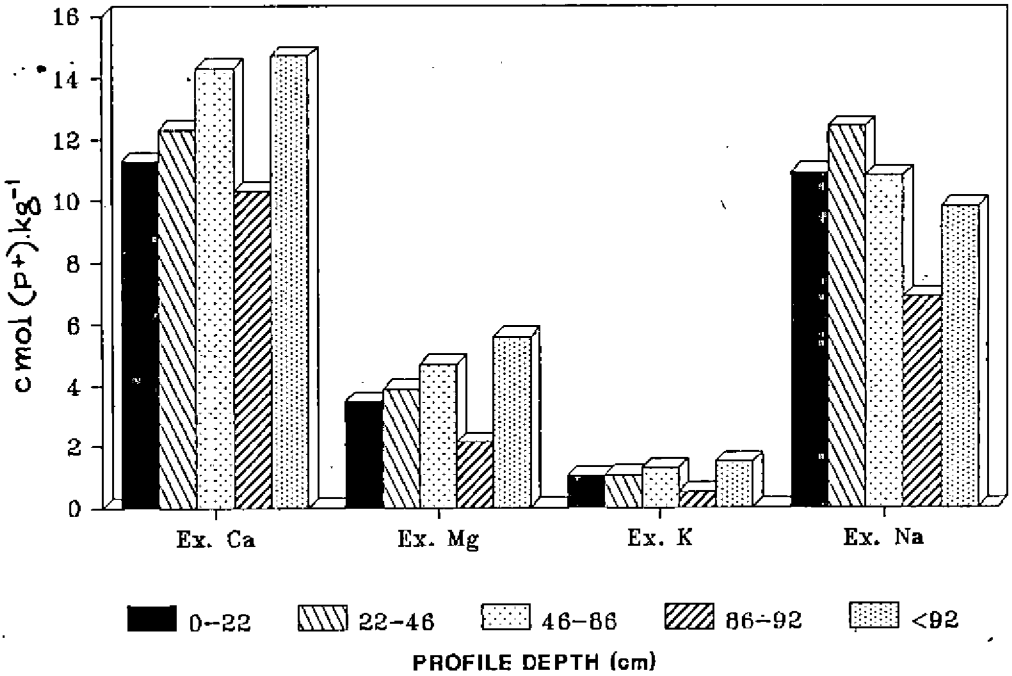
Fig. 1.3.3.1 a. Total nutrient and organic matter status of Kari soil profiles (Thuravoor)



Source: Varghese, 1973.

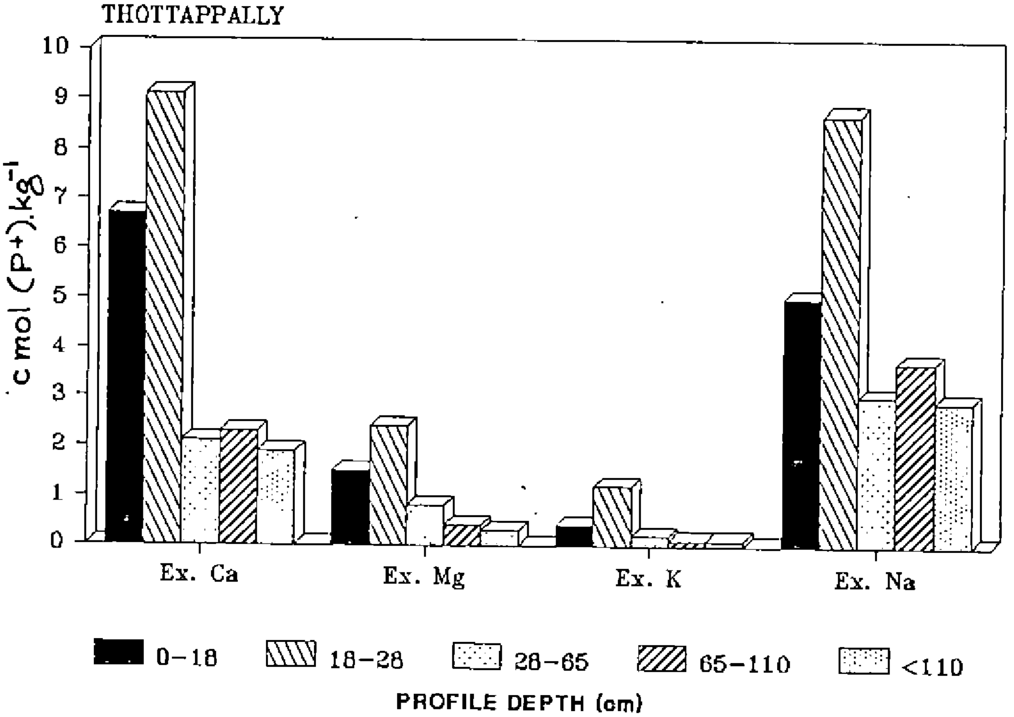
Fig. 1.3.3.1 b. Total nutrient and organic matter status of Kari soil profile (Thottappally)



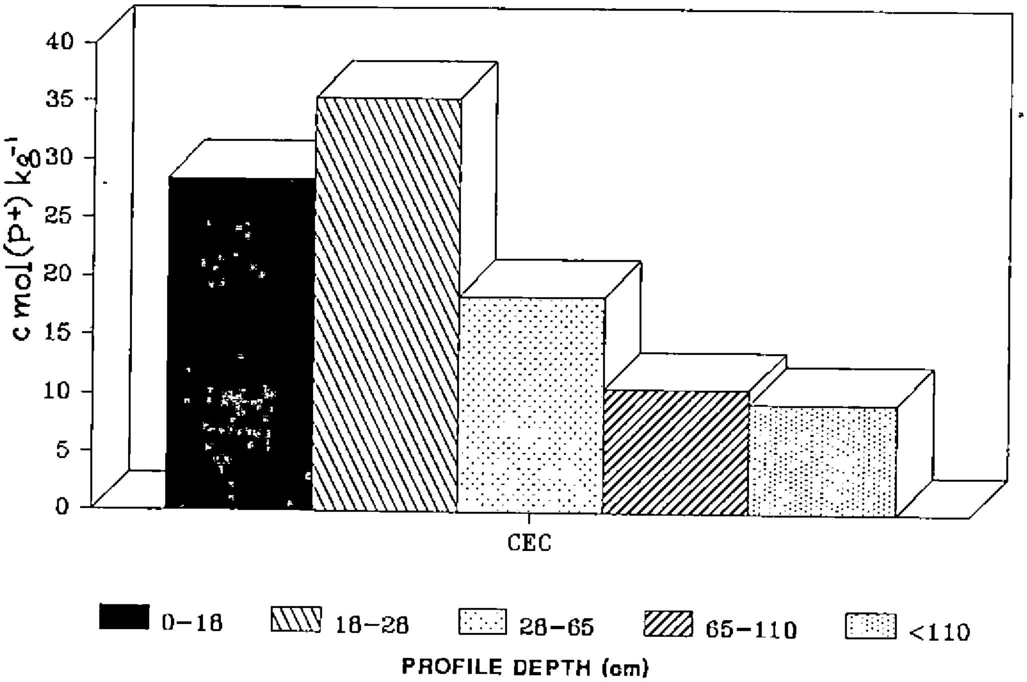


Source: Varghese, 1973.

Fig. 1.3.3.2 a. Exchangeable cation and cation exchange capacity of Kari soil profile (Thuravoor)



Source: Varghese, 1973.



Source: Varghese, 1973

Fig. 1.3.3.2 b. Exchangeable cation and cation exchange capacity of Kari soil profile (Thottappally)

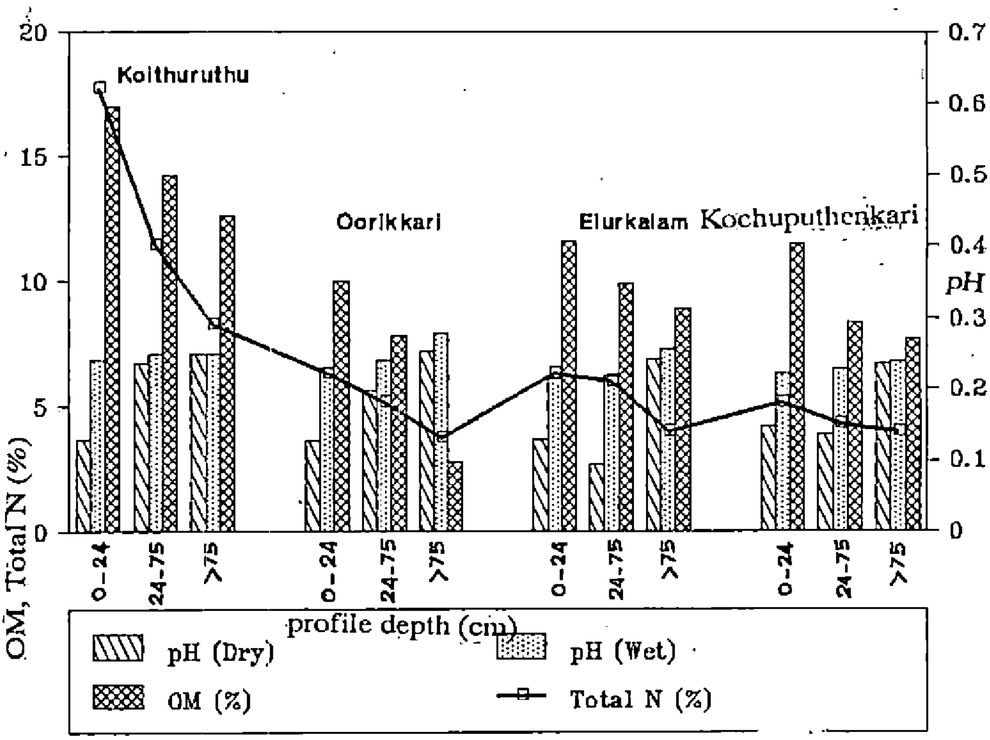


Fig. 1.3.3.3 pH, nitrogen and organic matter status of Kari soil profiles

Greater heterogenity is observed in the colour and texture of various profiles. Texture ranged from clay to sandy loam. Lime shells or calcium carbonate nodules are seen in the profiles mostly in the lower horizons but sometimes distributed throughout the profile.

Undecomposed plant residues are seen in the profiles at different depths, but mostly in the surface horizons. Morphology of the profiles indicates that these soils are formed from coastal sandy soils by sedimentation and deposition. The undecomposed wood fossils is a clear indication of the existence of dense forest vegetation in the past.

C/N ratio of the soils of different horizons are wider than normal soils indicating the presence of undecomposed plant residues of higher carbohydrates like lignin of wood fossils. pH of the soils increased with depth. Air drying doubled intensity of acidity mainly due to oxidation of sulphur compounds of the soil of upper horizons but the lower layers turn to neutral or alkaline. Dissolution of clacium carbonate in the form of lime shells which are mostly seen in the lower horizons neutralize acidity and change the pH to neutral or alkaline range. Though most of the soils are having comparatively higher total nutrient content, the plant available status is low probably due to lower mineralization rate of organic matter with wide C/N ratio, low pH and anaerobic soil conditions which are not congenial for the existence and multiplication of beneficial microorganisms.

1.4 Sulphur status

Soil and associated wood fossils contained different forms of sulphur such as free organically combined sulphide and sulphate forms (Subramoney, 1958). Sulphur oxidising and reducing bacteria were present in the soils. It was assumed that there existed a bacterial cycle in these soils which convert organic forms of sulphur to sulphuric acid. The acid thus formed causes extreme acidity of these soils.

Sulphate sulphur accumulated mostly in the surface, whereas sulphides were seen concentrated in the lower horizons of the soils. *Thiobacillus thiooxidans* was found to be the most important sulphur oxidising bacteria in these soils. (CMA, Scheme, 1966).

Sulphur content increased with depth in Vaikkom taluk of Kottayam district (Table 1.4.1). Organic sulphur constituted more than 90 per cent of the total sulphur considering all depths together. Total sulphur content was highly correlated with other forms of sulphur like morgans reagent extractable sulphur, neutral normal ammonium acetate extractable sulphur and neubauer test values of sulphur (Jacob, 1966).

Table 1.4.1 Forms of sulphur in Kari soils of Vaikkom taluk

			Organic sulphur		Humus sulphur		Water soluble sulphur		sulphate sulphur	
Depth of sampling (cm)	Total sulphur (per cent)	Nitrogen/ Sulphur	Total content (per cent)	% to total sulphur	Total content (per cent)	% to total sulphur	Content percent	% to total sulphur	Total content (per cent)	% to total sulphur
0 - 20	0.4247	0.32	0.4173	98.2	0.0508	12.2	0.0038	0.9	0.0058	1.4
20 - 40	0.5206	0.29	0.5019	96.4	0.0690	11.8	0.0046	0.9	0.0074	1.4
40 - 60	0.5246	0.29	0.5123	97.7	0.0621	12.1	0.0050	1.0	0.0083	1.6

Source: Jacob, 1966

Varghese (1973) assessed the different forms of sulphur and vertical distribution of sulphur in the profiles of Thottappally and Thuravoor area. Total sulphur was seen increasing with depth in the profile except in the sandy C horizon of Thottappally soil. Major portion of the sulphur was in the organic form, which varied from 81 to 93 per cent of the total. Organic sulphur content increased with increasing depth of the profile. Sulphate accounted for the major portion of the inorganic sulphur, (Table 1.4.2).

Table 1.4.2 Distribution of sulphur in the profiles of Thuravoor and Thottappally area

Sample No.	Location	Depth (cm)	Horizon	Sulphur (ppm)				
				Water soluble sulphate	Total sulphate	Sulphide	Organic	Total
1	Thuravoor	0-22	A	1020.2 (12.69)	1271.5 (15.7)	132.9 (1.7)	6695.7 (82.7)	8100.0
2		22-46	B1	1475.2 (15.20)	1685.9 (17.4)	110.6 (1.1)	7903.8 (81.5)	9700.3
3		46-86	B2	2884.6 (14.50)	2990.5 (15.0)	92.6 (0.5)	16817.4 (84.5)	19900.8
4		86-92	C1	1710.0 (6.80)	1900.7 (7.5)	89.7 (0.4)	23309.6 (92.2)	25300.0
5		92 and above	C2	2005.6 (6.60)	2800.6 (7.2)	57.7 (0.2)	28062.6 (92.6)	30300.9
6	Thottappally	0-18	A	1394.3 (8.90)	1753.2 (11.2)	61.2 (0.4)	13886.1 (86.4)	15700.5
7		18-28	B1	1336.4 (7.40)	1352.6 (9.0)	38.5 (0.3)	15328.9 (90.7)	16900.0
8		28-65	B2	396.0 (9.00)	520.7 (11.9)	12.0 (0.3)	3867.3 (87.9)	4400.0
9		65-100	C1	237.4 (6.30)	360.5 (9.6)	4.3 (0.1)	3429.9 (90.3)	3800.7
10		100 and above	C2	160.5 (5.40)	210.0 (7.0)	2.8 (0.1)	2787.6 (92.4)	3000.4

Figures in paranthesis indicate per cent of total S

Source: Varghese, 1973

Organic sulphur constitutes major portion of soil sulphur. Sulphur content increases with depth in most of the profiles.

1.5 Micronutrient status

Water soluble silica content varied from 75-100 ppm whereas citric acid soluble silica content was 675 ppm (Nair, 1966) Cu and Zn deficiencies were observed in Kari soils. (Praseedom, 1970).

Soil samples collected from Vadayar, Thuravoor and Thottappally areas showed copper content ranging from 18.8. to 23.0 ppm with an average of 19.0 ppm in surface samples. Available copper content varied from 0.4 to 1.5 ppm and the average being 0.9 ppm in the surface layers. Total copper was negatively related to pH, organic carbon and sesquioxide contents of the soil samples, whereas available copper showed significant negative relationship with organic matter (Gopinath, 1973).

Soil samples collected from Thottappally area were rich in total iron and zinc, medium in manganese and low in copper. Total zinc content varied from 12.5 to 41.6 ppm with an average of 27.0 ppm in the surface samples. Average available zinc content of the surface samples was 1.38 ppm.

Kari soils were found deficient in available copper but adequately supplied with available Zn and Mn, but Rajendran (1981) observed Zn deficiency in Kari soils. Available Fe was found in toxic levels in many of the soils. Significant negative correlation was observed between organic matter and available copper, while the relationship was positive and significant between organic carbon and available iron. Available iron was positively correlated with cation exchange capacity whereas it was negatively related with pH, exchangeable calcium and magnesium (Aiyer et al. 1975).

Among the micronutrients, copper deficiency is much prominent in Kari soils. Zinc deficiency is also observed in different locations. Available iron content is found in toxic levels in these soils.

1.6 Mineralogical characteristics

Illite, montmorillonite and a mixture of hydrous mica were the dominant clay minerals (Gopalaswamy, 1958) in these soils.

Kari soils were classified as peaty marine mud clays and could be included in the soil order Histosols of the USDA system (Gopalaswamy and Raychowdhary, 1969).

Sand fractions contained a number of minerals derived from acid igneous and metamorphic rocks, schists, crystalline gneisses, ferromagnesium minerals and synites. Limonite, siderite and sulphides were present along with mineral species like tremolite, zeolite and hypersthene (Gopalaswamy and Raychaudhary, 1971; Gopalaswamy, 1961).

Kaolinite was the dominant mineral in the clay associated with fairly large amounts of smectites. Electron micrographs showed small amounts of halloysite also. The fine and coarse silt were found to contain quartz, mica, feldspars, kaolinite and chloritic minerals as the major components. Fine sand was fairly rich in ferromagnesium minerals (Sudhansu et al. 1973).

The clay fraction of Thuravoor and Thottappally contained mainly montmorillonite as the dominant clay mineral (Varghese, 1973).

Kaolinite was the dominant mineral in the clay fraction associated with fairly large amounts of smectite and comparatively smaller amounts of halloysite. Silt fraction was found to contain primary minerals like quartz, mica and feldspars and secondary minerals like kaolinite and chlorite (Kuruvila, 1974) in Thottappally and Vadayar kari.

Kaolinite is the mineral that dominates in the clay fraction, while silt fraction is found to contain primary minerals like quartz, mica and feldspars and secondary minerals like kaolinite and chlorite.

1.7 Microbiological characteristics

A new species of Azotobacter which grow equally well in media supplied with free form of calcium carbonate and could grew well even under highly acidic conditions of Kari soils was isolated (Subramoney, 1950).

Thiobacillus thiooxidans was the most important sulphur oxidising bacteria and the population of these organisms increased with soil acidity.

These soils had low nitrifying bacterial population (Money, 1961a and Pillai, 1964) but ammonifying capacity was found to be high (Table 1.7.1.). Among the algal flora, blue green algae dominated (Amma et al. 1966)

Table 1.7.1 Microbiological properties of Kari soils

Sample no.	Depth (cm)	pH	Total count millions g^{-1}	Ammonifying power mg Ng^{-1} soil	N fixing capacity mg Ng^{-1} of sucrose
Profile I. Koithuruthu					
1	0-24	5.4	0.58	21.53	3.30
2	24-75	6.7	0.52	19.46	3.80
3	Below 75	7.1	4.53	21.42	10.20
Profile II. Oorkari					
4	0-24	3.6	0.44	26.17	3.67
5	24-75	5.6	0.23	22.54	2.48
6	Below 75	7.2	1.90	16.10	8.91
Profile III. Elurkalam					
7	0-24	3.7	0.39	23.38	1.22
8	24-75	2.7	0.11	12.46	1.08
9	Below 75	6.9	1.53	11.34	9.72
Profile IV. Kochuputhenkari					
10	0-24	4.2	0.27	23.94	1.79
11	24-75	3.9	0.22	16.10	2.57
12	Below 75	6.7	4.51	9.38	11.46

Source: Pillai, 1964

1.8 Management of Kari soils

Pot culture study using graded levels of lime (0, 1/4, 1/2, 3/4, full and twice the lime requirement) indicated that liming at all the rates significantly increased pH, available nitrogen and phosphorus and consequently growth and yield of rice (Kurup, 1967). Contrary to the above observation,Kabeerathumma (1974) could not obtain any favourable influence by liming on rice in Kari soil. According to her, lime at full lime requirement was necessary to raise the pH to a favourable range. Liming the surface soil could not correct acidity of the lower layers of Kari soils (Money, 1951). Field experiments conducted using different liming materials at graded levels of 1/20, 1/10 and 1/5 of the lime requirement to study the effect of liming materials on toxic factors indicated that application of 1/10 and 1/5 of lime requirement appreciably reduced soluble salts, exchangeable hydrogen and aluminium and water soluble iron content of the soils. Burnt lime and dolomite were almost equal in their effectiveness in reducing exchangeable hydrogen and acidity. Burnt lime was found to be more effective than unburnt lime in decreasing exchangeable aluminium and water soluble iron contents.

Incubation and pot culture studies conducted using Kari soils (Kuruvila and Patnaik, 1973) indicated toxicity as the main reason for crop failure in these soils and could be ameliorated for growing a good crop of rice. Washing and liming was found better than liming alone for amelioration.

Improvement of hydrological conditions was of primary importance for increasing productivity of Kari soils (Money, 1961). According to him, the chief sources of toxicity in Kari soils were extreme acidity, solubility of iron and high amounts of soluble salts especially chlorides and sulphates. He had suggested for change in the periods of cultivation and application of lime to increase productivity of Kari soils. He had suggested creation of bunds to prevent intrusion of flood water and use of acid resistant varieties of rice for improving productivity. Seasonal variations in soil reactions and soluble salt content in Kari soils of Kuttanad were studied by estimating these parameters at monthly intervals (Kurup and Aiyer, 1973). They suggested for shift in cultivation season from August to January. According to their study, this would enhance rice yield by eliminating salinity hazards during flowering and grain filling stages.

Zinc sulphate (0.5 per cent solution) as foliar spray or soil application at the rate of 20 kg ha^{-1} recorded good yield in a field experiment conducted in farmers field (Namboodiri, 1980).

Adoption of tile drainage system helped to remove acidic toxic products from the soil and lowered acidity. Installation of tile drains reduced the content of water soluble iron, sulphate, calcium and magnesium contents of the soil. (Research report, Karumadi, 1989-92).

Surface ploughing is desirable in these soils since deep ploughing may expose sulphur compounds of sub-surface layers, the oxidation of which produce sulphuric acid. Shallow field drains to wash away toxic products from the soil and at the same time to keep sulphur deposits of the lower layers in the reduced state is very much essential to prevent extreme acidity. Partial drainage also allow subsidence of the organic rich soil to a desirable level for cultivation. Sub-surface drainage system is found technically feasible, but its economic viability need to be assessed.

Liming to neutralize acidity in Kari soil is very expensive. Application of small doses of lime (600 kg ha^{-1}) before planting or sowing after draining the field helps to neutralize acidity temporarily and also helps to reduce toxicity due to soluble iron, aluminium and other reduced compounds. Burnt lime and dolomite are equally effective in neutralizing acidity. As the soil is deficient in copper and zinc, seed treatment or foliar application of zinc and copper compounds may be resorted to get higher yield of rice.

2 KARAPPADOMS

2.1 General characteristics

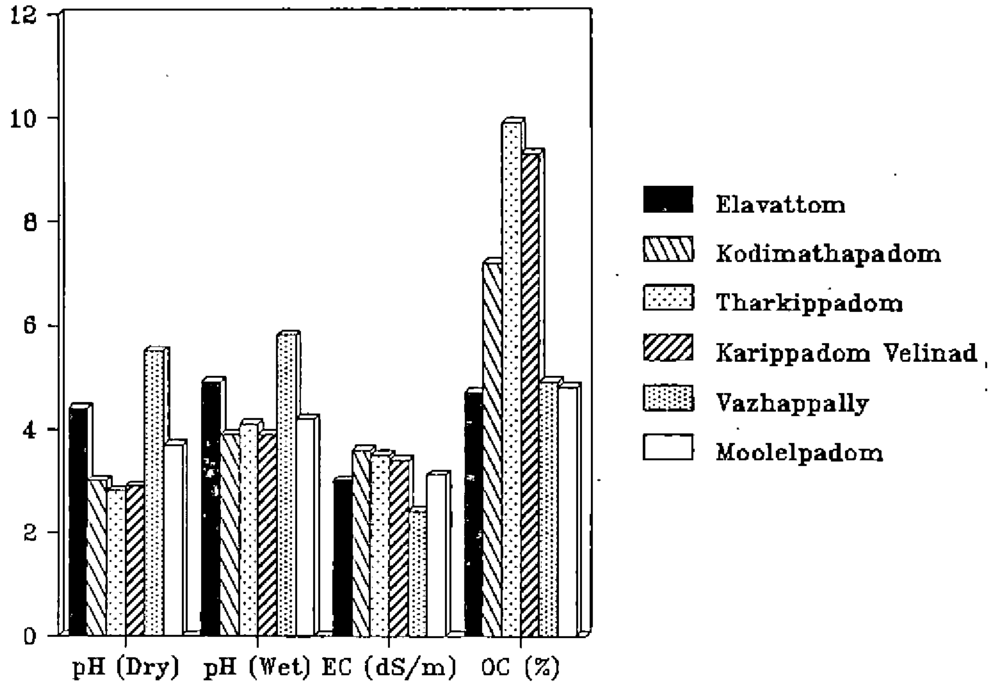
Karappadom soils occur along the inland waterways and rivers and form the major part of upper Kuttanad. This extends in 1014 padasekharams in Alappuzha and Kottayam districts. These are river borne alluvial soils. They occur in fields which are about 1-2m below mean sea level. Soils are very deep, poorly drained, dark grey in colour with clay loam surface texture followed by silty clay sub-soil. The sub-soils also show the presence of abundant, prominent red and yellow mottles, gley horizons, streaks and concretions. Presence of sand pockets in the sub-surface horizons is another feature. Soils are characterised by high acidity, high salt content and a fair amount of decomposing organic matter. Karappadom, is further divided into north Kuttanad, mid Kuttanad and upper Kuttanad.

The entire area in the zone is under rice during punja season. In some areas, an additional crop of paddy is also being taken from April-May to August-September. The patches of garden land are used for raising coconut and other annual and seasonal crops like banana and vegetables.

2.2 Physico-chemical properties of surface soil

The physical and chemical properties of Karappadom soils of seventeen different locations were studied at Rice Research Station, Moncompu. Bulk density ranged from 0.84 to 1.30 g cc^{-1} and particle density from 1.32 to 1.86 g cc^{-1}. Soils possessed a water holding capacity of 24.3 to 54.9 per cent, analysed a pore space of 32.4 to 47.0 per cent and a volume expansion of 2.66 to 15.70 per cent.

Among the chemical properties, pH of fresh soil samples varied from 3.85 to 5.75 and that of dry samples from 2.8 to 5.5. These soils recorded an EC of 2.4 to 3.6 dSm^{-1} at 25°C (Fig.2.2.1). The amount of total exchangeable cations ranged from 1.92 to 10.66 and CEC from 13.1 to 25.3 cmol $(p^{+})kg^{-1}$. Exchangeable Ca ranged from 0.95 to 6.60; Mg, 0.53 to 3.33; K, 0.28 to 0.48 and Na, 0.32 to 0.79 cmol $(P^{+})kg^{-1}$ (Fig. 2.2.2). Hydrogen was the most dominant exchangeable cation. Percentage base saturation varied from 7.8 to 55.2 and aluminium saturation ranged from 6.7 to 34.1 per cent. Lime requirement ranged from 3.0 to 18.8 t ha^{-1} (Fig. 2.2.3). These soils recorded a C:N ratio of 11.9 to 24.6. Available N, P_2O_5 and K_2O ranged from 114 to 218, trace to 14 and 56 to 113 kg ha^{-1} respectively (Fig. 2.2.4 a & b).



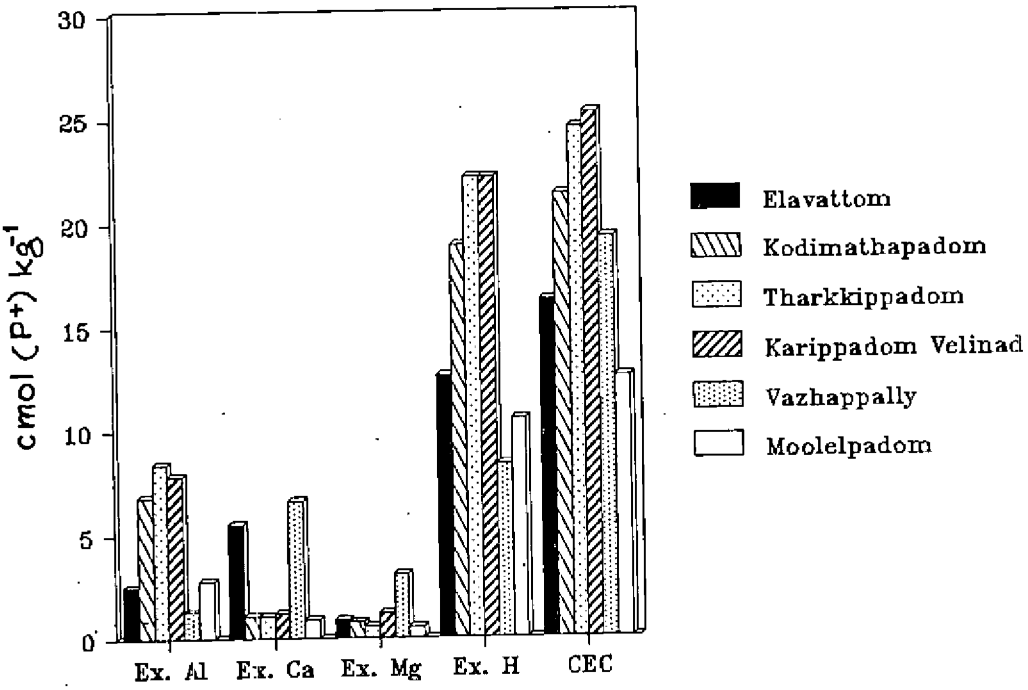
Source: Kurup, 1967.

Fig. 2.2.1 pH, electrical conductivity (EC) and organic carbon (OC) content of Karappadom soils

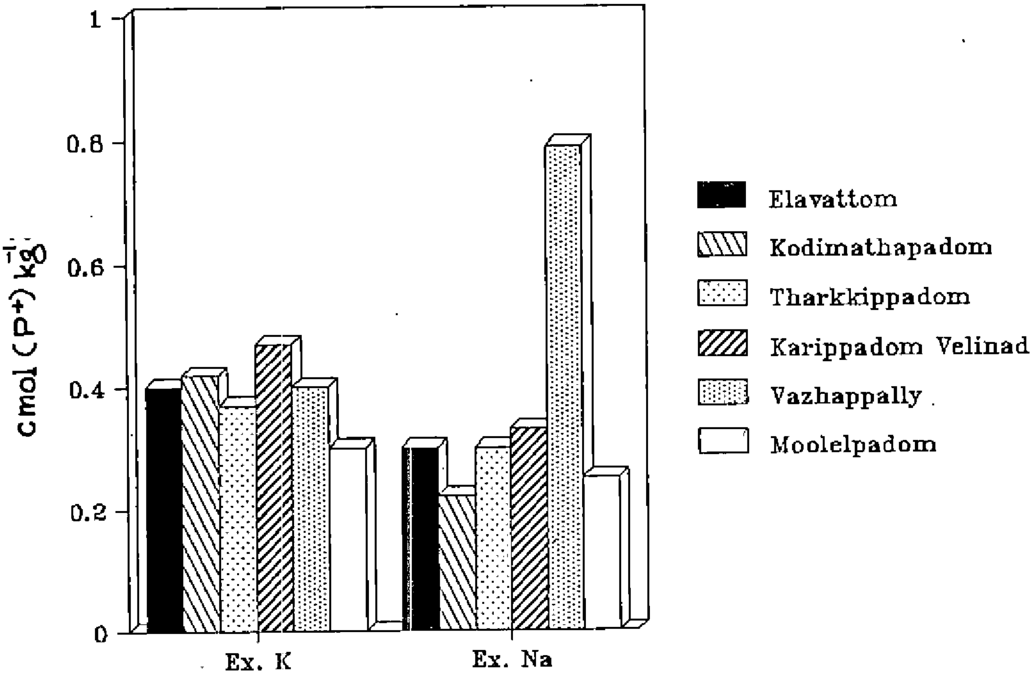
Seasonal variations in pH and EC of the soil indicated maximum pH during October-November and minimum in April-May. EC was maximum in April-May and minimum in October-November (Fig.2.2.5).

Soil of Tharkkippadom registerd maximum acidity, recording a pH of 2.8. Cumulative effect of high organic matter content, low base saturation, high hydrogen and aluminium saturation have resulted in high acidity. Lime requirement for this soil was comparatively high due to the very low pH. CEC was also high in this location, which may be due to high organic matter content.

C/N ratio of most of the Karappadom soils is above ten indicating the presence of undecomposed plant residues. Available phosphorus and potassium are very low in these soils.

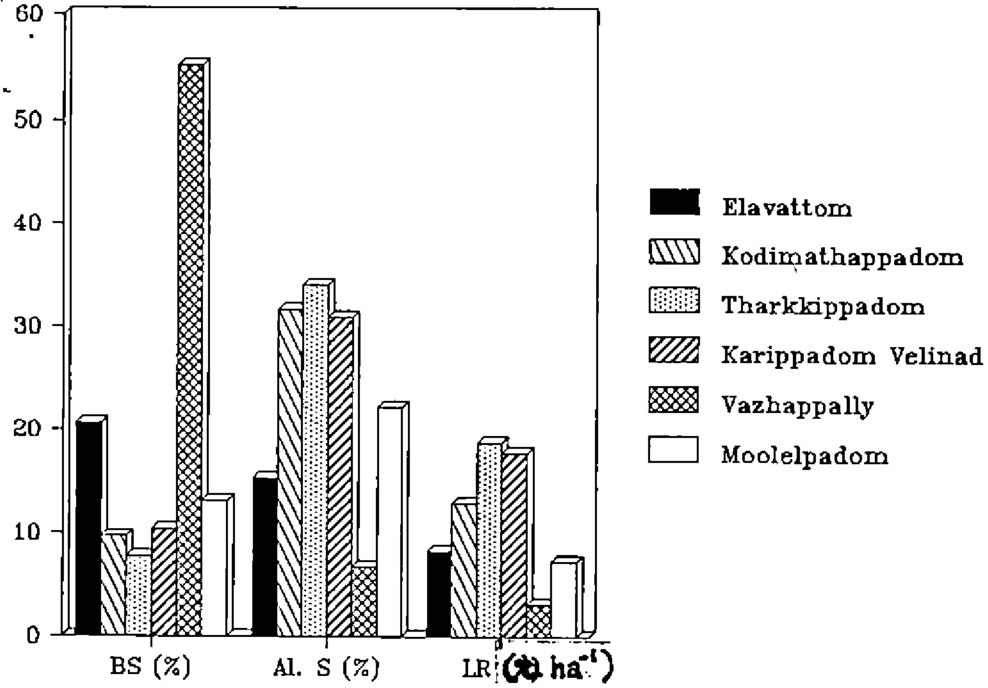


Source: Kurup, 1967.



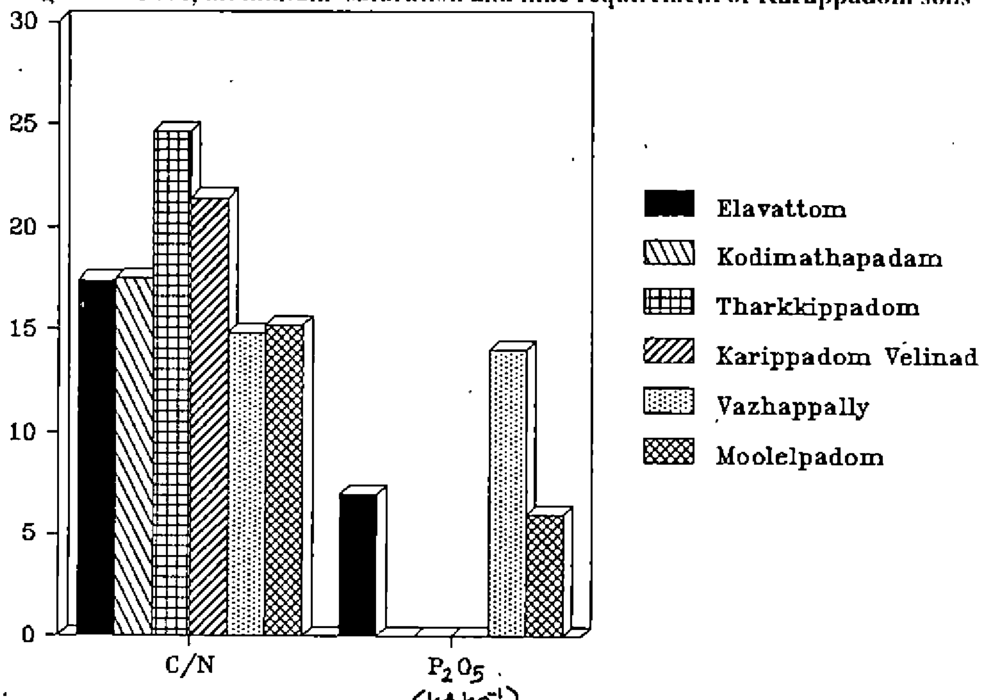
Source: Kurup, 1967.

Fig. 2.2.2 Exchangeable cations and CEC of Karappadom soils



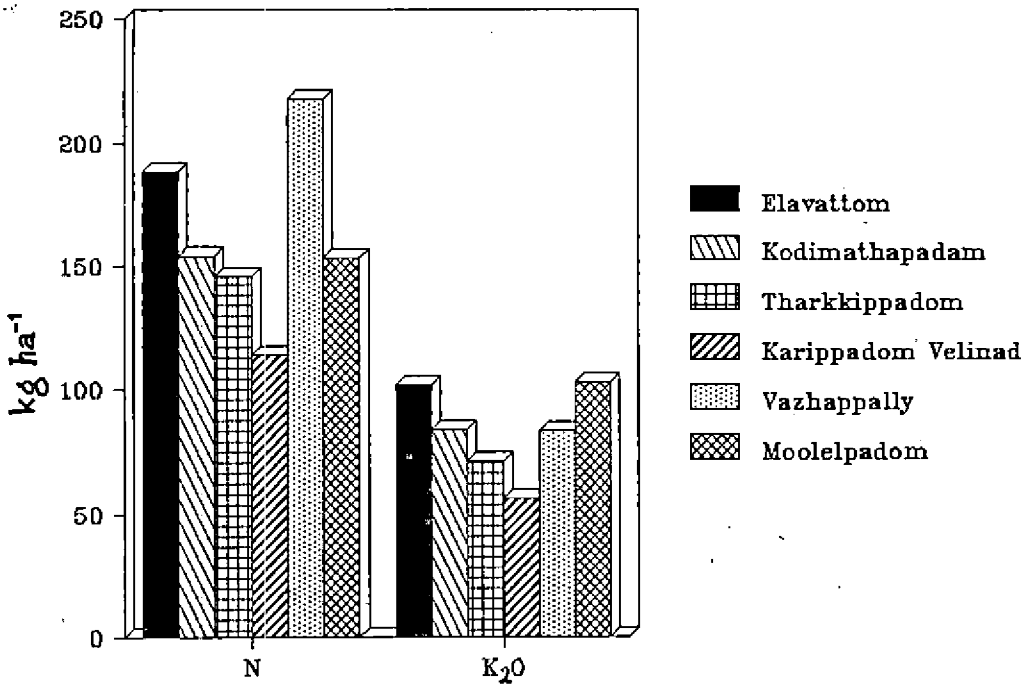
Source: Kurup, 1967.

Fig. 2.2.3 Base, aluminium saturation and lime requirement of Karappadom soils



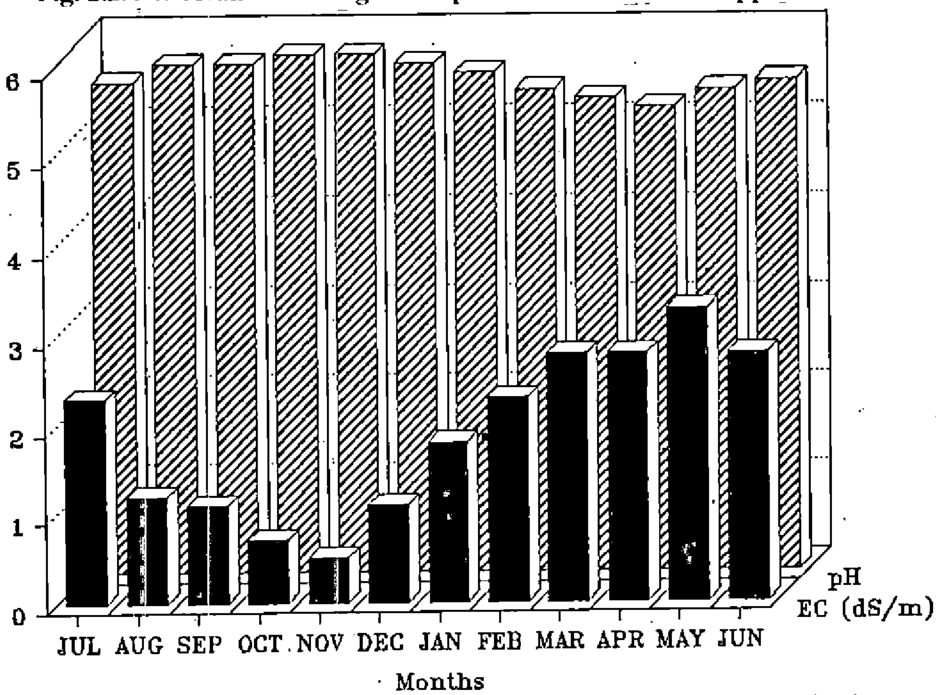
Source: Kurup, 1967.

Fig. 2.2.4 a. C/N ratio and available phosphorus status of Karappadom soils



Source: Kurup, 1967.

Fig. 2.2.4 b. Available nitrogen and potassium status of Karappadom soils



Seasonal variations in pH and electrical conductivity (EC)
(Vazhappally Karappadom)

Maximum pH and minimum EC recorded in October-November is due the rains received during the period and inflow of fresh water from rivers. In April-May, soil undergoes partial dehydration which result in oxidation of sulphur compounds to sulphuric acid and this inturn reduced the soil pH and enhanced EC.

2.3 Profile characteristics

Soil productivity is highly influenced by its morphological and physico-chemical properties. Vettikkarappadom profile has been taken as a typical one and its properties have been depicted in Table 2.3.1.

2.3.1 Morphological properties

Soil layer upto about 15 cm depth was generally dark brown to black in colour. Variations were observed in different locations. Dry roots were present at a depth of about 15 cm. Presence of dry roots was also observed in other profiles also, though the depth of occurrence varied. Soil was sticky when wet and formed hard lumps on drying. Though mottlings were absent in Vettikkarappadom, profiles of Kidangara and Chambakulam exhibited mottles of various colours like white, yellow and reddish yellow in the lower horizons. Concretions were present in the lower horizon of Chambakulam profile.

2.3.2 Physical properties

The texture of the soil was clayey in the surface layer of Vettikkarappadom and loamy sand in the lower depths. While in Muthurpadom, silt was prominent in the surface soil and clay in the lower depths. But in Muthurvadakkepadom, it was loamy in the surface layer and silty loam in the lower layers. Water holding capacity increased with increase in finer fractions. (Santhakumari, 1975).

2.3.3 Chemical characteristics

pH of fresh soil collected from Vettikkarappadom did not show much variations in the first two horizons whereas in the dry soil samples, pH increased with depth. Muthurpadom soils showed reduction in pH from the surface to deeper layers both in fresh as well as in dry soil samples. Muthurvadakkepadom soil was highly acidic in both fresh as well as in dry conditions and acidity was more intense in the dry state especially in the lower layers (Fig. 2.3.3.1). Conductivity of the soils of different horizons increased with depth in Muthurpadom and Muthurvadakkepadom whereas no defenite pattern was noticed in Vettikkarappadom (Santhakumari, 1975).

Table 2.3.1 Profile description (Vettikkarappadom of Punnapra village)

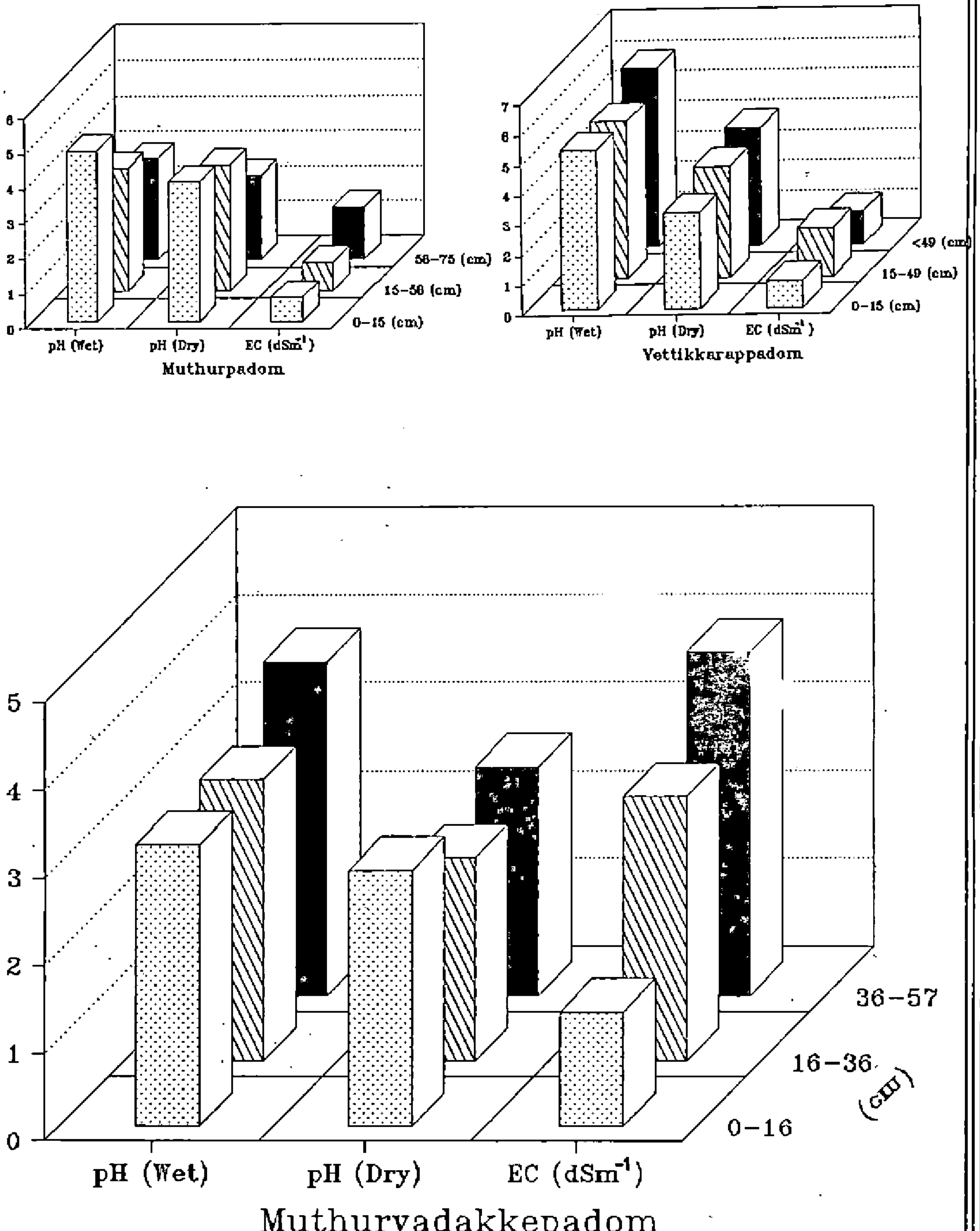
I. General information of the site

a.	Higher category classification	:	entisol
b.	Elevation	:	1 to 3 m below sea level
c.	Land form		
	i. Physiographic position of the site	:	water-logged area
	ii. Land form of surrounding	:	Vembanad lake
	iii. Microtopography	:	flat
d.	Slope on which profile is situated	:	level
e.	Vegetation and land use	:	paddy, punja crop from September to March. Second crop being taken as a trial
f.	Climate	:	tropical humid climate with wet and dry periods
g.	Rainfall	:	2700 mm
h.	Parent material	:	mixed silty alluvium
i.	Drainage	:	poorly drained
j.	Moisture condition	:	wet
h.	Depth of ground water table	:	77 cm
i.	Presence of surface stones	:	no stones and rocks
j.	Evidence of the erosion	:	nil
k.	Presence of salt and alkali	:	moderate with seasonal fluctuations
l.	Human influence, if any	:	reclaimed from lake, cultivated area

II. Profile characteristics

Depth cm	Colour	Texture	Consistence	Pore space	Roots	Mottlings/ cementation	pH
0	Moist-10 YR 2/1 black Dry-2.5Y 3/2 very dark greyish brown	Clay	Wet - slighty sticky Moist - firm Dry - hard	Disconti-nuous	Abundant	Mottlings-nil weakly cemented	5.3
15	Moist-10YR 3/1 Very dark grey Dry -10 YR 3/2 Very dark greyish brown	Loamy sand	Wet - nonsticky Moist - friable Dry - hard	Disconti-nuous	None	Mottlings-nil weekly cemented	4.5
49	Moist-10YR2/1 Very dark brown Dry-2.5Y 3/2 very dark greyish brown	Loamy sand	Wet-non sticky Moist-loose Dry-hard	Disconti-nuous	None	Mottlings-nil weekly cemented	3.2

Source: Santhakumari, 1975



Source: Santhakumari, 1975

Fig. 2.3.3.1 Chemical properties of Karappadom profiles

Organic carbon content varied from 0.79 to 4.09 per cent and nitrogen content from 0.11 to 0.30 per cent. C/N ratio of the profiles varied from 6.58 to 18.33. Upper horizon of Vettikkarappadom showed a high content of both total as well as available P. In Muthurpadom and Muthurvadakkepadom profiles, the lowest layers and in Vettikkarappadom, the top layer had the highest percentage of potassium. Calcium and magnesium contents were high in Muthurvadakkeppadom soil where they increased with depth. But in Vettikkarappadom and Muthurpadom, Ca and Mg decreased as the depth increased (Table 2.3.3.1). CEC of these profiles were fairly high and it varied from 8.36 to 24.08 cmol (p^+) kg^{-1} soil. Total exchangeable metallic cations varied from 7.38 to 18.55 cmol (p^+) kg^{-1} of soil. Except in Vettikkarappadom, CEC of all the profiles increased with depth.Exchangeable Al was the most dominant cation occupying nearly 50 per cent of the exchange complex. It was found to decrease with depth in Vettikkarappadom and Muthurvadakkepadom whereas a reverse trend was noticed in Muthurpadom. Exchangeable Al followed the same trend whereas exchangeable Ca followed a reverse pattern as that of pH (Table 2.3.3.2)

pH of the surface (0-23 cm) dry soil of RRS, Moncompu was 5.1. Total nitrogen and potassium were 0.06 and 0.05 per cent in the surface soil which increased to 0.07 and 0.08 per cent at 23 to 45 cm depth and 0.08 and 0.10 per cent at 45-90 cm depth respectively. Calcium as CaO, increased from 0.01 per cent in the surface soil to 0.17 per cent at 90 cm depth whereas Mg as MgO decreased from 0.09 per cent from the surface to 0.03 per cent at 90 cm depth (Table 2.3.3.3).

Data on chemical characteristics of Champakulam soil showed accumulation of organic matter and all the major nutrients in the surface soil which decreased with depth. CEC was found to increase with depth, probably due to the accumulation of finer fractions on the lower horizons. Slight reduction of pH was observed with increase in depth of the soil profile (Table 2.3.3.4).

Surface soil is generally dark brown to black in colour. Dry roots are present in the profiles at different depths. Soils are sticky when wet and form hard lumps on drying, exhibiting mottles of different colours in most of the profiles. Variations in pH and EC are observed with depth in different profiles. Increase in CEC is noticed with depth in most of the soil profiles. Exchangeable Al appears to be the dominant cation in the profiles.

Table 2.3.3.1 Chemical properties of Karappadom profiles (Total and available nutrient status)

Sample No.	Location	Profile No.	Depth (cm)	Organic carbon %	Total Nitrogen %	C/N ratio	Available P kg ha^{-1}	Total P %	Total K %	Total Ca %	Total Mg %
1	Vettikkarappadom	I	0 - 15	4.09	0.30	13.63	64.4	0.052	0.146	0.229	0.083
2.	Vettikkarappadom		15 - 49	2.21	0.12	18.33	8.0	0.008	0.051	0.222	0.030
3.	Vettikkarappadom		> 49	1.96	0.13	15.07	18.1	0.020	0.030	0.182	Trace
4.	Muthurpadom	II	0 - 15	2.49	0.23	10.82	17.4	0.011	0.095	0.233	0.032
5.	Muthurpadom		15 - 58	0.79	0.12	6.58	21.0	0.011	0.158	0.231	0.032
6.	Muthurpadom		58 - 75	2.04	0.13	15.69	17.8	0.011	0.335	0.194	0.227
7.	Muthurvadakkepadom	III	0 - 16	1.33	0.14	9.50	11.2	0.010	0.071	0.224	0.031
8.	Muthurvadakkepadom		16 - 36	1.83	0.11	16.63	80.8	0.053	0.189	0.284	0.315
9.	Muthurvadakkepadom		36 - 57	3.01	0.17	17.70	162.8	0.033	0.407	0.396	0.946

Source: Santhakumari, 1975

Table 2.3.3.2 Chemical properties of Karappadom profiles (cation exchange capacity and exchangeable cations)

Sample No.	Location	Depth (cm)	Na	K	Ca	Mg	H	Al	Fe	Total exchangeable cations	C.E.C.
			cmol(P^+)kg^{-1}								
1.	Vettikkarappadom	0 - 15	0.32	0.16	0.10	3.00	4.98	8.12	0.12	17.82	22.80
2.	Vettikkarappadom	15 - 49	1.11	0.01	2.25	2.96	1.86	4.97	0.10	11.50	13.36
3.	Vettikkarappadom	> 49	0.65	0.14	3.28	Trace	0.98	3.08	0.23	7.38	8.36
4.	Muthurpadom	0 - 15	0.17	0.58	5.17	3.00	0.61	7.05	0.06	15.93	16.54
5.	Muthurpadom	15 - 58	2.37	0.43	3.80	1.74	0.44	8.03	0.04	16.41	16.85
6.	Muthurpadom	58 - 75	0.30	0.05	6.00	3.30	5.53	8.40	0.50	18.55	24.08
7.	Muthurvadakkepadom	0 - 16	0.40	0.02	4.49	2.48	1.36	7.41	0.04	14.84	16.20
8.	Muthurvadakkepadom	16 - 36	0.68	0.01	6.02	2.88	2.29	6.64	0.06	16.19	18.48
9.	Muthurvadakkepadom	36 - 57	2.57	0.53	6.40	2.50	2.98	5.00	0.08	17.10	20.08

Source: Santhakumari, 1975

Table 2.3.3.3 Chemical properties of the profiles of Rice Research Station, Moncompu

Horizon	Depth (cm)	pH (dry soil)	Total (percentage)						
			N	P_2O_5	K_2O	CaO	MgO	Fe_2O_3	CEC (cmol $(P^+)kg^{-1}$)
1	0-23	5.1	0.06	0.11	0.05	0.01	0.09	20.2	12.6
2	23-45	5.3	0.07	0.06	0.08	0.14	0.07	21.8	11.0
3	45-90	5.2	0.08	0.06	0.10	0.17	0.03	21.3	11.3

Source: Rice Research Station, Moncompu.

Table 2.3.3.4 Chemical properties of Champakulam soil

Depth (cm)	Gravel %	Particle size distribution				Organic carbon %	Total N %	Total P_2O_5 %	Total K_2O %	Total CaO %	R_2O_3 %	Fe_2O_3 %	CEC cmol $(P^+)kg^{-1}$	pH	EC dSm^{-1}	Base saturation %
		Coarse	Fine	Silt	Clay											
0-17	Nil	18.30	24.5	16.6	31.0	6.5	0.414	0.042	0.316	0.116	32.5	6.7	13.8	5.3	0.2	47.10
17-53	Nil	3.20	2.8	28.2	60.2	4.9	0.245	0.033	0.280	0.114	37.7	5.8	33.6	4.2	0.5	44.34
53-130	Nil	1.80	2.1	27.8	65.2	3.3	0.134	0.018	0.120	0.082	33.3	5.9	34.15	4.2	2.5	36.26

Source: Soils of Kerala, 1978.

2.4 Sulphur status

Jacob (1966) reported that organic sulphur constituted more than 90 per cent of the total sulphur considering all the depths in the soil profile together. A decrease in sulphur content was observed with increase in depth (Table 2.4.1). Water soluble sulphur ranged from 2 to 3 per cent of total sulphur.

Table 2.4.1 Sulphur status and fractions of sulphur of Karappadom soil of Moncompu

Depth of sampling (cm)	Total sulphur (per cent)	Nitrogen sulphur ratio	Organic sulphur		Humus sulphur		Water soluble sulphur		Sulphate sulphur	
			Fraction %	% to total sulphur	Fraction %	% to total sulphur	Fraction %	% to total sulphur	Fraction %	% to total sulphur
0-20	0.2466	0.56	0.2343	95.6	0.0312	13.3	0.0048	1.9	0.0094	3.8
20-40	0.2055	0.66	0.1907	93.3	0.0241	12.6	0.0045	2.2	0.0086	4.2
40-60	0.1022	1.30	0.0946	92.6	0.0152	16.1	0.0034	3.3	0.0070	6.8

Source: Jacob, 1966

In Karappadom soils, sulphur content of the soil is contributed mainly by organic matter.

2.5 Micronutrient status

Available micronutrient content of Karappadom soil was studied by collecting soils from seven locations. (Aiyer et al. 1975). The soils were deficient in available copper. Significant negative correlation was observed between organic carbon and available Cu and CEC.

Available micronutrient status of soil profiles was estimated by Santhakumari (1975). Maximum available Zn was recorded in the surface layer of Vettikkarappadom, available Cu in the middle layer of Muthurpadom, available iron in the surface layer of Muthurvadakkepadom and Mn in the lowest layer of Muthurvadakkepadom.

Among the micronutrients, Cu was deficient in most of the soils (Table 2.5.1).

Rajendran (1981) estimated available Mn and Zn content of Karappadom soils collected from six locations by using five different extractants. Most of the soils were found deficient in available Zn.

Table 2.5.1 Available micronutrient status of Karappadom soil

Location	Zn (ppm)	Cu (ppm)	Fe (ppm)	Mn (ppm)
Moncompu	10.5	0.22	110.0	14.0
Velinad	1.0	0.30	74.0	10.0
Neelamperoor, West	0.3	0.26	74.0	10.0
Neelamperoor, East	2.2	0.22	36.0	2.0
Punnapra	10.5	0.16	156.0	18.0
Muthurpadom, Nedumudi	2.0	0.20	82.0	6.0
Muthurvadakkepadom, Nedumudi	2.5	0.26	212.0	25.0

Source: Rice Research Station, Moncompu

Karappadom soils are found uniformly deficient in available copper. Zn content is also below the critical level for successful crop production in several locations. Complexing with organic fractions of soil as well as antagonistic effects with more dominant cations like iron may likely to reduce plant availability of these micronutrients in Karappadom soils which are rich in active iron and organic fractions.

2.6 Soil management for rice cultivation

Results of the trials conducted at Rice Research Station, Moncombu are reviewed here.

2.6.1 Nitrogen management

Among the three sources of nitrogen tried viz. ammonium sulphate, urea and calcium ammonium nitrate, ammonium sulphate recorded significantly higher yield for Ptb-10 followed by urea. Calcium ammonium nitrate was the least effective one. Addition of calcium with ammonium sulphate and urea did not fetch any additional yield (Table 2.6.1.1).

Table 2.6.1.1 Comparative efficiency of sources of nitrogen on grain yield of Ptb-10 during punja season

Treatments	Grain yield kg ha^{-1}*
A/S@ 40 $kgha^{-1}$	3376
CAN@ 40 $kgha^{-1}$	2882
Urea@ 40 $kgha^{-1}$	3226
A/S@ 40 $kgha^{-1}$ + Calcium equal to the quantity in CAN	3240
Urea@40 $kgha^{-1}$ + Calcium equal to the quantity in CAN	2966
Control	2618
CD(0.01)	145.1

A/S - Ammonium sulphate
CAN - Calcium ammonium nitrate
* Mean data of 3 punja seasons

Source: Rice Research Station, Moncompu

Effect of split application of nitrogen was studied in three punja seasons from 1968-71 using the variety IR-8. Grain yield obtained by the application of entire quantity of N in three equal splits at tillering, panicle initiation and booting stages was on a par with application of half the total quantity of N at tillering and the other half in two equal splits either at panicle initiation and booting stages or at booting and heading stages. Application of the entire dose in five equal splits at planting, tillering, panicle initiation, booting and heading stages was also found equally effective for medium duration rice (Table 2.6.1.2).

Application of 90 kg N ha^{-1} recorded significantly higher yield over the yields recorded by 67.5, 45.0 and 0 kg N ha^{-1}. Application of 45 kg N ha^{-1} either as basal dose or at active tillering along with 22.5 kg N ha^{-1} each at maximum tillering and panicle initiation did not make any significant difference in grain yield of Aswathy (Table 2.6.1.3). Severe reduction in both grain and straw yields was observed when P and K fertilizers were applied without nitrogen.

Application of 90 kg N ha^{-1} as basal dose in paper balls was as effective as application of same dose in splits as per Kerala Agricultural University package of practice recommendations. Mud ball application was not found effective both at 90 and 60kg N ha^{-1}. At the lowest level of 45 kg N ha^{-1}, no significant difference was observed in yield with the method of application (Table 2.6.1.4).

Table 2.6.1.2 Grain yield of rice as influenced by split application of nitrogen

Treatments	Application of N (Percentage of total dose - 90 $kgha^{-1}$) at					
	Planting	Tillering	Panicle initiation	Booting	Heading	Grain yield ($kgha^{-1}$)
1	75	-	25	-	-	4932
2	75	-	12.5	12.5	-	5377
3	75	-	12.5	-	12.5	5061
4	75	-	-	12.5	12.5	4879
5	-	50	25	25	-	5933
6	-	50	-	25	25	6039
7	50	-	25	25	-	5538
8	50	-	-	25	-	5105
9	-	33	33	33	-	6178
10	-	33	-	33	33	5455
11	33	-	33	33	-	5631
12	20	20	20	20	20	5812
CD (0.05)						443

Source: Rice Research Station, Moncompu

Table 2.6.1.3 Effect of split application of nitrogen on grain and straw yield of Aswathy

Treatments		Grain yield* kg ha^{-1}	Straw yield* kg ha^{-1}
1	90kg N-50% basal, 25% MT, 25% PI	4022	8233
2	90 kg N-50% AT, 25% MT, 25% PI	3922	8286
3	67.5 kg N-50% basal, 25% MT, 25% PI	3550	7591
4	67.5 kg N-50% MT, 25% MT, 25% PI	3588	8055
5	45 kg N-50% basal, 25% MT, 25% PI	3180	7313
6	45 kg N-50% AT, 25% MT, 25% PI	3244	7222
7	No N control	2444	5183
8	No manure control	2318	5369
CD(0.05)		315	1058

AT-Active tillering stage MT-Maximum tillering stage PI-Panicle initiation stage

Source: Rice Research Station, Moncompu

Table 2.6.1.4 Effect of methods of application of N on grainyield

Treatments		Grain yield kg ha^{-1}*
1	90 kg N PPR	4798
2	90 kg N as MB	4300
3	60 kg N as MB	3776
4	45 kg N as MB	3524
5	90 kg N as PB	4778
6	60 kg N as PB	4173
7	45 kg N as PB	3847
8	90 kg N mixed with goat manure as basal	4195
9	60 kg N mixed with goat manure as basal	4381
10	45 kg N mixed with goat manure as basal	3626
11	90 kg N mixed with 6 times moist soil	4200
CD(0.05)		464

PRR-Package of practices recommendation of KAU
MB-Mud ball
PP-Paper ball
*Mean data of 3 punja seasons

Source: Rice Research Station, Moncompu

The efficiency of neem cake blended urea for grain production was tested in experiments conducted in cultivators' fields of Kizhakkumbhagam and Niranam villages in 12 locations and in Pulimkunnu village in 8 locations during the punja season of 1977-78. Seventy five and 50 per cent of the recommended dose (67.5 and 45.0 kg N ha^{-1} respectively) were applied with and without neem cake blending and compared with the recommended dose of N (90 kg ha^{-1}). Treatment differences, though not statistically significant in Kizhakkumbhagam village, application of 67.5 kg N as urea neem cake blend recorded maximum yield whereas in Pulimkunnu, same dose of N as urea alone recorded the highest yield.

In 1979-80 punja season, the same experiments were conducted in Edayodichempu and Niranathuthada villages in upper Kuttanad and kayal blocks C and D representing lower Kuttanad. Though statistical analysis of pooled data did not reveal any significnt difference, average grain yield of both upper and lower Kuttanad indicated beneficial effects of blending urea with neem cake at 5:1 ratio. Seventy five per cent of the recommended dose was found better than the recommended dose if blended with neem cake.

During the punja season of 1980-81, experiments were conducted in 4 locations in cultivator's field to study the efficiency of 67.5 kg nitrogen as urea with the same quantity blended with neem cake (5:1) and punna cake (5:1). All the above treatments were compared with farmer's local practice. Results, though not statistically significant, neem cake blended urea recorded maximum grain yield in all the 4 locations.

Non edible oil cakes at different levels were mixed with recommended dose of urea and applied to paddy crop to find out the best non edible oil cake and its rate of mixing with urea for maximum grain yield and lesser incidence of pest and diseases in a field experiment conducted at RRS, Moncompu. Results showed that application of neem cake, marotti cake, and punna cake at different levels increased grain yield, though the increase was not significant. Different cakes did not influence incidence of pests and diseases.

Ammonium sulphate is found to be the best nitrogen source for rice followed by urea. Heavy basal dose of nitrogen (> 90 kg N ha^{-1}) is not found beneficial in Karappadom soil for rice in Moncompu since available nitrogen status of the soil is high. Application of nitrogen in three equal splits at active tillering, panicle initiation and booting stages or half at tillering and 25 per cent at panicle initiation and 25 per cent at booting stages or application of the entire dose in five equal splits are on a par. Basal application of N can be delayed by 2 to 3 weeks without any yield reduction. Among the different levels tried, 90 kg N ha^{-1} is found to be the best for Karappadom soils of Moncompu.

Experiments conducted in different locations indicated that neem cake blending helps to save 25 per cent N for medium duration rice.

2.6.2 Phosphorus management

Hyperphosphate at the rate of 100 kg P_2O_5 ha^{-1} was superior to bonemeal applied at the same rate and the treatment recorded 10 per cent increase in yield over bonemeal for the variety Ptb-10. No significant difference in grain yield was observed between superphosphate, hyperphosphate, bonemeal and rock phosphate. At 40 kg P_2O_5 ha^{-1} applied with and without lime, superphosphate, fused magnesium phosphate, deflourinated phosphate and multiphosphate behaved similarly and were superior to rock phosphate, hyperphosphate and basic slag. Rock phosphate at 60 kg

P_2O_5 ha^{-1} was significantly superior to superphosphate and rock phosphate at 30 kg level and on a par with superphosphate at 60 kg level. Though superphosphate behaved similarly at both the levels, rock phosphate recorded significantly higher yield at the higher level. Basic slag at 60 kg P_2O_5 ha^{-1} recorded highest yield which was on a par with rock phosphate and fused magnesium phosphate (Table 2.6.2.1.). At equal P_2O_5 level (40 kg ha^{-1}) superphosphate was superior to Laccadive phosphate (Table 2.6.2.2).

Table 2.6.2.1 Effect of different phosphatic fertilizers on grain yield of rice

Treatments	Grain yield (kg ha^{-1})		
	$P_2O_5^{-1}$ (kg ha^{-1})		Mean yield
	30	60	
Superphosphate	3254	3314	3283
Rock phosphate	2858	3425	3145
Fused magnesium phosphate	3156	3342	3271
Defluorinated phosphate	3234	3336	3285
Multiphosphate	3156	3305	3231
Hyperphosphate	3024	3240	3131
Basic slag	3034	3482	3258
Mean	3105	3105	3227

CD between forms - 145.26

CD between levels within forms - 205.44

CD between levels - 77.63

Source: Rice Research Station, MoncomPu

Table 2.6.2.2 Effect of Laccadive phosphate on grain yield of rice

Treatments		Grain yield kg ha^{-1}*
1	No P_2O_5	3364
2	NPK - 30-40-30 kgha^{-1} P_2O_5 as SP	3560
3	NPK 30-40-30 kgha^{-1} P_2O_5 as LP	3373
CD (0.05)		127.6

*Mean data of 3 punja seasons LP - Laccadive phosphate SP - Super phosphate

Source: Rice Research Station, Moncompu

Rock phosphate from six sources (Idalio, Florida Central, Florida north, North Carolina, Tennesse and Udaipur) behaved similarly with single and triple superphosphate at 50 and 200 kg P_2O_5 ha^{-1}.

Superphosphate, phosmak and ultraphos applied at 20, 40 and 60 kg P_2O_5 ha^{-1} levels did not affect grain yield significantly. Comparative efficiency of water soluble and mineral acid soluble phosphates alone and in combination with pyrite was studied in a field experiment during punja and additional cropping seasons. It was observed that during both seasons, 60 kg P_2O_5 ha^{-1} as rock phosphate along with pyrite at 1:1 ratio by weight recorded higher grain yield (Table 2.6.2.3).

Table 2.6.2.3 Grain yield of rice as influenced by combined application of different forms of phosphorus

	Treatments (P as P_2O_5)	Grain yield ($kgha^{-1}$)	
		Additional crop	Punja crop
1	No P	2322	5788
2	20 $kgha^{-1}$SP, basal	2450	6206
3	60 $kgha^{-1}$RP, basal	2895	5632
4	30 kg RP+30kg ha^{-1} SP, basal	2500	6176
5	60 kgRP + Pyrite (1:0.5 W/W)	2816	5781
6	60 kg RP+Pyrite (1: 1 W/W)	2994	6304
7	30 kg RP, basal + 30 kg SP, tillering	2766	5711
8	30 kg RP+Pyrite (1:0.5 W/W) + 30 kg SP, tillering	2717	6156
9	30 kg RP+Pyrite (1:1 W/W), basal+30 kg SP, tillering	2816	6225
	CD(0.05)	320	660

SP - Single superphosphate RP - Rock phosphate

Source: Rice Research Station, Moncompu

Basal application of P_2O_5 was found as good as split application (Table 2.6.2.4).

Table 2.6.2.4 Effect of time of application of phosphorus on grain yield of rice.

Treatment (kg P_2O_5 ha^{-1})	Grain yield (kg/plot) 1981-82 punja	1982-83 Additional crop	1982-83 Punja	Mean
T1 - Control (no P_2O_5)	15.0 (26.8)	13.6 (24.1)	25.4 (40.9)	18.00 (10.14)
T2 - 15 kg as basal	10.3 (24.0)	17.9 (24.1)	30.8 (39.9)	19.70 (10.88)
T3 - 30 kg as basal	11.0 (23.7)	18.6 (37.8)	30.4 (45.1)	20.00 (11.84)
T4 - 45 kg as basal	12.6 (28.5)	21.3 (43.6)	29.2 (45.5)	21.03 (13.04)
T5 - 7.5 kg as basal + 7.5 kg at tillering	12.8 (23.8)	16.5 (34.7)	29.8 (40.0)	20.77 (10.94)
T6 - 15 kg as basal + 15 kg at tillering	15.1 (31.1)	17.4 (33.6)	29.8 (40.5)	20.77 (11.87)
T7 - 15 kg as basal + 7.5 kg tillering + 7.5 kg PI	12.5 (26.7)	18.6 (39.9)	30.5 (44.5)	20.53 (12.34)
T8 - 22.5 kg basal + 15 kg tillering + 7.5 kg at PI	11.3 (29.5)	19.4 (39.2)	32.6 (46.9)	21.10 (12.91)
	-	-	-	NS

PI - Panicle initiation state

Figures in paranthesis indicates straw yield (kg $plot^{-1}$).

Source: Rice Research Station, Moncompu

Finely powdered rock phosphate or hyperphosphate at 100 kg $P_2O_5ha^{-1}$ is better than raw rock phosphate. Single superphosphate, hyperphosphate, rock phosphate and bone meal are equally efficient at 40 kg P_2O_5 ha^{-1} level. At 30 kg P_2O_5 ha^{-1}, superphosphate was as effective as thermal phosphate. At 60 kg P_2O_5 ha^{-1} level, rock phosphate is found significantly superior to superphosphate at 30 kg and is equally efficient as superphosphate at 60 kg level. No significant difference in grain yield is obtained by split application of P over basal application.

2.6.3 Potassium management

Maximum grain yield was obtained by the split application of potassium ie. 50 per cent K_2O (25 kg ha^{-1}) as basal dose, 25 per cent (12.50 kg ha^{-1}) at tillering and 25 per cent at panicle initiation stage of the rice crop. But the yield was on a par with no K_2O, control (Table 2.6.3.1). Another field experiment was conducted to compare the Kerala Agricultural University Package of Practices (1982) recommendations (1/2 as basal and 1/2 at panicle initiation (PI) stage of rice crop with that of 2/3rd as basal and 1/3rd at PI stage, 1/2 as basal and 1/4th at active tillering and 1/4th at PI stage. The above treatments were compared with a no K_2O control. Treatment differences were not significant.

Table 2.6.3.1 Effect of time of application of potassium on grain yield.

Treatments		Grain yield (1970-71) ($kg\ ha^{-1}$)
1	Control (no K_2O)	6297
2	50 kg K_2O ha^{-1} as basal	6231
3	2/3 basal + 1/3 PI stage	6429
4	1/3 basal + 1/2 PI stage	5928
5	1/2 basal + 1/4 AT + 1/4 PI stage	6674
CD (0.05)		390

PI - Panicle initiation AT - Active tillering

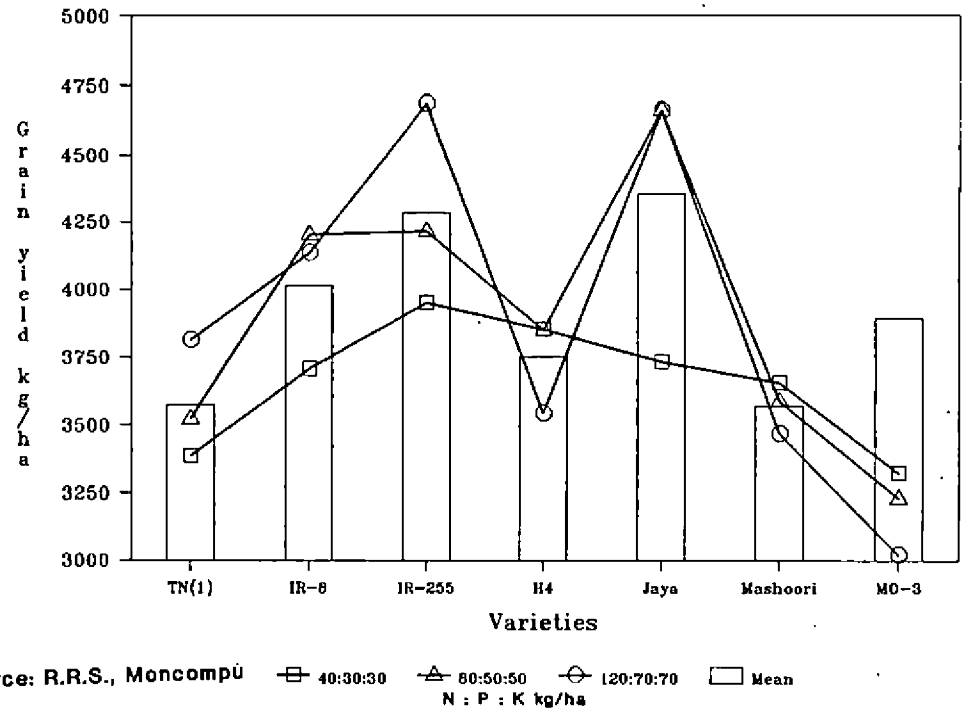
Source: Rice Research Station, Moncompu

In general, no response is obtained for potassium in Karappadom soil of Moncompu.

2.6.4 Management of major nutrients

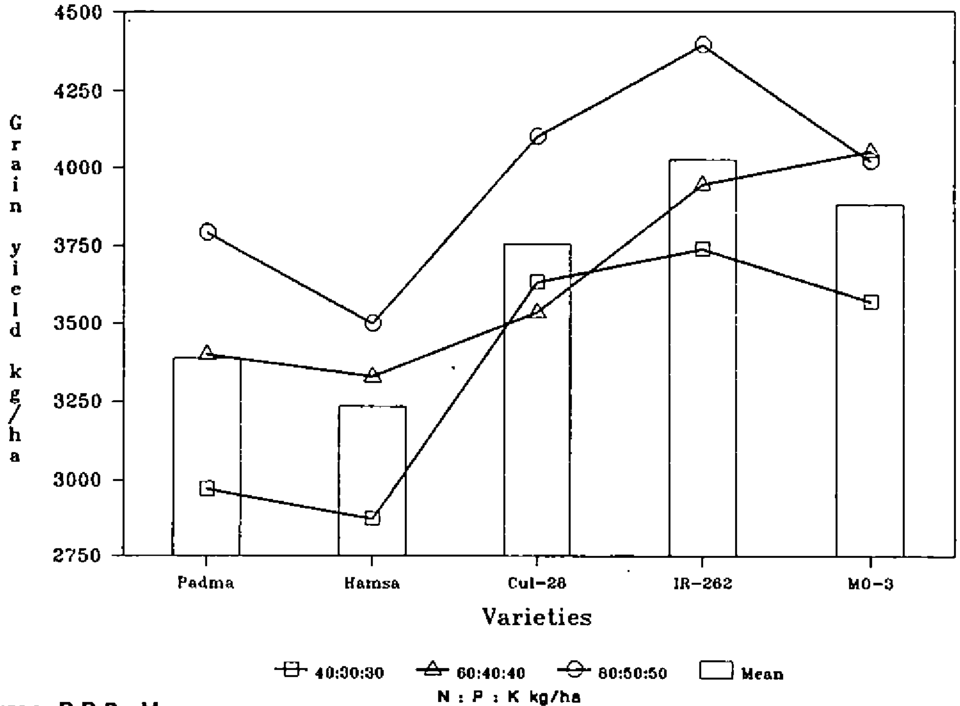
Varietal differences in grain yield were assessed at different nutrient managements. Jaya recorded the highest yield followed by IR-255. H_4, Mashoori and MO-3 recorded lower yields compared to Jaya and IR-255. Yields recorded for a dose of 120-70-70 and 80-50-50 kg NPK ha^{-1} were significantly higher than the yield realised at 40:30:30 kg NPK ha^{-1} for all varieties except H-4, Mashoori and MO-3. The treatment with 120-70-70 kg NPK ha^{-1} was the best for TN-1 and IR-255. But for Jaya, effects due to 120-70-70 and 80-50-50 kg NPK ha^{-1} were similar (Fig. 2.6.4.1). Mashoori, H-4 and MO-3 responded only upto the lowest level of 40:30:30 kg NPK ha^{-1}. Among the varieties, Padma, Hamsa, Culture-28, IR-262 and MO-3, maximum grain yield was recorded by IR-262 followed by MO-3 and culture-28. All the rice varieties except MO-3 recorded highest yields at 80-50-50 kg NPK ha^{-1} (Fig. 2.6.4.2) among the NPK levels tried (40-30-30, 60-40-40 and 80-50-50 kg ha^{-1}).

Combined application of 60 kg N ha^{-1} along with 80 kg P_2O_5 ha^{-1} and 80, 100 and 120 kg N ha^{-1} along with 40, 60 and 80 kg P_2O_5 ha^{-1} respectively behaved similarly with respect to grain yield of IR-8 (Table 2.6.4.1).



Source: R.R.S., Moncompu

Fig. 2.6.4.1 Response of rice varieties to levels of major nutrients



Source: R.R.S., Moncompu

Fig. 2.6.4.2 Response of rice varieties to different levels of major nutrients

Table 2.6.4.1 Response of IR-8 to different levels of N and P (1968-1971, Punja)

Treatments	Mean grain yield (kg ha^{-1})
60kg N+40kg P_2O_5 ha^{-1}	3296
60kg N+ 60 kg P_2O_5 ha^{-1}	3676
60kg N+ 80 kg P_2O_5 ha^{-1}	3777
80kg N+ 40 kg P_2O_5 ha^{-1}	3957
80kg N+ 60 kg P_2O_5 ha^{-1}	3946
80kg N+ 80 kg P_2O_5 ha^{-1}	3935
100kg N+ 40 kg P_2O_5 ha^{-1}	4032
100kg N + 60 kg P_2O_5 ha^{-1}	3987
100kg N + 80 kg P_2O_5 ha^{-1}	4008
120kg N + 40 kg P_2O_5 ha^{-1}	4185
120kg N + 60 kg P_2O_5 ha^{-1}	4355
120kg N + 80 kg P_2O_5 ha^{-1}	4210
CD (0.05)	655

Source: Rice Research Station, Moncompu

Table 2.6.4.2 Effect of skipping P and K on grain yield of rice

	Treatments									
Treatment No.	Punja 74-75	Addl. '75	Punja 75-76	Addl. '76	Punja 76-77	Addl. '77	Punja 77-78	Grain yield kg ha^{-1}	Regression coefficient	Index of stability
1	NPK	NPK	NPK	NPK	NPK	NPK	NPK	4050	1.0000	1.0000
2	NPK	NK	NPK	NK	NPK	NK	NPK	3740	1.3444	0.5534
3	NK	NPK	NK	NPK	NK	NPK	NK	3777	0.8720	1.3152
4	NPK	NK	NK	NPK	NK	NK	NPK	3835	1.0047*	0.9906
5	NK	NPK	NK	NK	NPK	NK	NK	3519	0.9812	1.0386
6	NPK	NP	NPK	NP	NPK	NP	NPK	3825	0.9441	1.1219
7	NP	NPK	NP	NPK	NP	NPK	NP	3968	0.7063	2.0046
8	NPK	NP	NP	NPK	NP	NP	NPK	3636	0.8006	1.5602
9	NP	NPK	NP	NP	NPK	NP	NP	3716	0.9654	1.0730
10	N	N	N	N	N	N	N	3369	0.9899	1.0206
C.D. (0.05)								308		

Addl. - Additional cropping season

* Significant at 0.05 level

Source: Rice Research Station, Moncompu

Residual effect of phosphatic and potassic fertilizers on the variety Thriveni using a fertilizer dose of 70-35-35 kg NPK ha^{-1} revealed that skipping of potassium once in two seasons did not affect grain yield significantly. However skipping of P_2O_5 once in two seasons starting with the first season, and also once in three seasons starting with the second season reduced grain yield considerably. Similarly continuous application of nitrogenous fertilizers alone had a deleterious effect on grain yield (Table 2.6.4.2).

Rice variety Jaya respond upto 80-50-50 while Mashoori and H-4 respond only upto 40-30-30 and MO-3 upto 60-40-40 kg NPK ha^{-1}. Potassium can be skipped once in two seasons without affecting grain yield of rice. Continuous application of nitrogenous fertilizers reduce grain yield significantly.

2.6.5 Management of micronutrients

Field experiments were conducted in 1980 in both the punja and additional crop seasons and in 1981 during the additional crop season to study the effects of application of micronutrients for rice and also to compare the efficiency of pre-soaking rice seeds in micronutrient solutions, soil application and foliar spray.

Pre-soaking seeds of the rice seeds in 1.0 and 2.0 per cent zinc sulphate, 0.4 and 0.8 per cent copper sulphate solutions and in distilled water were compared with soil application of 20 and 40 kg ha^{-1} of zinc sulphate and copper sulphate, and foliar spray of 0.5 and 1.0 per cent zinc sulphate and 0.2 and 0.4 per cent copper sulphate solutions. Though not significant, trend of the results indicated clearly that higher grain yields could be obtained by pre-soaking seeds in 2 per cent zinc sulphate and 0.4 per cent copper sulphate solutions. Pre-soaking treatments may also economise costly micronutrient carriers.

Another experiment was also taken up as a continuation of the micronutrient experiment conducted during the year 1980-81. Four concentrations of $ZnSO_4$ (1, 2, 3 and 4 per cent) and three concentrations of $CuSO_4$ (0.5, 1.0 and 1.5 per cent) were used for pre-soaking seeds. Treatment differences were not statistically significant, but trend of the results indicated that pre-soaking seeds in 2 per cent $ZnSO_4$ and 1 per cent $CuSO_4$ solutions were beneficial for increasing grain yield of rice.

Pre-soaking rice seeds in 2 per cent zinc sulphate and 0.4 to 1.0 per cent copper sulphate solutions is found beneficial.

2.6.6 Organic manures and biofertilizers

Application of 20 tons (fresh weight) of salvinia did not give any significant increase in grain yield of rice. Combined application of salvinia and fertilizer @ 90:45:45 kg NPK ha^{-1} significantly increased grain yield over application of either of them alone. Lime application along with salvinia recorded significantly higher grain yield than that recorded by salvinia alone (Table 2.6.6.1).

Table 2.6.6.1 Grain yield of rice as influenced by salvinia application

Treatments		Grain yield* kg ha^{-1}
1	Control	1858
2	Lime alone	2063
3	Fertilizer alone	2559
4	Salvinia alone	1660
5	Salvinia + lime	2178
6	Fertilizer + lime	2708
7	Salvinia + fertilizer	3215
8	Salvinia + fertilizer+lime	3012
CD (0.01)		509.3

* Mean data of 2 punja seasons

Source: Rice Research Station, Moncompu

Application of BGA and bacterial culture did not give any beneficial effect on grain yield of rice.

In the presence of FYM @ 5 t ha^{-1}, yields realised with 90:45:45 and that with 60:15:30 kg NPK ha^{-1} were on a par. But no significant difference in straw yield was observed. Incorporating daincha raised with a basal dose of 45 kg P_2O_5 ha^{-1} along with N and K @ 45:45 kg ha^{-1} in two equal splits (1/2 as basal and 1/2 at PI stage) recorded maximum cost benefit ratio of 1.59. Maximum input cost was required for the treatment that received FYM @ 5 ton ha^{-1} along with NPK @ 90:45:45 kg ha^{-1} (Table 2.6.6.2).

Application of salvinia alone @ 20 t ha^{-1} gives less grain yield compared to that realised by the application of NPK @ 90:45:45 kg ha^{-1}. Combined application of salvinia and fertilizer increase grain yield by 25.6 per cent over

Table 2.6.6.2 Effect of different sources of organic manures on grain yield (pooled data of 4 seasons)

	Treatments	Grain yield	B : C
1	FYM 5 t + NPK 90:45:45 kg^{-1}	3906	1.39
2	FYM 5 t + NPK 60:15:30 kg^{-1}	3836	1.58
3	FYM 5 t + NPK 45:45:45 kg ha^{-1}	3597	1.43
4	FYM 5 t + NPK 45:45:45 kg + Coir dust 500 kg ha^{-1}	3542	1.38
5	FYM 2.5 t + NPK 45:45:45 kg ha^{-1}	3563	1.46
6	Compost 5 t + NK 45:45: kg ha^{-1}	3532	1.53
7	FYM 2.5 t + NPK 45:45:45 + BGA 10 kg ha^{-1}	3568	1.47
8	FYM 2.5 t + NPK 45:45:45 + Azolla 5 t + BGA 10 kg ha^{-1}	3591	1.46
9	Neemcake 100 kg + NPK 45:45:45 kg ha^{1}	3592	1.39
10	Daincha with 45 kg P_2O_5 + 45:45:NK kg ha^{-1}	3609	1.59
CD (0.05)		193.5	

Source: Rice Research Station, Moncompu

that obtained by the application of fertilizer alone. Biofertilizers like BGA or bacterial cultures are not found beneficial for rice in these soils. FYM @ 5t ha^{-1} can save 30 kg N, 30 kg P_2O_5 and 15 kg K_2O ha^{-1}. Incorporation of daincha fertilized with phosphorus can save half the quantity of nitrogen in rice and fetch maximum return per rupee invested in Karappadom soils of Moncompu.

2.6.7 Soil amendments

Kinetics of solution pH of limed and unlimed soils of Karappadom soils collected from Moncompu and Pallathuruthi indicated that the pH was raised by one unit in limed soil than unlimed soil within one hour after liming and the change was maintained at Moncompu. But in Pallathuruthy soil, a difference of 0.4 unit was observed only after three days of liming. The general increase in pH observed in both the soils two weeks after liming may probably be due to the effect of submergence.

A study on variations in pH, EC, CO_3^{2-}, HCO_3^-, Cl^- and SO_4^{2-} of river, well and field water in different seasons indicated that a high pH and EC were noted during the period of May-June. pH decreased in all water samples towards the end of September. EC decreased rapidly from June to September in well and river water but that of field water, it remained almost steady during this period. Carbonate and bicarbonate contents of well water were found maximum during May and was reduced to a low level in August-September. River and field water did not contain any carbonate. Bicarbonate content of field water increased slightly in August-September and was minimum in May-June. Calcium and magnesium contents of well water were also maximum in May-June and decreased thereafter. Chloride content of river water was unaffected till July and a slight increase was noted thereafter, but in field and well water a steady decrease was seen from June onwards. The adapative trials conducted in cultivator's field in Pulinkunnu and Kizhakkumbhagam villages showed that 600 kg lime ha^{-1} slightly increased grain yield in Pulinkunnu village whereas the increase was more prominent in Kizhakkumbhagam. In both locations yield reduction was noticed at the highest level.

Magnesium silicate and sodium silicate to supply 25 and 50 kg Si O_3 ha^{-1} behaved similarly in Karappadom soil. The individual effect of magnesium and silica was studied by applying them as magnesium carbonate and sodium carbonate respectively at the same rate. Treatment differences were not statistically significant in individual years as well as in pooled analysis.

The influence of nitrogen, phosphorus and lime on grain yield was studied using the rice variety Ptb-4. Nitrogen was applied at two levels of 30 and 45 kg ha^{-1}, phosphorus at two levels of 40 and 60 kg P_2O_5 ha^{-1} and lime at three levels of 0,300 and 600 kg ha^{-1}. Maximum grain yield was obtained at 45, 60 and 600 kg N, P_2O_5 and lime ha^{-1} respectively. At all levels of N and P, grain yield increased with increased application of lime.

The effect of split application of lime @ 500 kg ha^{-1} at different growth stages of IR-8 variety of rice indicated no response for the treatments. Similarly MnO_2 at three different levels viz. 0,500 and 1000 kg ha^{-1} behaved similarly. No beneficial effect was observed by the application of carbide ash, calcium carbonate, calcium oxide and dolomite @ 250 and 500 kg $CaCO_3$ equivalent ha^{-1}. A field experiment was conducted to compare the effect of liming, washing alone, washing and applying lime and applying lime and then washing. Here also treatments failed to give any significant difference in grain yield.

Lime was applied both as basal and as split doses at different growth stages of rice. Time of application was not found to have any significant influence on grain yield.

Response of lime was observed in some locations like Pulimkunnu and Kizhakkumbhagam villages upto 600 kg ha^{-1} lime. More than 600 kg lime ha^{-1} is unfavourable for rice in Karappadom soil probably due to reduction in the availability of micronutrients. Time of application is not found to have any significant influence on grain yield of rice.

2.6.8 Effect of management practices on pest and disease incidence and grain yield

Increasing levels of nitrogen from 60 to 90 and 120 kg ha^{-1} increased the incidence of BPH. BPH population increased with narrower spacing. Maximum BPH count was observed at 10x10 cm spacing and minimum in 30x20 cm spacing. Though higher nitrogen level increased BPH attack, these levels gave higher grain yields (Tables 2.6.8.1 a & b).

Table 2.6.8.1 a. Effect of spacing on BPH count and grain yield

Spacings	BPH count $hill^{-1}$				Grain yield (kg ha^{-1})		
	1976-77	1977-78	1978-79	1979-80	1976-77	1977-78	1978-79
30x20 cm	10.26	23.81	36.0	13.63	2992	5985	3893
30x15 cm	12.21	27.86	45.1	17.88	3022	5879	3934
30x10 cm	15.67	26.77	46.8	20.80	3303	6110	4315
20x15 cm	16.38	38.00	60.0	25.70	3391	6416	4289
20x10 cm	20.38	39.97	66.6	27.21	3537	5886	4131
15x10 cm	23.62	-	-	-	-	-	-
10x10 cm	36.42	-	-	-	-	-	-
C.D (0.05)	1.62	1.87	2.66	2.98	242.5	304	225

Source: Rice Research Station, Moncompu

Table 2.6.8.1 b. Effect of N levels on BPH count and grain yield

N level kg ha^{-1}	1976-77	1977-78	1978-79	1979-80	1976-77	1977-78	1978-79	1979-80
	BPH count $hill^{-1}$				Grain yield (kg ha^{-1})			
60	18.27	28.75	48.3	18.98	3067	5716	3599	5056
90	19.44	32.28	50.2	20.17	3405	6153	4209	5420
120	20.12	32.83	53.9	23.94	3675	6299	4530	5639
CD (0.05)	—	2.10	2.06	2.30	158.8	236	174	206

Source: Rice Research Station, Moncompu

Significant decrease in brown plant hopper population was observed with the application of 90 kg K_2O ha^{-1} and above (Table 2.6.8.2).

Table 2.6.8.2 Effect of graded levels of K on incidence of BPH

Treatments	K_2O (kg ha^{-1})	BPH count $hill^{-1}$*		
		60 days prior to harvest	40 days prior to harvest	20 days prior to harvest
1	0	28.71	48.50	34.41
2	45	25.87	48.68	30.65
3	90	23.08	39.25	28.32
4	135	20.44	33.69	23.83
5	180	19.82	32.75	23.15
C.D (0.05)		4.82	2.19	4.25

* Mean of three seasons data

Source: Rice Research Station, Moncompu

Field experiments were conducted in five locations to study the effect of graded doses of N (30, 50 & 70 kg ha^{-1}) on the incidence of bacterial leaf blight, sheath blight and sheath rot during the additional cropping season of 1981. 35 kg each of phosphorus and potash were applied uniformly in all plots. Levels of N had significant effect on the incidence of bacterial leaf blight and sheath blight. Bacterial leaf blight was significantly less in plots receiving N @ 30 kg N ha^{-1} than that in 70 kg N level. Sheath rot incidence though not statistically significant showed an increasing trend with incresing levels of nitrogen. Though increasing levels of N increased incidence of all diseases, it is not seen reflected in grain yield.

Adaptive trials were conducted in two locations in Mathikayal of lower Kuttanad and Edayodichembu of upper Kuttanad to study the effect of different levels of K_2O on the incidence of brown plant hopper and grain yield of rice. Treatments with 45.0, 67.5 and 90.0 kg K_2O ha^{-1} were compared with a "no K_2O" control. Brown Plant hopper infestation and grain yield did not reveal any significant influence of treatments on either of them in the pooled analysis of the data.

An adaptive trial was conducted in Karappadom soil to find out the efficiency of calcium peroxide coating of seeds on germination, crop stand and control of weeds under submerged condition. It was found that this practice controlled growth of wild rice as well as grassy weeds efficiently. Calcium peroxide coating increased the number of panicles and grain yield (Table 2.6.8.3).

Table 2.6.8.3 Effect of calcium peroxide coating on weed growth and grain yield of rice

Treatments	Crop stand/ m^2	Wild rice/ m^2	Grasses/ m^2	Dry wt. of weeds/ m^2(g)	Height (cm)	Productive tillers/ m^2	Grain yield kg ha^{-1}
Calcium peroxide treatment	162	9	5	3.45	95.5	249.5	5100
Control	233	39	29	15.22	90.2	209.0	4150
CD (0.05)							325

Source: KAU Annual Report, 1984-85

Brown plant hopper incidence is higher at N levels above 60 kg ha^{-1} and by closer spacing. Increase in succulence by increased application of N and high humidity caused by closer spacing favoured BPH incidence. Higher levels of N recorded higher grain yield in spite of high BPH incidence. A reduction in the incidence of BPH was observed with increase in the dose of K_2O, but yield reduced slightly above 135 kg K_2O ha^{-1}. Bacterial leaf blight and sheath blight incidence significantly increased at nitrogen levels above 30 kg ha^{-1}. CaO_2 coating of rice seeds controlled wild rice and grassy weeds efficienty and increased grain yield in wet sown rice.

3 KAYAL LANDS

3.1 General characteristics

Kayal lands extending over an area of 8,000 ha constitute about 14.3 per cent of the total area of Kuttanad. These soils are seen in the reclaimed beds of Vembanad and Kayamkulam lakes. In the early years of reclamation, a single crop of rice was raised in these lands for 2 to 4 years continuously and then left fallow for one or two years as continuous cropping decreased grain yield. Fields are submerged 1.5 to 2.0 m below mean sea level for a period of 5 to 6 months in a year. These soils are more severely affected by salinity than other soil types of Kuttanad, and crop failure is a common feature. Intrusion of sea water is prevented to a certain extent by the construction of the permanent bund between Vechoor and Thanneermukkam in Shertalai taluk and two crops are being raised in many places. Another project has been implemented in one of the blocks of Kayal lands viz. the R block, where the construction of a rubble ring bund permanently cut off saline water intrusion. This bund was completed in 1965. At present, there is continuous pumping out of saline seepage water and rain water, which collects in the channels inside the R block.

3.2 Physico-chemical properties of surface soil

Soil samples analysed from 20 different locations of Kayal lands indicated that pH of air dried soils varied from 4.5 to 6.9 and that of submerged soils ranged from 5.05 to 7.10. The electrical conductance ranged from 2.6 to 3.9 dSm^{-1} at 25°. Organic carbon content ranged from 0.58 to 3.30 per cent (Kurup, 1967). Lime requirement as determined by Hutchinson and Mc Lennan's method was comparatively low in this soil, the value ranged from 0.08 to 6.20 t $CaCO_3$ ha^{-1} (Fig. 3.2.1. a&b).

Cation exchange capacity ranged from 11.6 to 17.2 cmol $(p)^+kg^{-1}$ soil. Exchangeable cations like Ca, Mg, K and Na varied from 2.20 to 10.30, 1.70 to 2.54, 0.33 to 0.58 and 0.40 to 0.80 cmol(p^+) kg^{-1} of soil respectively. Values for exchangeable hydrogen ranged from 0.24 to 12.55 and that of aluminium, 0.03 to 2.85 cmol(p^+) kg^{-1} of soil. Base saturation varied from 22 to 98 per cent. CEC and exchangeable cation status of Mangalam, Irupathinayiram and Chithiramangalam kayals studied by Kurup (1967) are presented in Fig. 3.2.2.

Soil was also low in available nitrogen and phosphorus but was comparatively richer in potassium. Available major nutrient status of Mangalam, Irupathinayiram and Chithiramangalam kayals are given in Fig. 3.2.3.

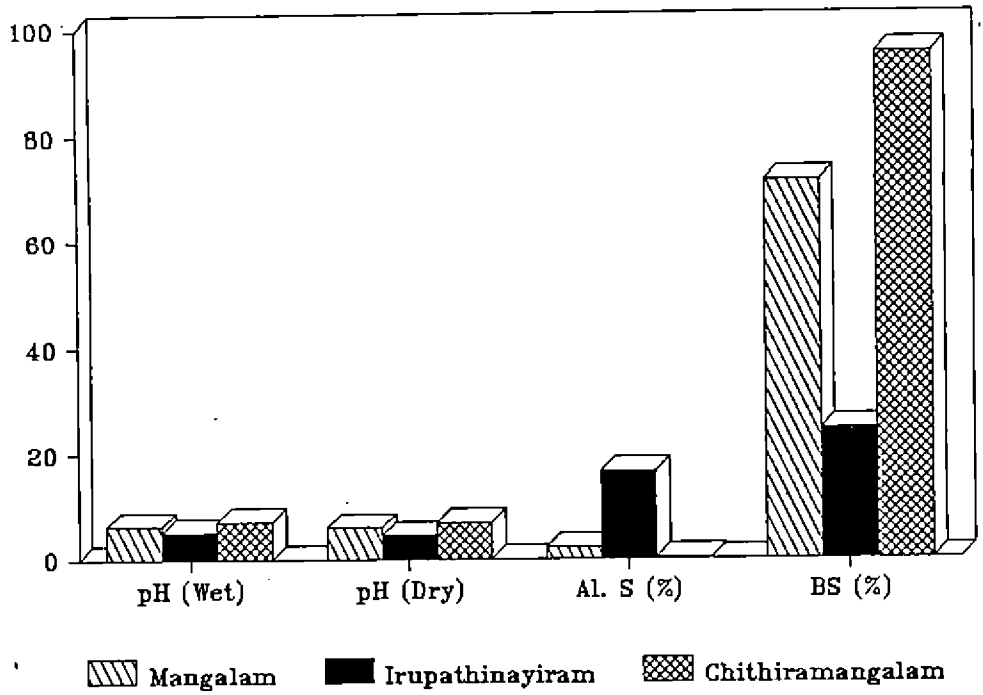
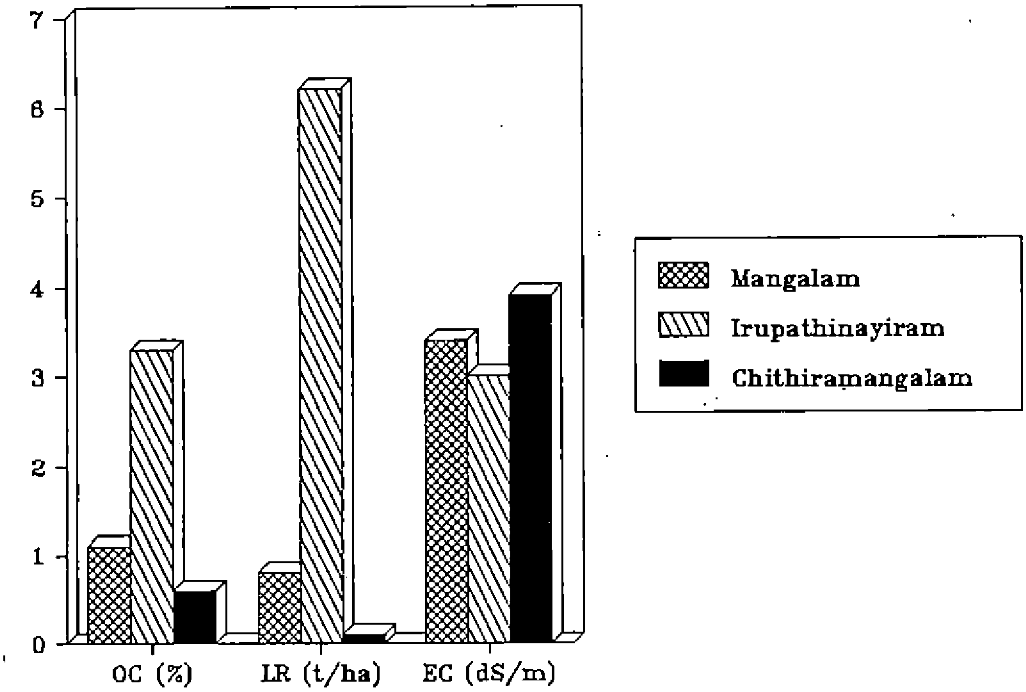


Fig. 3.2.1 a. pH, aluminium saturation (Al S) and base saturation (BS) of Kayal oils



Source: Kurup, 1967.

Fig. 3.2.1 b. Organic carbon, lime requirement and electrical conductivity of Kayal soils

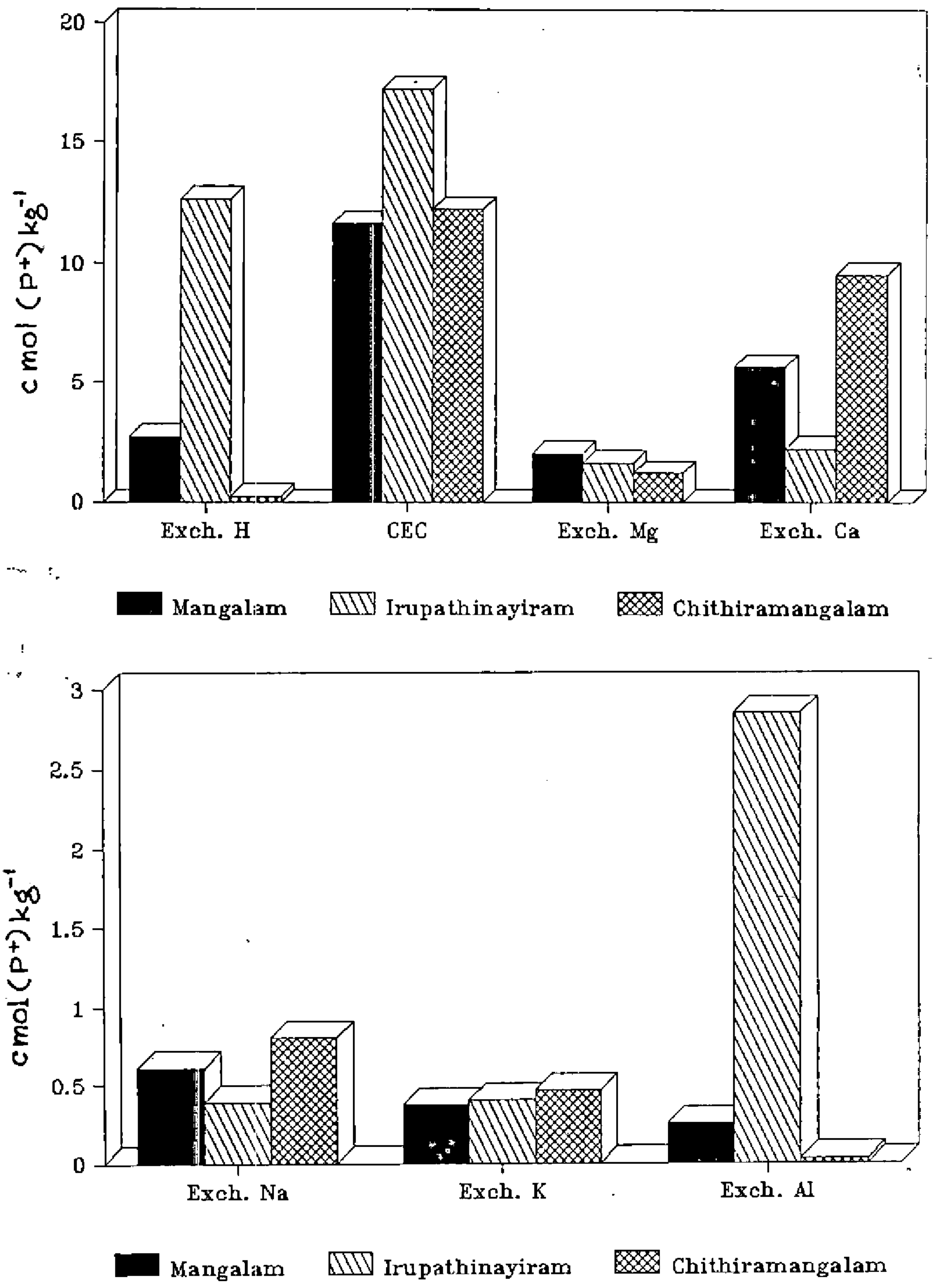


Fig. 3.2.2. Percentage saturation of exchange complex by different cations in some typical Kayal soils

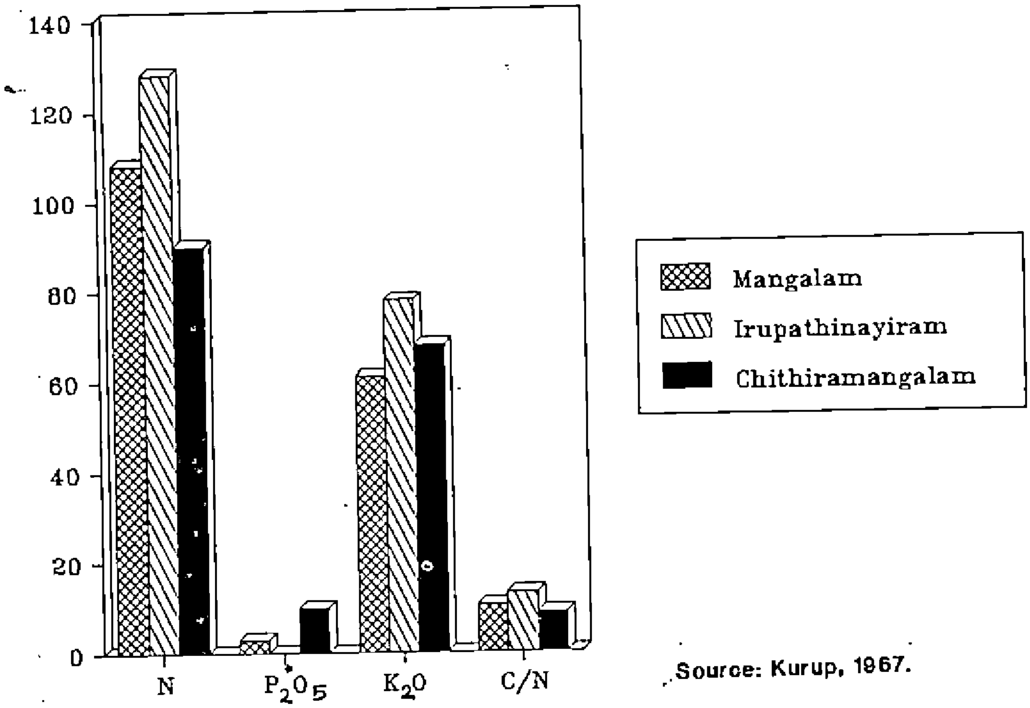


Fig. 3.2.3. Available major nutrient status (kg ha⁻¹) and C/N ratio of Kayal soils

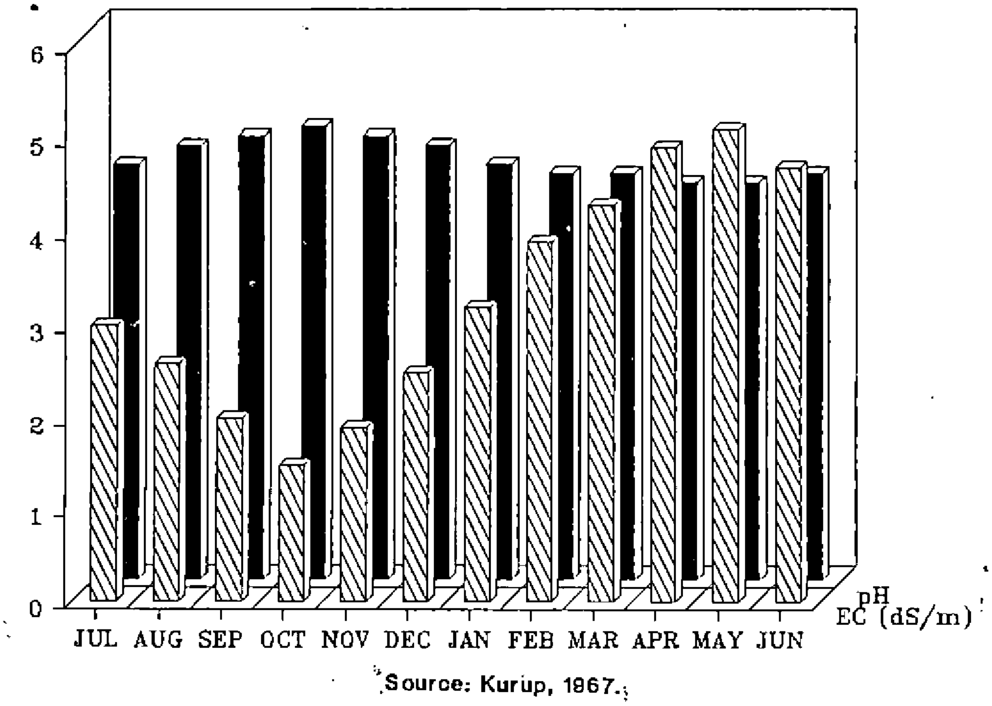


Fig. 3.2.4. Seasonal variations in soil pH and EC of Kayal soils (Irupathinayiram kayal)

Soils showed seasonal variations in soluble salt content. Maximum pH and minimum electrical conductivity were recorded in October-November (Fig. 3.2.4).

Low pH recorded in Kayal soils is due to high concentration of hydrogen and aluminium in the exchange complex. But organic carbon content, C/N ratio, total and exchangeable Fe, H and Al are low in this soil compared to Kari and Karappadom. Available N and P status are low, but K content is comparatively higher. Minimum pH and maximum EC are recorded in April-May due to oxidation of sulphur compounds on drying and sea water intrusion in summer months through Thanneermukkam bund and Thottappally spillway. Maximum pH and minimum EC are noted in October-November. Fresh water from rain and rivers help in washing of acidity and salts and this results in the rise of pH and lowering of EC.

3.3 Profile characteristics

Menon (1975) studied the morphological and physico-chemical properties of Kayal profiles of Kuttanad. He classified these soils in the soil order, Entisol; sub-order, Aquent and great soil group, Hydraquent of soil taxonomy.

3.3.1 Morphological properties

Profile descriptions of Chithira Kayal are given in Table 3.3.1.1. Kayal soils were mostly silty loam or sandy clay loam in texture, fine sand being the most dominant fraction in all the profiles (Menon, 1975). The Vechoor Kayal soil of Kottayam district was deep and poorly drained. Sub-soil showed the presence of lime shells. Soil exhibited typical aquic characteristics such as grey colour, red and brown mottles and streaks. Soil was seriously affected by salinity and hence crop failures are not uncommon. Vechoor belongs to isothermic family of Aeric Tropaquents. (Soils of Kerala, 1978). Lime shells were present in all the different layers.

3.3.2 Physical properties

Physical properties of Rani kayal D and G block, R block and Chithira kayal are given in Tables 3.3.2.1 and 3.3.2.2 respectively. Only the surface soil of Chithira kayal was clayey in texture with a maximum of 36.5 per cent clay. The two profiles of D Block showed a decrease in clay content with increase in depth while G Block showed a reverse trend for clay as well as for fine sand. The fine sand was maximum in the middle layers of the profile of D Block. In the R Block kayal, maximum clay content was observed in the middle layer, whereas in Chithira kayal, it was maximum in the surface layers. But, distribution of clay in other layers did not follow any regular

Table 3.3.1.1 Profile description (Chithira kayal, Alappuzha district)

I. General information of the site

a.	Higher category classification	:	Entisol
b.	Elevation	:	1.5 m below sea level
c.	Land form		
	i. Physiographic position of the site	:	kayal
	ii. Land form of surrounding	:	Vembanad lake
	iii. Microtopography	:	flat
d.	Slope on which profile is situated	:	level
e.	Vegetation and land use	:	paddy
f.	Climate	:	tropical humid climate with wet and dry periods
g.	Rainfall	:	2700 mm
h.	Temperature	:	70-75°C
i.	Parent material	:	mixed silty alluvium
j.	Drainage	:	poorly drained
k.	Moisture condition	:	wet
l.	Depth of ground water table	:	about 65 cm
m.	Presence of surface stones	:	no stones and rocks
n.	Evidence of the erosion	:	nil
o.	Presence of salt and alkali	:	moderate with seasonal fluctuations
p.	Human influence, if any	:	reclaimed from lake, cultivated area

II. Profile characteristics

Depth cm	Colour	Texture	Consistency	Structure	Presence of lime shell	pH	Cementation
0	2.5YR 3/2 Very dark greyish brown	Clay	Wet - very sticky Moist-very firm Dry-extremely hard	Structure less	Nil	5.9	Weakly cemented
12	2.5Y3/2 Very dark greyish brown	Clayloam	Wet-sticky Moist - firm Dry - very hard	Structure less	Present	7.2	Weakly cemented
20	10YR 2/2 Very dark brown Dry-hard	Silty loam	Wet-slightly sticky Moist - friable	Structure less	Nil	3.9	Weakly cemented
44	10YR 2/1 black loam Moist-friable Dry-hard	Silty	Wet-slightly sticky	Structure less	Nil	2.9	Weakly cemented

Table 3.3.2.1 Physical properties of Kayal profiles

Sample No.	Location	Depth cm	Percentage on oven dry basis				
			Clay	Silt	Fine sand	Coarse sand	Textural class
1.	Rani Kayal Plot, D	0-25	22.70	21.30	53.04	1.08	Loam
2.	Rani Kayal Plot D	25-40	16.82	1.68	75.91	1.34	Sandy clay loam
3.	Rani Kayal Plot D	40-92	6.80	35.40	54.50	0.78	Silty loam
4.	Rani Kayal Plot G	0-20	12.20	37.50	43.70	0.67	Silty loam
5.	Rani Kayal Plot G	20-44	16.80	35.80	45.80	0.42	Silty loam
6.	Rani Kayal Plot G	44-67	22.00	23.50	49.42	0.78	Clay loam
7.	R. Block Kayal	0-15	8.00	33.50	53.40	1.68	Silty loam
8.	R. Block Kayal	15-52	19.05	1.90	72.78	0.29	Sandy clay loam
9.	R. Block Kayal	> 52	5.00	32.50	59.19	0.80	Silty loam
10.	Chithira Kayal	0-12	36.50	7.50	47.87	2.55	Clay
11.	Chithira Kayal	12-20	21.50	9.00	59.86	1.85	Clay loam
12.	Chithira Kayal	20-44	15.60	33.80	41.13	0.58	Silty loam
13.	Chithira Kayal	> 44	25.00	25.00	45.20	1.33	Silty clay loam

Source: Menon, P.K.G., 1975

Table 3.3.2.2 Single value constants and moisture content (Oven dry basis)

Sample No.	Location	Depth cm	Absolute specific gravity	Apparent specific gravity	Pore space %	Maximum water holding capacity %
1.	Rani Kayal Plot D	0-25	2.21	1.12	53.93	51.94
2.	Rani Kayal Plot D	25-40	2.05	0.96	58.30	68.27
3.	Rani Kayal Plot D	40-92	2.03	0.96	57.39	63.73
4.	Rani Kayal Plot G	0-20	2.02	1.00	55.10	62.35
5.	Rani Kayal Plot G	20-44	2.03	1.00	58.64	56.62
6.	Rani Kayal Plot G	44-67	2.00	0.90	59.07	66.37
7.	R. Block kayal	0-15	2.31	1.30	47.30	36.79
8.	R. Block kayal	15-22	2.09	1.00	58.12	61.84
9.	R. Block kayal	> 22	1.97	0.94	55.58	66.10
10.	Chithira Kayal	0-12	2.08	1.07	51.65	52.04
11.	Chithira Kayal	12-20	2.18	1.15	50.51	48.14
12.	Chithira Kayal	20-44	1.90	0.98	51.96	[illegible]
13.	Chithira Kayal	> 44	1.92	0.91	57.02	68.14

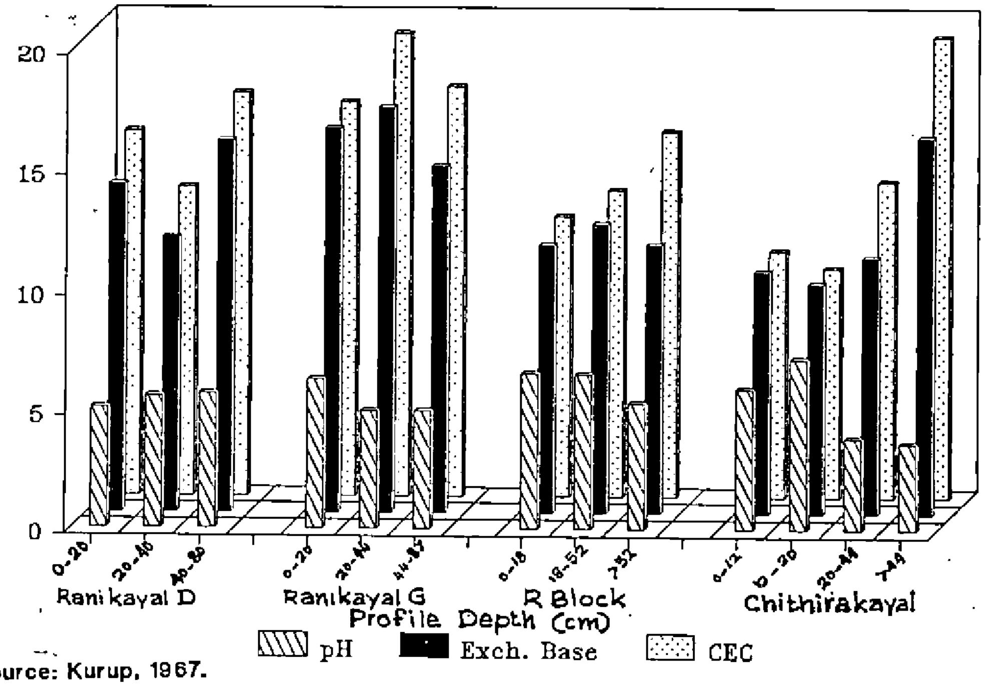
Source: Menon, P.K.G., 1975

pattern. Absolute and apparent specific gravities decreased with depth whereas pore space, water holding capacity and volume expansion increased with depth and showed negative relationship with organic matter.

3.3.3 Chemical characteristics

Cation exchange capacity of the soil ranged from 9.60 to 19.30 cmol (p^+) kg^{-1}. Exchangeable Al and H were more concentrated in the lower layers. Percentage base saturation ranged from 73.5 to 97.7. Surface layers were more saturated with bases. Calcium and magnesium formed the dominant bases in all the profiles studied. But in Chithira kayal and Rani kayal Profiles, exchangeable Na was equally dominant in all the layers. Chemical properties of R block, Rani and Chithira kayal are presented in Fig. 3.3.3.1.

Electrical conductivity steadily increased with depth. Unlike in the case of Kari soils, organic carbon as well as C/N ratio increased with depth in Kayal soils. Total nitrogen was low in all the profiles whereas total potassium was high. Total potassium increased with depth. Soils from R Block showed comparatively lower total and available potassium when compared with the soil of other blocks. Available phosphorus status was medium to high. Total phosphorus was more concentrated in the surface layers. Calcium status of all the profiles was comparatively higher. Magnesium status also increased with depth (Table 3.3.3.1).



Source: Kurup, 1967.

Fig. 3.3.3.1. pH, exchangeable bases and CEC (cmol (p^+) kg^{-1} of Kayal soils

Table 3.3.3.1 Chemical properties of Kayal soils

Sample No.	Location	Depth cm	pH		Conductivity $d Sm^{-1}$	Organic carbon %	Total nitrogen %	C/N ratio	Available P ($kg\ ha^{-1}$)	Total nutrients (per cent)			
			Wet soil 1:2.5 soil water	Dry soil 1:2.5 soil water						P	K	Ca	Mg
1	Rani Kayal Plot D	0-25	5.1	6.8	1.7	1.43	0.24	5.96	44.0	0.06	0.24	0.56	0.07
2	Rani Kayal Plot D	25-40	5.6	6.3	1.8	2.52	0.19	13.26	34.0	0.05	0.29	2.21	0.07
3	Rani Kayal Plot D	40-92	5.7	3.7	3.0	3.09	0.22	14.04	40.0	0.04	0.38	0.75	0.31
4	Rani Kayal Plot G	0-20	6.3	6.6	1.2	1.90	0.21	9.05	76.0	0.06	0.28	0.95	0.11
5	Rani Kayal Plot G	20-44	5.0	3.4	2.9	3.98	0.25	15.92	60.0	0.06	0.34	0.99	0.23
6	Rani Kayal Plot G	44-67	5.0	4.8	3.2	3.98	0.26	15.92	80.0	0.06	0.36	0.58	0.37
7	R. Block kayal	0-15	6.6	6.7	0.7	1.14	0.20	5.70	74.0	0.07	0.11	0.28	0.05
8	R. Block kayal	15-52	6.5	6.5	1.2	2.07	0.19	10.89	84.0	0.05	0.21	2.22	0.06
9	R. Block kayal	> 52	5.3	2.9	1.5	3.84	0.17	22.59	56.0	0.04	0.29	0.83	0.28
10	Chithira kayal	0-12	5.9	5.3	0.65	1.35	0.15	9.00	88.0	0.08	0.19	0.28	0.08
11	Chithira kayal	12-20	7.2	6.7	0.66	0.86	0.11	7.82	44.0	0.04	0.12	0.37	0.17
12	Chithira kayal	20-44	3.9	3.9	1.60	3.04	0.21	14.48	62.0	0.07	0.21	0.41	0.22
13	Chithira kayal	> 44	3.7	2.9	3.95	3.58	0.25	14.32	81.0	0.06	0.36	0.48	0.44

Source: Kurup, 1967

Texture of Kayal soils do not follow any regular pattern. Lime shells are seen evenly distributed through out the profile. pH decreased with increase in depth in most of the profiles. Total nitrogen status is low and K content is comparatively higher. Potassium is more concentrated in the lower layers whereas phosphorus is more in the upper layers. Calcium and Mg are the dominant exchangeable bases in most of the profiles studied, but in Chithira kayal and Rani kayal, exchangeable Na is equally dominant.

3.4 Sulphur status

Jacob (1966) made a detailed study on the distribution of different forms of sulphur at different depths in the R Block Kayal profile. Distribution of different forms of sulphur showed that water soluble as well as total sulphate sulphur increased with depth in R Block Kayal profile. Sulphide-sulphur decreased sharply after twenty centimeters of depth whereas its organic form was found to be high in the surface and lower most layers (Table 3.4.1).

Table 3.4.1. Forms of sulphur expressed as percentage of total sulphur (R block)

Soil samples	Water soluble sulphate sulphur	Total sulphate sulphur	Sulphide sulphur	Organic sulphur
`R' Block				
0-20 cm	2.74	3.38	1.51	95.11
20-40 cm	2.23	6.88	0.82	22.30
40-60 cm	9.67	12.50	0.11	87.30

Source: Jacob, 1966

Distribution of different forms of sulphur do not follow any regular pattern.

3.5 Micronutrient status

Aiyer et al. (1975) reported the micronutrient status of Kayal soils (0-20 cm depth) collected from fourteen locations after harvesting rice crop in the month of March-April. Available Zn, Cu, Fe and Mn status of these soils are given in Table 3.5.1. Kayal soils in general were deficient in Cu. About 50 per cent of the locations were deficient in Zn. Available Cu and Fe contents were significantly and positively related to CEC and organic carbon content (Table 3.5.2).

Available micronutrient distribution in the profiles of Rani Kayal Plots D and G, R Block Kayal and Chithira Kayal as recorded by Menon 1975 revealed that the available zinc was highest in the lower most layers in almost all the profiles studied. All the profiles were equally deficient in copper. (Table 3.5.3). Available iron and manganese were more concentrated in the lower most layers.

Table 3.5.1 Available micronutrient status in different locations of Kayal soils

Sl. No.	Locations	Zn	Cu	Fe	Mn
		ppm			
1.	A block - Kuttanad	2.6	0.0	20.0	2.0
2.	Marthandam Block	1.0	0.04	2.0	33.0
3.	R. Block	3.0	0.	1.8	20.0
4.	R. Block	1.8	0.04	8.2	25.0
5.	Marthandam block	5.5	0.04	2.0	25.0
6.	Marthandam block	1.8	0.04	15.6	15.0
7.	Chithira kayal	0.2	0.12	4.0	19.0
8.	Chithira kayal	0.2	0.12	2.0	5.0
9.	14000 kayal old	-	0.62	52.6	4.0
10.	24000 kayal head	6.2	0.16	16.0	12.0
11.	Rani kayal D block	-	0.16	14.0	7.0
12.	Rani kayal G block	-	0.20	12.0	7.5
13.	R block V Sub block	1.0	0.26	6.	10.0
14.	Chithira kayal	0.3	0.16	6.0	10.0

Source: Aiyer et al. 1975

Table 3.5.2 Available micronutrient status of some Kayal profiles

Sample No.	Location	Profile No.	Depth cm	Zn	Cu	Fe	Mn
				<——	ppm		——>
1.	Rani kayal Plot, D	1	0-25	0.0	0.16	14.0	7.0
2.	Rani kayal Plot, D		25-40	0.3	0.16	8.0	20.0
3.	Rani kayal Plot, D		40-92	6.2	0.26	520.0	110.0
4.	Rani kayal Plot, G	2	0-20	0.0	0.20	12.0	7.5
5.	Rani kayal Plot, G		20-44	5.5	0.40	164.0	80.0
6.	Rani kayal Plot, G		44-67	5.0	0.32	704.0	105.0
7.	R Block kayal	3	0-15	1.0	0.26	6.0	5.0
8.	R Block kayal		15-52	0.3	0.14	14.0	20.0
9.	R Block kayal		> 52	9.0	0.22	210.0	108.0
10.	Chithira kayal	4	0-12	0.3	0.16	6.0	10.0
11.	Chithira kayal		12-20	0.2	0.16	2.0	11.0
12.	Chithira kayal		20-44	0.4	0.12	111.3	21.0
13.	Chithira kayal		> 44	7.2	0.16	162.0	100.0

Source: Menon, P.K.G., 1975

Table 3.5.3 Relationship between available micronutrients with other soil parameters

	Org. Carbon (%)	CEC	Exch. Ca & Mg	pH	Clay
Zn	+0.013	-0.215	+0.099	-0.014	+0.001
Cu	+0.482*	+0.400*	+0.203	-0.265	+0.040
Fe	+0.689*	+0.566*	+0.408*	-0.425*	+0.270
Mn	+0.205	+0.523*	-0.338	+0.301	+0.349

Source: Menon, P.K.G., 1975

Kayal profiles are uniformly deficient in Cu. Zinc deficiency is observed in 50 per cent of the samples analysed.

3.6 Management of Kayal lands

Results of experiment conducted at Regional Agricultural Research Station, Kumarakom on coconut are briefly summarised below.

3.6.1 Major nutrients

A field experiment in 3^3 factorial design was conducted at RARS, Kumarakom to find out the best dose, frequency and method of application of fertilizers for maximising yield of coconut in Kayal lands of Kuttanad. Fertilizers were applied in basins of five feet radius around the trunk. Linear trenches were formed five feet away from the trunk in trench method of manuring. Manuring every year with 500-600-1000 g N, P_2O_5 and K_2O tree^{-1} had recorded the highest yield. It was significantly superior to the same dose applied in alternate years. For the highest dose of fertilizer, application in linear trenches taken at 5 feet distance from the trunk had recorded the highest yield (Table 3.4.1.1).
6

Treatments

Levels of NPK		Frequency of application		Method of application	
M1	$N_1P_1K_1$ (250-350-750 g of N, P_2O_5 and K_2O palm^{-1}	E	Manuring every year	C1	Applying fertilizers in basins
M2	$N_2P_2K_2$ (375-475-and 875 g N, P_2O_5 and K_2O palm^{-1}	A1	Manuring in alternate years (starting from first year)	C2	Applying fertilisers in linear trenches
M3	$N_3P_3K_3$ (500-600-and 1000 g N, P_2O_5 and K_2O palm^{-1}	A2	Manuring in alternate years (starting from second year)	C3	Applying fertilizers by broadcasting

Basin method - fertilizers were applied in basins of 5' radius around
Trench method - fertilizers were applied in linear trenches 5' away from the trunk

Table 3.6.1.1. Effect of NPK and time of application on the yield of coconut (nuts $palm^{-1}$ $year^{-1}$)

Levels of NPK	Time of application			Mean
	E	A_1	A_2	
M_1	308.05	283.87	301.00	297.64
M_2	273.76	319.05	302.00	323.68
M_3	361.78	330.77	265.47	319.20
Mean	339.78	311.24	289.50	

Time x method of application

Time of application	Method of application			Mean
	C_1	C_2	C_3	
E	358.67	329.40	331.33	339.80
A_1	301.66	354.50	277.60	311.35
A_2	309.33	253.83	305.37	289.51
Mean	323.16	312.60	304.80	

Levels of NPK x method of application

Levels of NPK	Method of application			Mean
	C_1	C_2	C_3	
M_1	335.70	296.10	261.00	297.64
M_2	345.99	277.65	347.55	323.68
M_3	287.88	363.00	305.70	319.20
Mean	323.16	312.60	304.80	

CD for comparison of A (Time of application) : 13.22
CD for comparison of combinations : 28.89

Source: RARS, Kumarakom

Comparative efficiency of different methods and levels of application of fertilizers on the health and flowering of coconut seedlings was studied. Fertilizers were applied in one single dose, in split doses, and as both soil and foliar spray to young coconut seedlings. Girth at collar and total number of leaves produced were recorded from third year onwards. The experiment was started in 1965. The manurial schedule for differnt age groups is given below.

Schedule of application of fertilizers for coconut seedlings

Year of planting	N_1	P_1	K_1	N_2	P_2	K_2
	<------------		g $tree^{-1}$			------------>
2nd year (1966)	50	50	100	100	100	200
3rd year (1967)	100	75	150	200	150	300
4th year (1968)	150	100	200	300	200	400
5th year (1969)	200	150	250	400	300	500
6th year (1970)	250	250	450	500	500	900

NPK was given in the form of urea, superphosphate and muriate of potash respectively.

Number of leaves differed significantly. (Table 3.6.1.2) Application of 500-500-900 g NPK $palm^{-1}$ in two equal splits or 250-250-450 g of NPK $palm^{-1}$ in two and three equal splits produced maximum number of leaves in 1970. Application of lower dose of NPK in three split doses and higher dose in two or three split doses helped for early flowering. Soil application of lower dose of NPK in three split doses and higher dose in two or three split doses resulted in early flowering, higher number of female flowers, and higher nut setting in coconut. (Table 3.6.1.3).

Table 3.6.1.2 Effect of treatments on leaf number (Average per palm)

Treatments	Year			
	1967	1968	1969	1970
T_1	7.6	5.1	5.8	8.9
T_2	8.3	6.2	6.3	9.3
T_3	7.1	6.1	7.3	9.2
T_4	6.5	6.8	8.2	10.8
T_5	6.0	6.8	7.5	10.7
T_6	5.9	6.3	7.3	9.3
T_7	6.3	6.0	6.7	9.5
T_8	8.8	5.1	6.0	8.4
T_9	8.1	5.8	6.8	9.3
T_{10}	6.6	5.2	6.2	8.6
T_{11}	5.8	4.5	5.4	7.4
CD	NS	0.7	0.8	1.2

Table 3.6.1.3 Effect of method of application of fertilizers on flowering and percentage setting of female flowers on coconut

Treatments	Number of palms flowered (per cent)		Number of spadices opened (Average palm^{-1})		No. of female flowers produced (average palm^{-1})		Setting of female flowers (per cent)	
	1971	1972	1971	1972	1971	1972	1971	1972
T_1	16.7	25.0	0.4	2.7	0.4	4.8	20.0	43.8
T_2	8.3	41.7	0.3	2.2	0.0	5.9	0.0	46.2
T_3	0.0	25.0	0.0	1.2	0.0	1.3	62.5	33.3
T_4	50.0	58.3	0.8	2.8	0.7	7.2	57.1	62.4
T_5	58.3	66.7	0.7	2.8	0.6	8.1	42.8	67.0
T_6	25.0	33.3	0.5	2.6	0.6	6.1	0.0	59.8
T_7	16.7	25.0	0.0	0.8	0.4	3.9	0.0	27.7
T_8	0.0	33.7	0.0	1.7	0.0	3.8	0.0	90.0
T_9	8.3	33.3	0.0	0.1	0.0	3.9	0.0	31.9
T_{10}	0.0	8.3	0.0	0.0	0.0	0.0	0.0	0.0
T_{11}	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CD (0.05)	2.3	30.0	0.4	0.9	0.4	2.1	20.2	27.4

Source: RARS, Kumarakom

Treatments

T_1 - Single application of $N_1P_1K_1$

T_2 - Single application of $N_2P_2K_2$

T_3 - T_1 in two equal split doses

T_4 - T_2 in two equal split doses

T_5 - T_1 in three equal split doses

T_6 - T_2 in three equal split doses

T_7 - 3/4 dose basally and 1/4 through foliage in two sprays (dose as T_1)

T_8 - 3/4 dose basally and 1/4 through foliage in three sprays (dose as T_1)

T_9 - 3/4 basally and 1/4 through foliage in four sprays (dose as T_1)

T_{10} - 1/2 basal & the dose through foliage in six sprays (dose as T)

T_{11} - Control (No manure)

Simple fertilizer trials were conducted in cultivator's field in reclaimed Kayal lands at eight locations to fix the economic dose of fertilizers for coconut palms. Application of 25 kg FYM along with 0.35, 0.17 and 0.68 kg N, P_2O_5 and K_2O $palm^{-1}$ gave maximum number of nuts $palm^{-1}$ (Table 3.6.1.4).

Table 3.6.1.4 Mean yield of nuts $palm^{-1}$ (1980-83)

Treatments	Mean (Eight locations)
T_1 - 25 kg FYM	53.12
T_2 - 25 kg FYM + 0.35 kg N + 0.17 kg P_2O_5 + 0.68 kg K_2O $palm^{-1}$	66.36
T_3 - 25 kg FYM + 0.5 kg N + 0.32 kg P_2O_5 + 1.2 kg K_2O $palm^{-1}$	57.95
CD (0.05) - 7.147	

Source: RARS, Kumarakom

Experiments conducted at RARS, Kumarakom on coconut, obtained the following results. Manuring every year with 500, 600 and 1000 g N, P_2O_5 and K_2O $palm^{-1}$ in linear trenches taken at five feet distance every year gave the highest nut yield.

A manuring schedule of 50, 75 and 100 g N, P_2O_5 and K_2O coconut seedling $^{-1}$ in the second year of planting and increasing the nutrient doses by 50, 25 and 50 g respectively every year till the sixth year induced earliness in flowering, produced maximum number of female flowers in the spadix and registered good fruit setting. Application of 350, 170 and 680 g N, P_2O_5 and K_2O along with 25 kg farm yard manure tree^{-1} give better nut yield than the treatment with 25 kg farm yard manure alone and 500, 320 and 1200 g N, P_2O_5 and K_2O palm^{-1} along with 25 kg farm yard manure tree^{-1}.

3.6.2 Micronutrients

Field experiment in RBD was conducted at Coconut Research Station, Kumarakom to study the effect of N, P, K fertilizers with and without micronutrient carriers on the nut yield and disease intensity of root wilt affected palms. Two levels of NPK @ 250-350-700 and 500-700-1400 g N, P_2O_5, K_2O palm^{-1} were tried either alone or in combinations with micronutrients like B, Mn, Cu, Mo and Zn. All the micronutrients except Mo were used as their sulphate salt @ 200 g palm^{-1}. All the micronutrients and their combinations were tried with the lower level of NPK. Each plot contained eight diseased palms of the age group of 30-40 years. Over and above fertilizers, each palm received 20 kg cattle manure and 20 kg green manure per tree. In addition, 87 cubic metre of river sand was also applied. Observations on the yield of nuts and intensity of disease syndrome were recorded at half yearly intervals from 1965 to 1971. The disease intensity was assessed by scoring for symptoms like flaccidity, yellowing and necrosis and expressed as per cent. The treatments were started in 1963 and continued upto 1971. Treatment differences were not significant for the incidence of the disease and nut yield differences were significant only in one year. Application of 200 g zinc sulphate along with 250, 350 and 700 g N, P_2O_5 and K_2O palm $^{-1}$ showed maximum response followed by the treatment 500, 700 and 1440 g N, P_2O_5 and K_2O palm $^{-1}$ year $^{-1}$.

Application of zinc sulphate is favourable for coconut palms in Kayal soils.

3.6.3 Soil amendments

The relative efficiency of carbide ash, a by-product of electrochemical industry was tested in a field experiment in the reclaimed Kayal soils (pH 5.2) of Kumarakom from 1968 to 1972. The carbide ash used in the trial was obtained from Travancore Electrochemical Industries Ltd., Chingavanam, Kerala. The ash contained 58.0 to 64.5 per cent $Ca(OH)_2$, 11.0 to 17.5 per cent SiO_2, 1.4 to 3.4 per cent Fe_2O_3+Al_2O and 5.1 to 10.0 per cent unreacted carbon. The experiment was conducted in RBD with five treatments replicated eight times. Each replication was formed of one coconut palm in the age group of 35-40 years. All the treatments were given a uniform dose of 250-350-500 g NPK $palm^{-1}$ $year^{-1}$. Dolomite and carbide ash were applied in two equal splits during May-June and September-October in circular basins of 1.85 m radius and incorporated into the soil a week after fertilizer application. Pooled analysis of the not yield data from 1970 to 1972 is presented in Table 3.6.3.1. Dolomite and carbide ash registered no favourable influence on nut yield.

Table 3.6.3.1 Effect of dolomite and carbide ash on the yield of coconut

Treatments			Mean number of nuts $palm^{-1}$			Mean
			1970	1971	1972	
T_1	-	Control	52.38	45.50	45.88	47.92
T_2	-	Dolomite @ 2.5 kg $palm^{-1}$	36.75	38.00	46.00	40.25
T_3	-	Dolomite @ 5 kg $palm^{-1}$	31.75	35.75	30.38	32.63
T_4	-	Carbide ash @ 2.5 kg $palm^{-1}$	42.13	41.00	37.63	40.45
T_5	-	Carbide ash @ 5 kg $palm^{-1}$	46.18	46.50	41.25	44.63
Mean			41.83	41.35	40.23	
CD (0.05)						8.60

Source: RARS, Kumarakom

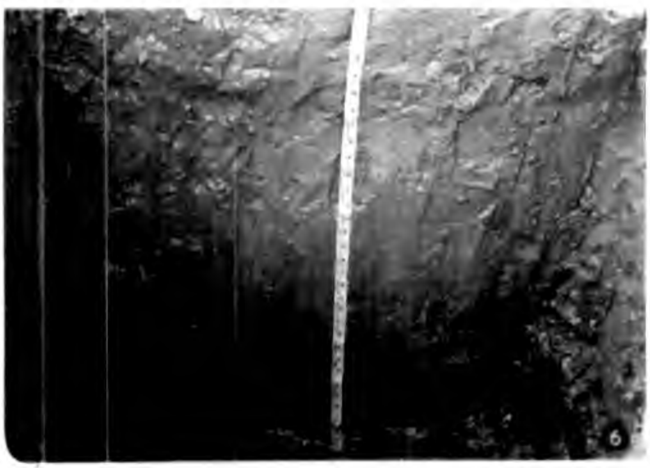
Liming coconut palms in Kayal lands reduce nut yield of coconut. The reasons for decrease in nut yield due to liming may be found out by conducting basic studies to monitor changes in physical, chemical and biological properties of soil consequent to liming at the rate given in field trials.

KARAPPADOM FIELDS

REDDISH BROWN SCUM DUE TO IRON
TOXICITY   KARAPPADOM FIELDS


1

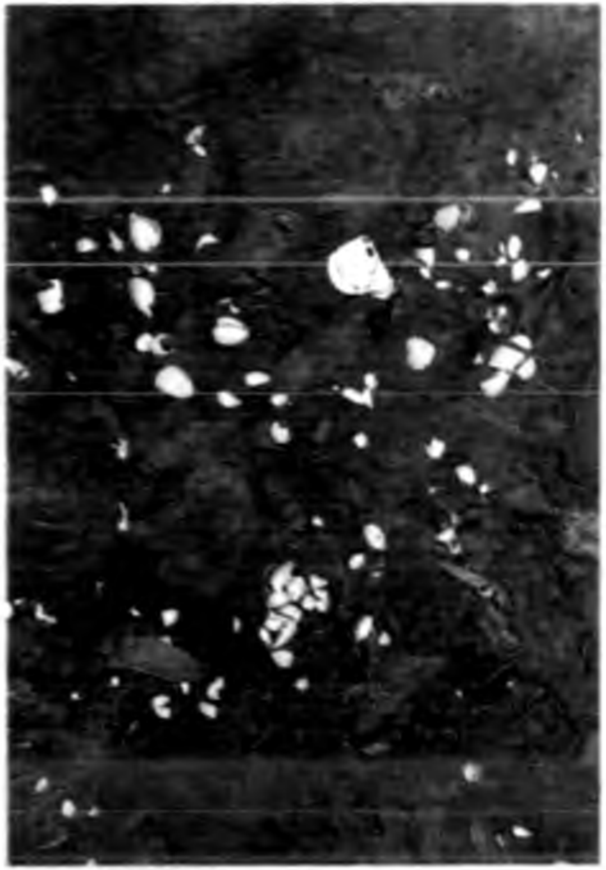

4


6

KARI LAND

1. Thanneermukkam bund
2. Thottappally spillway
3. Sub-surface tile drainage system
4. Thottappally spillway
5. Rice field
6. Soil profile
7. Soil profile showing wood fossils

KAYAL LAND BELOW MSL



SOIL PROFILE WITH SEA SHELLS

R-BLOCK KAYAL WITH RUBBLE RING BUND

3.6.4 Other Experiments

A field experiment using salt bittern, a by-product of salt industry obtained from M/s Sankaran Allam Pvt. Ltd., Nagarcoil was conducted for 5 years from 1965-69. The material contained 4 per cent each of N, K_2O, $MgCl_2$, and $MgSo_4$; 20-25 per cent $Mg(OH)_2$, 10-15 per cent NaCl and 40-45 per cent moisture. The trial was conducted in RBD with four replications. Each plot contained eight coconut palms of the west coast tall variety having an age group of 35-40 years. A uniform dose of 8:8:16 fertilizer mixture and 40 kg green leaves $tree^{-1}$ were applied irrespective of treatments. River sand @ $88m^3$ and lime @ 750 kg ha^{-1} were also applied every year during November-December and incorporated into the soil. Observations on the yield of nuts were recorded for five years from 1965. The intensity of foliar yellowing were graded as grade-1 (upto 10% leaf area showing yellowing symptoms) grade-2 (11-30 per cent); grade-3 (31-50 per cent) and grade-4 (above 50 per cent).

Pooled analysis of the nut yield data indicated significant difference between treatments and also between years (Table 3.6.4.1). Use of 2 kg salt bittern as foliar spray was found significantly superior to soil appplication of the same quantity and control. Salt bittern @ 1 kg each, applied both as soil and foliar spray recorded similar yield to that of supply of salt bittern as foliar spray alone. Salt bittern was not found to have any influence on yellowing of leaves of coconut palms.

Table 3.6.4.1 Effect of salt bittern on the yield of coconut palms (Mean $plot^{-1}$ of eight palms) and intensity of yellowing and intensity of yellowing

Treatments	Nut yield	Intensity of yellowing
	(Mean of eight years)	
Control	277.6	15.0
Salt bittern 2 kg $palm^{-1}$ as soil application	245.5	15.4
2 kg $palm^{-1}$ as foliar spray	346.5	14.4
1 kg as soil application and 1 kg as foliar spray	322.4	15.4

CD for comparison of treatments = 46.72

Source: RARS, Kumarakom

Applying salt bittern a by-product of salt industry as foliar spray @ 2 kg $palm^{-1}$ increases nut yield whereas soil application of the same reduces it. The yield reduction is more than control receiving normal rate of nutrients. Salt bittern is rich in sodium, magnesium and chlorides. The above observation calls for an indepth study of Kayal soil on nutrient interaction involving sodium, magnesium and chlorides.

4 POKKALI, KAIPAD AND ORUMUNDAKAN LANDS
(Acid saline soils)

4.1 General characteristics

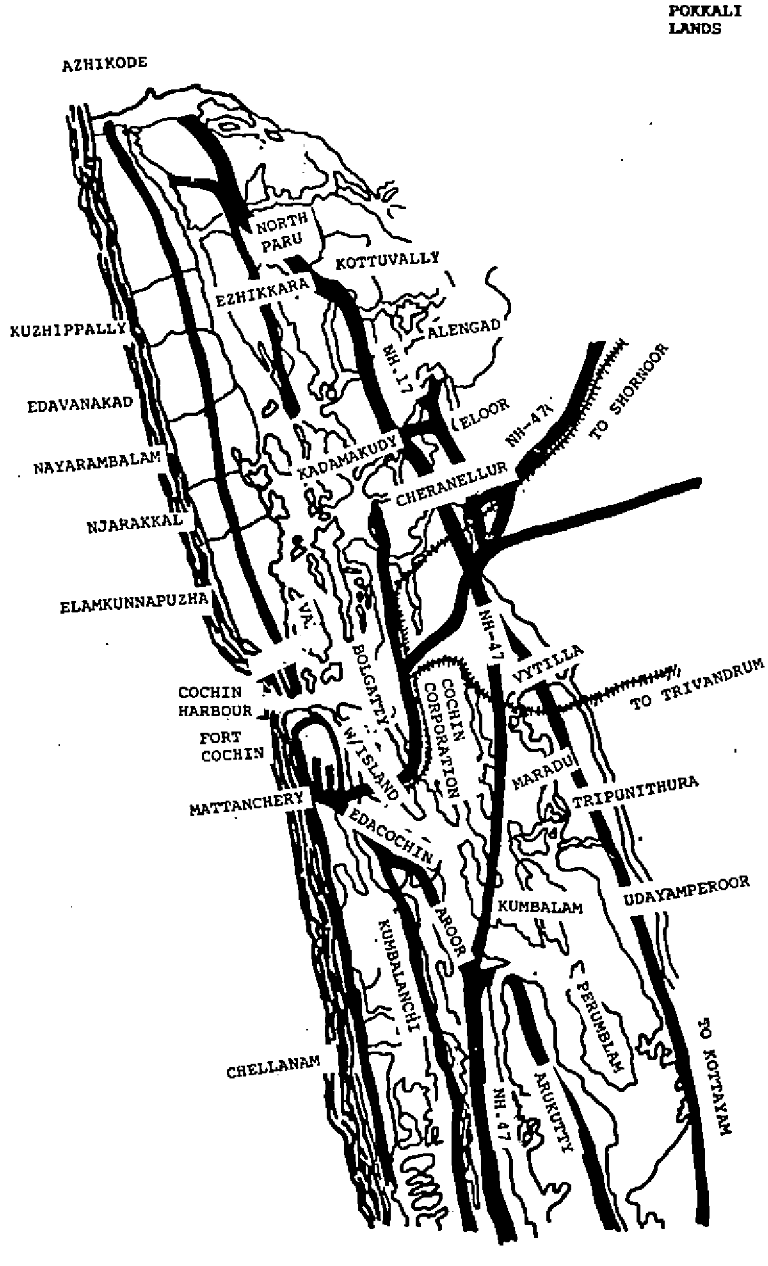
Kerala with its long coastal line of about 580 km has sixteen lagoons or backwaters covering an area of about 650 km^2 linked to the sea. Out of 41 rivers flowing into the Arabian sea, about 20 empty into the adjoining backwaters. Most of the coastal land, deltaic areas at river mouths and reclaimed backwaters are either at sea level or 1.0 to 1.5 m below MSL. This leads to intrusion of sea water upto a distance of 10 to 20 km upstream during high tides. These periodically saline water inundated lands constitute the major saline soil areas of the state.

Based on the location, extent and intensity of salinity, three types of saline soils are recognised in Kerala. They are (1) Pokkali lands, known after the Pokkali type of cultivation; located between the Thannermukkam and Enamakkal bunds ie. in the coastal areas of Ernakulam and Thrissur districts mostly distributed in Cochin, Kanayannur, Paravoor, Thrissur and Kodungalloor taluks (2) Orumundakan lands of Alappuzha and Kollam districts known after the long duration variety of rice grown there and distributed mostly in Sherthalai and Ambalappuzha taluks (3) Kaipad lands of Kannur district situated in the low lying deltaic areas of river mouths. The different types of land described above constitute an area of about 30,000 ha. Pokkali, Kaipad and Orumundakan lands are cropped with paddy once in a year from June-July to October-November when the salinity level in the surface soils is brought below the critical level of less than 4 dSm^{-1} for the saturation extract of the soil by monsoon showers.

As distinct from the saline soils found in other states, the origin, genesis and development of these soils are under peculiar climatic and environmental conditions. These soils as already pointed out, comprise of low lying marshes near the rivers and streams, waterlogged and ill-drained and are subjected to tidal waves. These lands in their original natural state had been overgrown with mangrove and other salt loving plants but at present it is difficult to identify such areas except in recently reclaimed areas like Puthuvaippu in Ernakulam district.

4.2 Physico-chemical properties of surface soil

Soils of Pokkali lands were deep, dark bluish black in colour, impervious and clayey in texture which form hard mass with cracks on drying and turned sticky on


POKKALI
LANDS
AZHIKODE
NORTH
PARU
KOTTUVALLY
EZHIKKARA
ALENGAD
KUZHIPPALLY
NH.17
EDAVANAKAD
ELOOR
NH-47
TO SHORNOOR
NAYARAMBALAM
KADAMAKUDY
CHERANELLUR
NJARAKKAL
ELAMKUNNAPUZHA
VA.
BOLGATTY
NH-47
VYTILLA
COCHIN
HARBOUR
COCHIN
CORPORATION
TO TRIVANDRUM
FORT
COCHIN
W/ISLAND
MARADU
TRIPUNITHURA
MATTANCHERY
EDACOCHIN
KUMBALAM
UDAYAMPEROOR
AROOR
KUMBALANCHI
PERUMBLAM
TO KOTTAYAM
CHELLANAM
NH.47
ARUKUTTY

wetting. Soils of Orumundakan and Kaipad lands contained more coarser fractions compared to Pokkali lands.

Sea and backwater tides make these soils saline. During monsoon season when rain water and fresh water from rivers enter the field, salinity is partially washed off. Under such conditions, the inherent acidity of these soils become more dominant. Chemical analysis of the soils of five representative Pokkali areas viz. Vyttila, Thrippunithura, North Paravur, Vypeen and Thuravoor indicated very low pH of 3.50 in North Paravur and 3.10 in Vypeen (Table 4.2.1). Nair and Money (1972) reported that most of the saline soils of Kerala were acidic with a pH ranging from 3.0 to 6.8 inspite of high conductivity.

Table 4.2.1 Chemical characteristics of surface soils

	Vyttila	Thripunithura	North Paravur	Vypeen	Thuravoor
O.C.(per cent)	0.13	0.21	0.41	0.14	0.26
Total N (per cent)	0.04	0.05	0.13	0.06	0.03
Total P_2O_5 (per cent)	0.01	0.03	0.02	0.03	0.05
Total K_2O (per cent)	0.38	0.46	0.84	0.52	0.24
Total Fe_2O3 (per cent)	15.50	11.25	10.55	5.50	6.78
Total CaO (per cent)	0.01	0.01	0.01	0.00	0.01
Total MgO (per cent)	0.36	0.33	0.38	0.17	0.29
pH	5.80	6.00	3.50	3.10	5.00
EC dSm^{-1}	1.50	14.00	20.00	14.00	3.40
Available P_2O_5 (kg ha^{-1})	Trace	6.00	14.00	16.00	12.00
Available K_2O (kg ha^{-1})	184	196.00	212.00	203.00	118.00
Na in water extract (per cent)	0.01	0.02	0.06	0.08	0.01
CEC [cmol (p^+) kg^{-1}]	38.20	46.10	53.80	48.70	40.80
Ex. Ca [cmol (p^+) kg^{-1}]	2.20	2.20	2.90	1.60	1.70
Ex. Mg [cmol (p^+) kg^{-1}]	7.80	6.30	7.10	11.30	0.30
Ex. Na [cmol (p^+) kg^{-1}]	2.60	3.80	4.20	3.90	2.60
Ex. Al [cmol (p^+) kg^{-1}]	0.10	1.00	7.80	8.20	5.80
Ex. H [cmol (p^+) kg^{-1}]	0.10	0.50	11.80	1.60	8.20
Chloride (per cent)	0.20	1.75	0.68	0.52	0.07
Sulphate (per cent)	0.32	0.32	0.29	0.12	0.02

Source: Nair and Money, 1972

A comparative study of the Pokkali and Kaipad soils collected from Ernakulam and Kannur districts (N.Paravur and Kattampally respectively) showed that both these soils were clayey or clay loam in texture having a pH of 3.3 and 3.8 and with a lime requirement of 10 and 9 t ha^{-1} respectively (Table 4.2.2 a).

Table 4.2.2 (a) Chemical characteristics of Pokkaliand Kaipad soils

	Pokkali (N. Paravur)	Kaipad (Kattampally Swamp)
Texture	Clayloam	Clayloam
pH (1:2.5) Soil-water suspension	3.30	3.80
(KCl) Suspension	3.10	3.50
EC (dSm^{-1})	15.10	9.00
Total N (per cent)	0.24	0.16
O.C (per cent)	3.45	2.18
Available P (ppm)		
Olsen (ppm)	8.70	9.70
Truog (ppm)	18.80	14.00
Bray (ppm)	206.00	225.00
CEC (cmol (p^+) kg^{-1})	20.00	12.80
Exchangeable cations (cmol (p^+)kg^{-1})		
K	0.64	0.32
Ca	5.10	3.55
Mg	6.45	3.85
Fe	0.09	0.08
Al	2.95	2.55
Mn	Tr	Tr
Lime requirement (kg ha^{-1})	10,000	9,000
Water soluble nutrients		
Ca (cmol (p^+) kg^{-1})	3.20	1.50
Mg (cmol (p^+) kg^{-1})	9.90	4.30
SO_4 (cmol (p^+) kg^{-1})	18.70	10.50
Fe (ppm)	15.00	10.20
Al (ppm)	44.00	28.10
Mn (ppm)	0.50	0.75
SO_4-S mg/100 g soil	311.00	150.00
Available S mg/100 g soil	242.00	130.00
NH_4OAc-Cu (ppm)	1.50	0.90
Dithionate-Zn (ppm)	14.40	12.20

Source: Kuruvila , 1974

Most of these soils had EC values higher than 14 dSm^{-1} (Varghese et al. 1970; Nair and Money, 1972 and Samikutty, 1977).

Out of the five soil samples collected (Varghese et al. 1970), the one from North Paravur recorded comparatively higher available plant nutrients. Among the exchangeable cations, Mg dominated all the others (Samikutty, 1977 and Varghese et al. 1970).

Detailed fertility investigations carried out in Pokkali, Orumundakan and Kaipad lands (Samikutty, 1977) showed that most of these soils were extremely deficient in phosphorus. Surface soils were richer in potassium. Total sodium content ranged from 0.49 to 2.80 per cent (Table 4.2.2 b). Exchangeable sodium percentage (ESP) and sodium adsorption ratio (SAR) values in the equilibrium soil solution ranged from 13.7 to 83.3 and 11.7 to 34.8 respectively. Significant positive correlation was also observed between ESP and SAR on one hand and clay content and organic matter on the other. The cationic and anionic composition indicated that these coastal saline soils were of $Na\text{-}Mg\text{-}Cl\text{-}SO_4$ type.

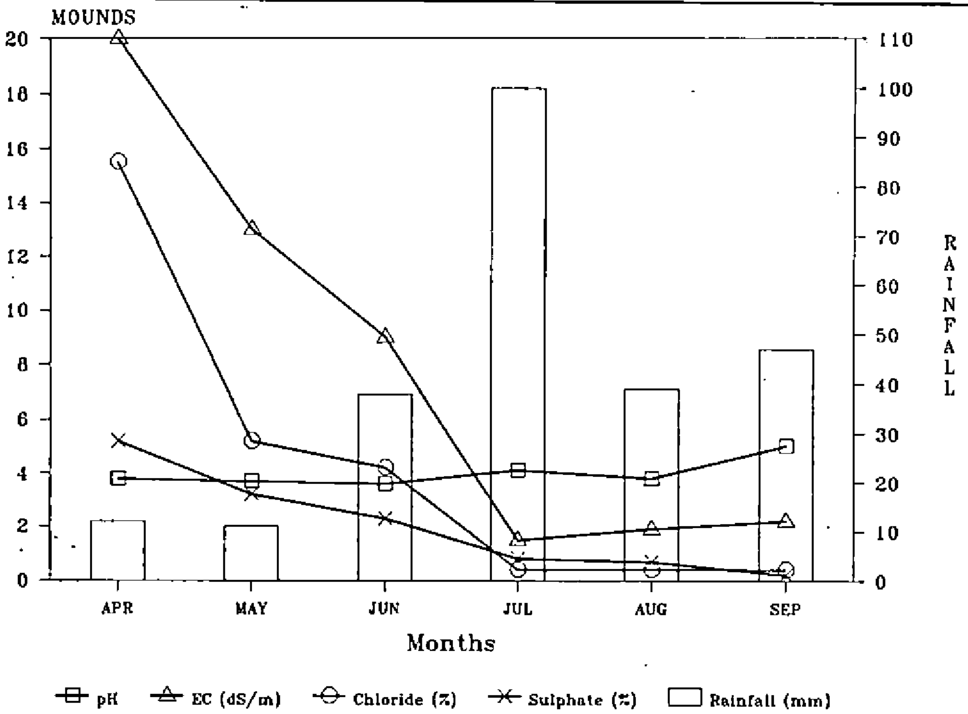
A comparative study of the seasonal variations in salinity and pH in these lands were conducted from March 1976 to February 1977 (Samikutty, 1977). High level of salinity was recorded during summer months in all the three soils. In Pokkali and Kaipad lands, salinity decreased rapidly upto August and was maintained till December-January. Orumundakan lands maintained high level of salinity in spite of leaching with rainwater. Soils on the mounds formed for sowing seeds attained low level of salinity on washing and leaching with rainwater, while salts accumulated in the soil between the mounds (Fig. 4.2.1).

The effect of flooding on the electro-chemical and chemical kinetics of Pokkali and Kaipad soils showed an increase in pH upto 20 days after which the level was maintained in Pokkali, whereas in Kattampalli swamp (Kaipad lands), pH steadily increased upto 50 days (Kuruvila, 1974). Eh steadily increased in Pokkali soil while in Kaipad soil, there was a marked decrease in ten days of submergence after which the decrease was slow. Oxidisable organic matter increased during the first ten days period after which there was not much change. NH_4-N increased with period of submergence. There was continuous increase of K as submergence advanced in Pokkali soil while in Kaipad it increased upto 10 days and then decreased. There was a sharp increase in iron concentration upto 30 days and then it decreased, while aluminium increased during the first ten days period and then decreased. Manganese also showed a similar trend as Al. Sulphate-sulphur increased during the first ten days and decreased thereafter (Table 4.2.3).

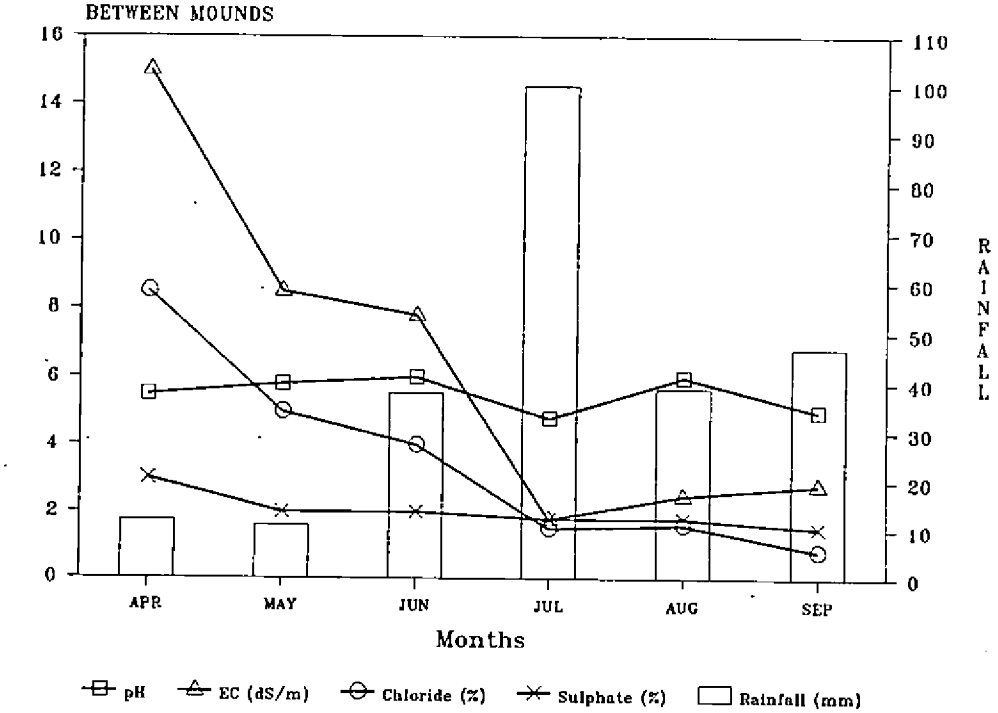
Table 4.2.2 (b) Chemical characteristics of surface soil

Location	O.C. (%)	N (%)	C/N	Total nutrients (oven dry basis) P	Ca	Mg	K	Na	pH (1:2.5)	E.C. 1:2 dSm^{-1}	C.E.C cmol $(p^+)kg^{-1}$	Ex. cation(cmol (p^+) kg^{-1}) Na	K	Ca	Mg
				(per cent)											
Pokkali & Orumundakan															
Madathilthara	1.17	0.036	32.50	0.003	0.96	0.37	0.10	0.57	3.2	20.7	14.8	2.2	0.2	2.2	4.4
Pandanayarkulangara	1.77	0.039	45.35	0.003	0.06	0.25	0.10	0.49	3.0	14.4	15.7	2.8	0.1	1.5	6.2
Puthuvaippu	1.41	0.053	26.60	0.022	0.32	0.65	0.58	2.88	6.4	37.3	31.7	8.5	6.2	6.5	3.3
Cherai	1.62	0.044	36.82	0.017	0.14	0.47	0.48	2.16	3.2	32.8	16.8	4.4	0.2	3.7	5.3
Kaipad															
Vayalappara	0.78	0.023	33.91	0.007	0.08	0.24	0.48	1.94	5.2	23.2	14.5	2.7	1.1	2.6	3.7
Thavom	0.27	0.013	20.77	0.004	0.19	0.24	0.28	1.69	5.4	29.1	12.8	3.5	0.9	0.2	7.4
Ramanthali	0.56	0.021	26.67	0.006	0.15	0.22	0.43	0.59	6.8	10.4	14.9	4.0	1.2	2.8	2.2
Cheruthazham	0.54	0.014	38.57	0.003	0.12	0.26	0.30	2.41	4.9	23.7	16.4	3.9	0.6	1.2	7.6

Source: Kuruvila, 1974



Source: R.R.S., Moncompu



Source: R.R.S., Moncompu

Fig. 4.2.1 Effect of climatic conditions on pH, EC, chloride and sulphate contents

Table 4.2.3 Effect of submergence on the electro-chemical and chemical changes in the acid saline "Pokkali" and "Kaipad" soils

Days of flodding	Pokkali (N. Paravur)						Kattampally Swamp (Kaipad)					
	0	10	20	30	50	Mean	0	10	20	30	50	Mean
pH	3.35	3.95	4.1	4.1	4.25	3.9	3.7	4.25	4.25	4.6	5.1	4.4
Eh_6 (mV)	179	190	191	206	223	198	82	18	-14	-24	-19	8.60
Oxd.O.M. (per cent)	1.00	2.10	1.90	2.00	1.70	1.74	0.80	2.0	1.80	1.70	2.00	1.70
NH_4-N (ppm)	112	123	136	160	187	145	102	113	136	149	189	138
K (ppm)	380	710	800	1120	810	764	450	750	710	700	544	629
Ca (ppm)	1996	1747	1874	2186	2292	2019	856	956	1041	728	1042	945
Mg (ppm)	2346	2546	2150	2000	2529	2314	1435	1568	1442	1189	1568	1440
Fe (ppm)	152	650	1050	2370	1210	1086	240	660	1210	1820	1315	1049
Al (ppm)	265	350	175	160	122	214	95	120	74	62	60	82
Mn (ppm)	28	39	25	20	14	25	12	26	23	22	8	18
SO_4-S (ppm)	2395	2540	1998	2163	2182	1819	1896	2163	1654	1830	1513	1811

Source: Kuruvila , 1974

Kaolinite was the dominant clay mineral in these soils with fairly large amounts of smectite and small amounts of halloysite. Fine sand and course sand fractions were found to contain quartz, mica, felspar, kaolinite and chloritic minerals as the major components (Kuruvila, 1974).

Surface soils of Pokkali lands are clayey in texture whereas that of Orumundakan and Kaipad lands are sandy or sandyloam. Inspite of high EC values, these soils recorded low pH. Phosphorus is extremely deficient but potassium is rich in these soils. Mg is the dominant cation in the exchange complex.

4.3 Profile characteristics

A detailed study on the physical and chemical characteristics of Pokkali soil profile of Vyttila was carried out by Varghese et al. 1970. Soil was light grey on the surface, the intensity of which increased with depth. The texture of the soil became finer with depth (Table 4.3.1).

Table 4.3.1 Characteristics of Pokkali profile

Location	:	Rice Research Station, Vyttila (Ernakulam)
Relief	:	Plane
Vegetation	:	Grasses and weeds
Climate	:	Humid tropical climate
Drainage	:	Impeded
Elevation	:	2.7 m.
Ground water depth and fluctuation	:	2 m (Fluctuating due to tidal changes)
Parent material	:	Lacustrine and alluvial deposits
Special features	:	Nearness to vembanad lake.

Horizon	A	B	C
Depth (cm)	0-20	20-50	50-75
Boundary	Diffuse	Clear	Clear
Colour	10 YR 5/2	10 YR 4/1	10 YR 3/2
	light grey	Dark grey	Very dark grey
Structure	Blocky	Blocky	Puddled
Texture	Sandy clay loam	Clay loam	Clay loam
Consistency	Compact	Sticky	Very sticky
Reaction (pH)	5.80	5.70	5.50
Presence of CO_3	Absent	Absent	Absent
Permeability	Permeable	Less Premeable	Impeded

Source: Varghese *et al.* 1970

Organic matter and total N were found increasing with increase in depth indicating the accumulation of humus in the lower layers of the profiles. Electrical conductivity also increased with depth due to the downward movement of salt water. CEC and exchangeable Mg also showed the same trend. Exchangeable Mg was higher than Ca in the upper horizon. Unlike in the case of EC, pH values decreased with soil depth. Phosphorus status was low in all the horizons but that of K was higher (Table 4.3.2).

Table 4.3.2 Physical and chemical characteristics of Pokkali profile

	Depth (cm)		
	0-20	20-50	50-75
Coarse sand (per cent)	32.30	24.60	22.20
Fine sand (per cent)	35.10	30.30	24.30
Silt (per cent)	13.20	14.20	15.70
Clay (per cent)	16.00	23.20	28.50
Organic carbon (per cent)	0.13	0.10	0.21
Total N (per cent)	0.04	0.04	0.06
Total P_2O_5 (per cent)	0.01	0.01	0.05
Total K_2O (per cent)	0.38	0.30	0.34
Total Fe_2O_3 (per cent)	4.20	6.40	3.10
Total Al_2O_3 (per cent)	14.90	9.10	12.10
Total CaO (per cent)	0.01	0.00	0.00
Total MgO (per cent)	0.36	0.37	0.39
pH	5.80	5.70	5.50
EC (dSm^{-1})	1.50	2.20	2.20
Available P	Trace	Trace	Trace
Available K (kg ha^{-1})	184.00	180.00	168.00
CEC [$cmol(p^+)kg^{-1}$]	38.20	43.70	49.10
Ex. Ca [$cmol(p^+)kg^{-1}$]	2.20	2.00	3.20
Ex. Mg [$cmol(p^+)kg^{-1}$]	7.70	2.00	3.20
Ex. K [$cmol(p^+)kg^{-1}$]	1.10	4.40	2.10
Ex. Al [$cmol(p^+)kg^{-1}$]	0.00	0.10	0.00
Ex. H [$cmol(p^+)kg^{-1}$]	0.10	0.10	0.00
Chloride (per cent)	0.20	0.49	0.43
Sulphate (per cent)	0.32	2.62	2.41

Source: Varghese *et al.* 1970

Morphological, physical and chemical properties of Pokkali, Kaipad and Orumundakan profiles are presented in Table 4.3.3 (Samikutty, 1977).

Table 4.3.3 Pokkali, Kaipad and Orumundakan soil profile characteristics

Location	Pokkali soils	Orumundakan soils	Kaipad soils
I. General			
Location	Cherai, Manappad (Ernakulam District) Halomorphic - Elevation - almost at sea level,land form -plain and flat; microtopography - artificial mounds are taken for paddy, humidtropical climate with a mean annual rainfall of 3200 m.m.;profile moist almost throughoutthe year; impeded drainage; no evidence of erosion; ground-water table is at 35 cm from thesurface; cultivated during asingle crop season with saltresistant varieties.	Karunagappally (Kollam Dist.)Halomorphic - (salt water inundation from coastal back-waters) Elevation - slightly above sealevel-land plain and almost flat; parent material - lacustrine deposit of sandy origin; land under water for 6-7 months (June-Nov.). Cultivated with salt resistant local variety viz.,"Orumundakan" of 270 days duration which tolerate high level of salinity.	Vayalappara, Cheruthazham village(Cannanore Dist.)- Halomorphic -(deltaic alluvium) Elevation - slightly below sealevel; land form-plain and flat; microtopography - artificial mounds are formed forpaddy cultivations; humid tropical climate with a mean annual rainfall of 2520 mm; parent material riverine deposits; drainage highly impeded; Except the surface layer the profile is moist almost throughout the year, land is under water from June-November.The soil is disturbed to a depth of 9-12", salt resistant varieties are cultivated.
II Profile			
Morphological features: (a)	Very dark grey (5YR 2/2); clayloam, structureless, moist - firm; wet - sticky; dry - slightly hard, many roots; concretions and mineral fragments absent; diffuse boundary, acidic pH 3.2.	Darkgrey (2.5 Y 4/0) to grey (2.5Y 2/0) sand; massive single grain; moist - loose; wet -non-sticky; dry - loose; red and yellow mottles present; roots very few; abrupt boundary; acidic pH 3.1.	Dark yellowish brown (10 YR 3/4) to reddish brown (5 YR 4/3); sandy clay; structureless, moist-friable; wet - sticky; dry - slightly hard; free from concretions and mineral fragments; many roots;clear and smooth boundary, acidic pH 5.1.
(b)	Black (5Y 2/2); clay loam; structureless, moist - firm; wet-sticky, dry - hard; free from concretion and mineral fragments. Very few roots; diffuse boundary; acidic pH 3.5.	Dark grey (2.5 Y 4/0); sand; massive single grain; moist-base; wet non-sticky, dry -loose; red and yellow mottles present, no roots; abrupt boundary; acidic -pH 3.0.	Very dark greyish brown 10 YR 3/2) to reddish grey (5 YR 5/2); sandy clay loam: blocky, moist - firm; wet - sticky, dry - hard; few brownish, yellow mottles,very few roots; clear and smooth boundary; acidic. pH 4.0.
(c)	Black (5 Y 2/1); clay loam; structureless; moist -firm; wet-sticky; dry - very hard; freefrom concretions and mineral fragments; no roots, acidic, pH 3.2	Dark grey (2.5 Y 5/0) to very dark grey (2.5 Y 4/0) sand; massive single grain; moist-very friable, wet -slightly sticky, dry-loose; concretion and mineral fragments absent; no roots, acidic, pH 3.3.	Very dark grey (10 YR 3/1) to reddish brown (5 YR 2/2) sandy loam; blocky, moist -very friable wet - slightly sticky; dry - slightly hard;few yellow mottles, diffuse and smooth boundary;no roots; acidic, pH 2.8.
(d)	-----	-----	Black (10 YR 2/1) to verydark grey (5 YR 3/1) sandy loam; blocky; moist very friable; wet slightly sticky, dry-slightlyhard; concretion and mineral fragments absent; no roots;acidic - pH 3.1.
Note:	Pokkali	Orumundakan	Karipad
	a) 0 - 10 cm	0 - 28 cm	0 - 15 cm
	b) 10 - 15 cm	28 - 48 cm	15 - 30 cm
	c) 15 - 35 cm	48 - 68 cm	30 - 60 cm
	d) —	—	60 - 110 cm

All the three soil types could be classified under the order Entisol. Wide variations were noticed in the texture of these saline soils and hence resulted in variations in salinity hazards also.

Pokkali lands were almost at sea level whereas, Orumundakan soils, slightly above MSL and Kaipad lands, below MSL. Pokkali and Orumundakan lands were dark grey in the surface layers whereas Kaipad lands were dark yellowish brown. Clay was the dominant fraction in most of the Pokkali profiles, whereas in Orumundakan and kaipad lands, coarser fractions dominated. Water holding capacity was maximum for Pokkali soil.

The C/N ratio in these soils were wide. When compared to other two soils, CEC of Orumundakan soils was very low. The general salinity levels of Pokkali, Kaipad and Orumundakan lands decreased below the critical level as the monsoon progresses. Lower salinity levels were maintained till December-January. Among the three types of lands Orumundakan lands maintained higher level of salinity.

Pokkali and Orumundakan profiles are greyish in colour, intensity of which increases with depth, whereas Kaipad profiles are yellowish brown in the suface which turn to dark grey at lower depths. Soil is clayey in Pokkali profile but sandy or sandy clay in Orumundakan and Kaipad profiles. pH of Pokkali and Orumundakan profiles are uniformly low ranging from 3.1 to 3.3. Surface horizons of Kaipad profiles are less acidic, but acidity increases with depth. Depth of ground water is more in Kaipad (110 cm) and lesser in Orumundakan (66 cm) and very low in Pokkali lands (33 cm).

4.4 Management of Pokkali, Kaipad and Orumundakan lands

Rice followed by prawn culture is the cropping pattern adopted in Pokkali and Kaipad lands.

Rice cultivation starts in April with the strengthening of outer bunds and setting up of sluices to control the level of water. The fields are then drained and sluices closed at high tides. In these lands, mounds are formed with about one metre base and half a metre height. With the onset of monsoon, the salts are washed down the mounds and drained off in rain water. Sprouted seeds are sown on the mounds which serve as an insitu nursery. In about 30-35 days, the seedlings attain a height of 30-35 cm. At this stage, the mounds are dismantled and seedlings along with soil of the mound are uniformly spread in the field. After the harvest of the first crop, fields are flooded and used for prawn culture or fish farming. Tall varieties which are tolerant to salinity as well as acidity are usually cultivated in these lands. In Orumundakan lands seeds are sown in the nursery in the month of June and 60-80 days old seedlings are transplanted in the main field. Tall photo insensitive salt and acid tolerant variety called Orumundakan is cultivated in this area which is harvested in December-January. Rice cultivation is not remunerative in Orumundakan lands. Coconut raised in the bunds of fields are the chief source of income for the farmers.

Results of experiments conducted at Rice Research Station, Vyttila to improve rice yield of Pokkali region is summarized below.

4.4.1 Nitrogen management

A simple observational trial was conducted from 1966 to 1970 with 20 and 40 kg N ha^{-1}, each level applied as ammonium sulphate, urea and calcium ammonium nitrate. 20 kg N as urea in the form of foliar application was also tried. In all the years, 20 kg N as ammonium sulphate, recorded the highest yield. It was found better than the same dose applied as urea.

Foliar application of urea at the rate of 20 and 40 kg N ha^{-1} did not give any consistant result in the experiment conducted during 1969 and 1970.

Deep placement of ammonium sulphate pellets at 5 cm depth after planting was better than the same dose applied by broadcasting.

Replicated trials were conducted in three years from 1975 to 1977 to compare the efficiency of foliar application of 5, 10 and 15 per cent urea solution with soil application of 20 kg N ha^{-1} as urea. A fertilizer schedule of 20:20:20 kg N, P_2O_5 and K_2O ha^{-1} was used. Though treatment differences were not significant, soil application of urea recorded the highest yield in all the years.

Ammonium sulphate is found to be a better source of nitrogen than urea in these soils. Better performance of ammonium sulphate may be due to the retention of NH_4 ions by clay particles. Urea being highly water soluble is more liable to different types of losses.

Deep placement of ammonium sulphate pellets in the field after transplanting is found better than broadcasting the same dose as ammonium ions can be retained in the clayey soil of the rice root zone for a longer period.

4.4.2 Phosphorus management

Comparative efficiency of basic slag and superphosphate was assessed in a field experiment for three years from 1967 to 1970. Fifty and hundred kg of P_2O_5 as superphosphate were compared with a 'no P' treatment and a 'no fertilizer', control. Except for no fertilizer control, 30 kg each of nitrogen and potassium were given in the form of ammonium sulphate and muriate of potash respectively. Grain yield was significantly increased by the application of phosphatic fertilizers. Basic slag and superphosphate were equally effective in the acid saline soils of Vyttila. Fifty kg P_2O_5 was found better than 100 kg ha^{-1}.

Basic slag and superphosphate are found equally efficient as P sources. Grain yield is considerably increased by P fertilizer application upto 50 kg P_2O_5 ha^{-1}, since the soil is highly deficient in phosphorus.

4.4.3 Management of major nutrients

An observational trial was conducted for three years to compare the efficiency of nitrogen, phosphorus and potassium for increasing grain yield of rice. The fertilizers were applied in the form of ammonium sulphate, superphosphate and muriate of potash on the mounds at the time of sowing germinated seeds. Application of nitrogen in the form of ammonium sulphate had given the highest yield which was 14 per cent more than that of control. Application of P_2O_5 and K_2O recorded 9 and 3 per cent more yield respectively than that of control.

Based on the results of the previous experiment, another experiment was laid out to study the effect of nitrogen and phosphorus applied either alone or in combination at two stages of crop growth ie.at the time of sowing and at the time of dismantling the mounds and distributing the seedlings in the field.

The experiment was conducted for three seasons. In two out of three seasons, treatment differences were significant and in all the seasons, application of 20 kg N and 40 Kg $P_2O_5ha^{-1}$ at the time of dismantling and distribution of seedlings recorded maximum yield. This treatment recorded 35.6 per cent more yield than "no manure" control. Application of 20 kg N in the form of ammonium sulphate at the time of dismantling of mounds was the next best treatment.

An observational trial was conducted to assess the efficiency of foliar application of major nutrients in the year 1969. Twenty kg each of N, P_2O_5 and K_2O ha^{-1} were applied in ten equal splits through foliar sprays before flowering. Application of nitrogen gave the highest yield among major nutrients in Pokkali soil.

Foliar application of two and four per cent solutions of ammonium phosphate quantifying 17 and 34 kg ha^{-1} P_2O_5 respectively were compared with soil application of the same quantity of the fertilizer. Ammonium phosphate at lower level as foliar spray was better than higher level. But, for soil application, higher level (34 kg ha^{-1})

was better. Ammonium phosphate (17 kg P_2O_5 ha^{-1}) as 2 per cent foliar spray was the best treatment.

Among the major nutrients, nitrogen is found to be the most efficient one in increasing grain yield followed by phosphorus and potassium in the decreasing order.

Application of 20 kg N and 40 kg P_2O_5 ha^{-1} consistently increased grain yield. The time of dismantling of mounds and distribution of seedlings in the field is found to be the best time of application of N and P fertilizers.

Foliar application of 17 kg P_2O_5 ha^{-1} as ammonium phosphate (2 per cent solution) is found effective for rice. For soil application double the dose is required.

4.4.4 Organic manures and biofertilizer

Efficiency of green leaf for increasing grain yield was tested in an observational trial. Fifteen per cent increase in grain yield was obtained by the application of green leaves @ 5t ha^{-1}.

As a part of the multi locational trial to evaluate the efficiency of blue green algae (BGA) in different agro climatic regions, an experiment was laid out in RRS, Vyttila. Full, 2/3 and 1/3 dose of N and recommended dose of P_2O_5 were compared with the same dose of N and P along with 10 kg of BGA culture. BGA multiplied fast in the field. Treatment differences were not significant for grain yield. The experiment was discontinued since the algal mat was swept away by the wind along with seedling causing crop damage. When the wind subsides, the algal mattings rested on the seedlings and led to total loss of crop.

Though blue green algae multiply rapidly it is not suitable for the agro-ecological situation of Pokkali lands.

4.4.5 Soil amendments

Ameliorating effects of different levels of lime in the acid-saline soils were tested in an observational trial. One, two and three tons of lime were compared with a "no lime" control. Half the quantity of lime was applied on the mounds while sowing and the other half at the time of dismantling and distribution of seedlings. Equal quantity of seeds were sown on mounds. The trial was conducted in three seasons from 1967 to 1970. In all the three seasons, 'no lime' control recorded the lowest grain yield

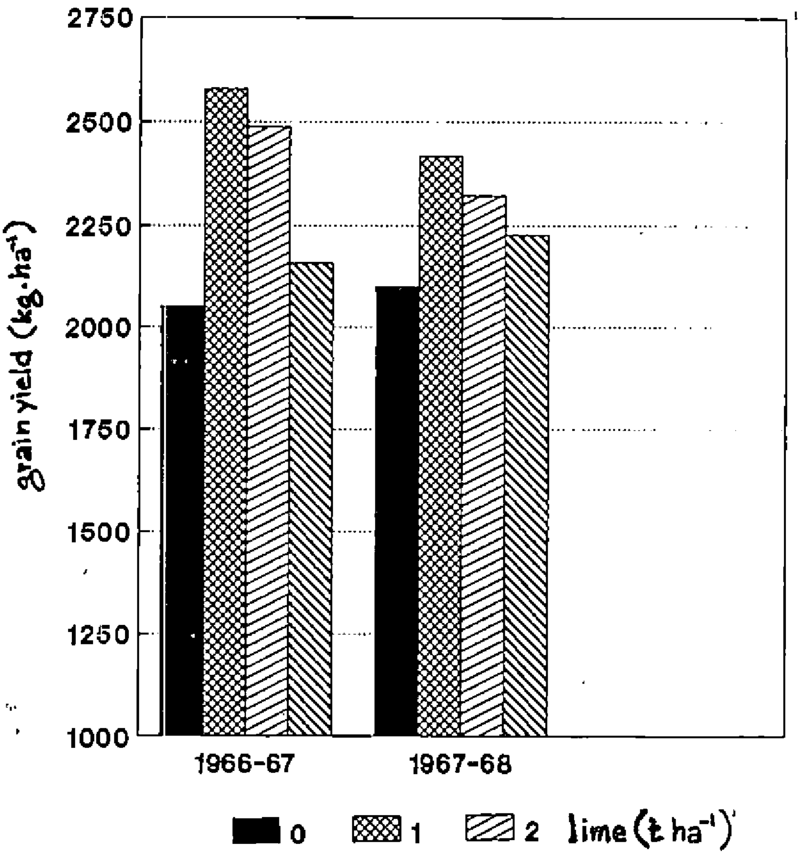


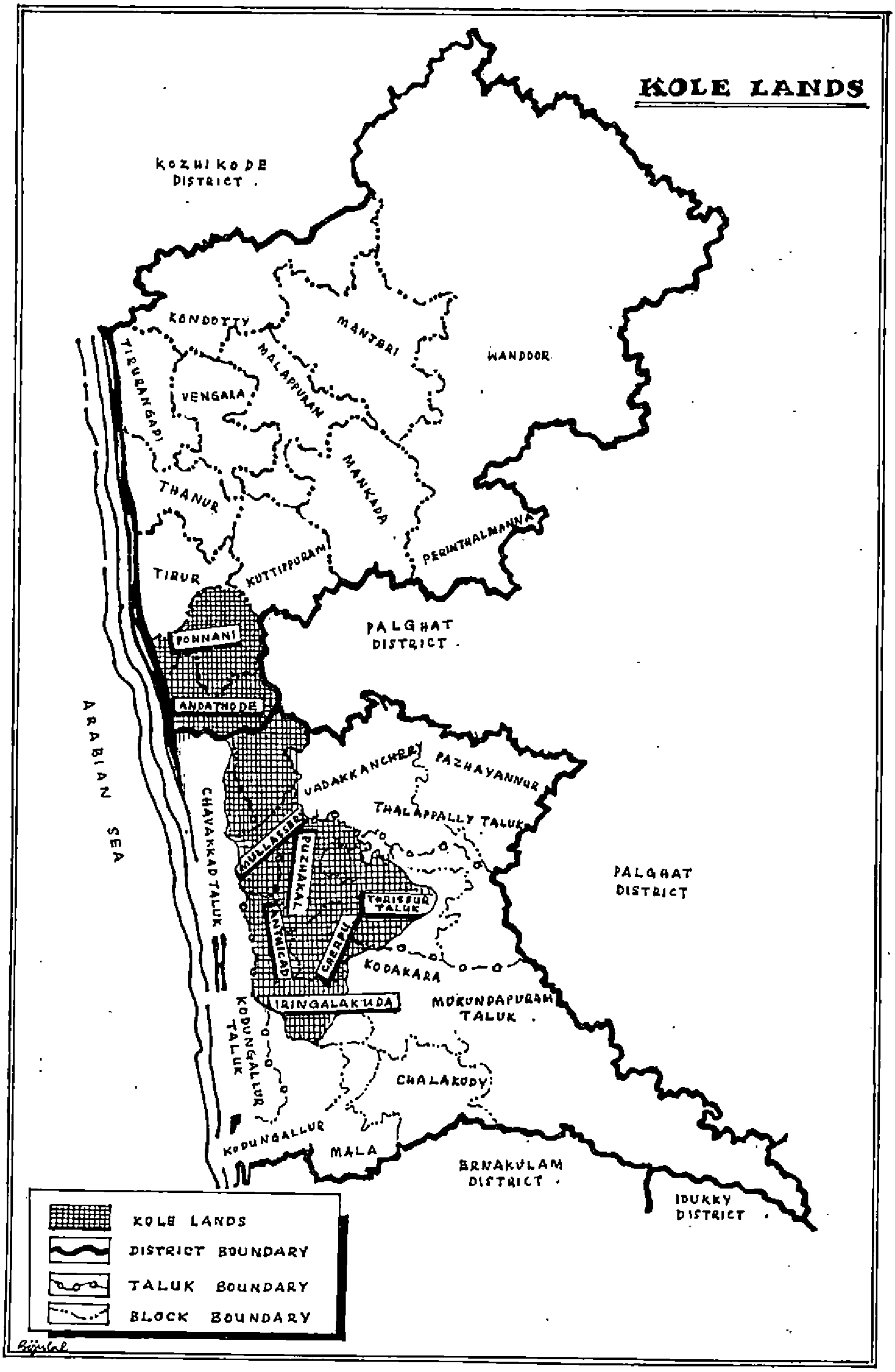
Fig. 4.4.5.1. Effect of lime on grain yield of rice

and 1000 kg lime over and above 20 kg N and 40 kg P_2O_5 ha^{-1} recorded the highest yield (Fig. 4.4.5.1). Application of lime above 1000 kg ha^{-1} reduced grain yield. Average yield increase was 21 per cent more than "no lime" control.

Saw dust @ 300 kg ha^{-1} as an amendment was not beneficial in Pokkali soils.

Application of 500 kg gypsum ha^{-1} in ten equal splits did not increase grain yield of rice in pokkali soil.

Though the soil is having a very low pH, ranging from 3.5 to 3.8, more than 1000 kg lime ha^{-1} is not found to increase grain yield. Application of 1000 kg lime ha^{-1} increases grain yield by 21 per cent. Detailed investigations are required to assess the cause for reduction in yield with higher doses of lime. As grain yield obtained by liming is not economical, varietal screening of the existing high yielding rice varieties for their adapatibility to the agro-ecosystem is warranted.


KOLE LANDS
KOZHIKODE DISTRICT
KONDOTTY
MANJERI
WANDOOR
TIRURANGADI
VENGARA
MALAPPURAM
MANKADA
THANUR
PERINTHALMANNA
TIRUR
KUTTIPPURAM
PALGHAT DISTRICT
PONNANI
ANDATHODE
ARABIAN SEA
CHAVAKKAD TALUK
VADAKKANCHERY
PAZHAYANNUR
THALAPPALLY TALUK
MULLASSERI
PUZHAKKAL
TRISSUR TALUK
ANTHICAD
CHERPU
KODAKARA
IRINGALAKUDA
MUKUNDAPURAM TALUK
PALGHAT DISTRICT
KODUNGALLUR TALUK
CHALAKUDY
KODUNGALLUR
MALA
ERNAKULAM DISTRICT
IDUKKY DISTRICT
KOLE LANDS
DISTRICT BOUNDARY
TALUK BOUNDARY
BLOCK BOUNDARY
Bijulal

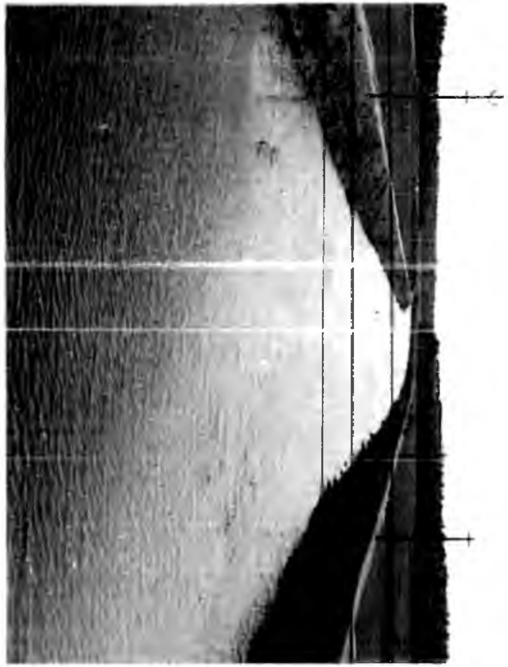
POKKALI CULTIVATION

MOUNDS FOR SOWING SEEDS

MOUNDS WITH SEEDLINGS

DISMANTLING MOUNDS

KOLE LANDS -- PETTI AND PARA



KOLE LANDS WITH IRRIGATION CANAL

KOLE LANDS WITH IRRIGATION CHANNEL

5 KOLE LANDS

5.1 General characteristics

Kole lands of Kerala extend over an area of 13,682 ha lie in Thrissur, Chavakkad and Mukundapuram taluks of Thrissur district and Ponnani taluk of Malappuram district. The tract is bordered by hilly area on the east, Kanoly canal on the west, Muriyad kayal on the south and Mulloor kayal on the north. They lie between 0.5 to 2.0 m below MSL and are under submerged condition for major part of the year. Soils of this tract are very unique in their characteristics and are in several respects similar to soils of Kuttanad.

The low lying Kole fields are flood plains running parallel to the sea coast with tongue like extensions eastwards. Due to the frequent flooding and deposition of fine particles, the surface soil is generally heavy textured. The sand occurring at a depth of 2-3 m below the surface of the soil might have been derived from the sea. Judged by its proximity to the sea and the climate of the region, it can be inferred that the Kole area might have been a marshy land in the recent past. During monsoon months, June to November, the entire area is covered by fresh water. When the monsoon recede by November, level of fresh water falls and the sea water tends to get in. The ingress of sea water has been prevented by the construction of bunds at Enamavu, Mulayam and Kottonkete.

Kole area is drained mainly by two rivers viz. Karuvannur and Kecheri. The Karuvannur river originates from the high lands and runs through narrow valleys and finally enters the plains. The river then assumes a long and meandering course to the backwaters and finally falls in Kanoly canal at the southern end of Thriprayar, which in turn finally reaches the sea at Chettuvai. The second major river, Kecheri has it's origin in Machad forest and flows north-west and enters Kole lands near Parappu and finally empties into Arabian sea at Chettuvai through Enamakkal regulator. The 20 km stretch of land lying between Arattupuzha and Karuvannur rivers is possibly a delta formed by silt of these two rivers.

Kole fields are generally classified into low lands and uplands. Some portion of Kole fields exhibit locustrine composition and contain carbonaceous clay with considerable quantities of vegetable matter. Weathered tree trunks and lime shell deposits are also seen in some places when dug deep. The sub-surface exploration of Kole lands show that they are sedimentary in origin.

On the basis of the climatic data recorded at Ollukkara and Irinjalakkuda, the nearest meteorological stations, the climate of the Kole area may be described as tropical. The annual average temperature varies from 23.4°C to 31.6°C. The maximum temperature rarely exceeds 37°C. March and April are the hottest months of the year. Because of the high humidity, the atmosphere is generally damp. The average annual rainfall is 3019 mm. Rains are received during both South-West and North-East monsoons. The South-West monsoon starts in June and continues upto September. The rainfall is intense during June-July. The North-East monsoon starts in September and lasts till November. Nearly 90 per cent of the rainfall is received during these two periods.

The history of Kole cultivation can be traced back to the period of Sakthan Thampuran of Cochin during whose reign (1790-1805), the canals of this tract were laid out. It was evident that the increase in population and the pressure on cultivable land led to the reclamation of these marshy and waterlogged lands. With the formation of canals and channels for irrigation, the vast fields were divided into several blocks locally known as padavus. In the olden days, all the padavus were not cultivated at the same time. Instead, cropping was done in alternate areas in alternate years. Wooden wheels with 24-30 leaves worked with human effort were used for dewatering. The dewatering would be completed before the end of December. Cultivation was done from December to May. After the preparation of land, sprouted paddy seeds will be sown. Very little fertilizers were used as the land had it's natural fertility. Water in the ramifying network of channels and the padavus, which were left fallow were used for irrigation, in addition to the occasional rains received during February-March. Otherwise, there was no irrigation from any external source. It used to be a bumper crop and a windfall for the farmers. Hence the fields came to be known by the name 'Kole', which is a Malayalam word equivalent to bumper yield of high returns.

With the increase in population, the practice of leaving the padavus fallow in alternate years ceased. It is not more than 50 years since this practice ended, and all padavus came to be cultivated simultaneously. The primitive wooden wheel was replaced by modern dewatering devices like the petti and para run by electric motors or diesel engines. Tractors and tillers are also being used widely. The channels were deep and wide enough to retain large quantities of water for irrigation purposes. But with the passage of time, the depth and width of the channels got reduced for several reasons. Even then, with the help of occasional rains in February and March, the crop yields used to be satisfactory. But, of late, there has been a tendency for extremely low rainfall during February-March and as a result of which it has now become necessary to depend on external irrigation. The adoption of intensive cultivation has reduced the soil fertility and hence fertilizers are also being used on an increasing rate.

Two crops of rice are being grown in the Kole lands, one in the punja season of January-May and the other during the mundakan season of September-December.

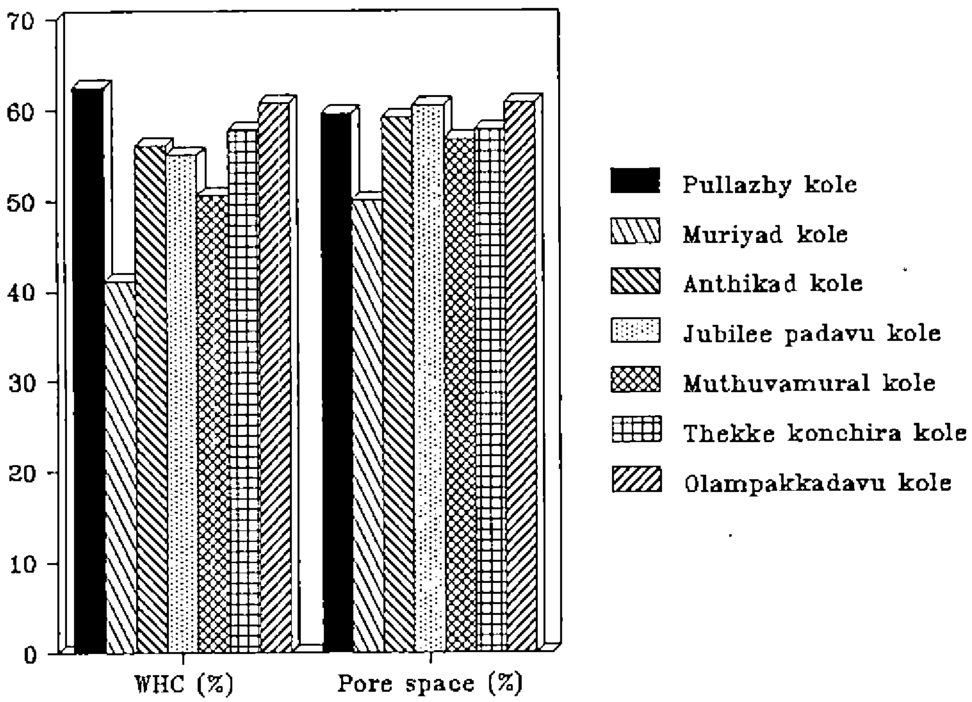
The cultivation of punja crop commences with the dewatering operations in the third week of January which lasts for 2-3 weeks. With the completion of dewatering by about first week of February, the field is harrowed 2 or 3 times with a local implement called pallimutti and levelled with changalamaram or njouri. Meanwhile, farm yard manure and fertilizers at the recommended rates are also added. Sprouted seeds are either sown or seedlings planted in these fields. Cheera, Triveni and Annapurna are the dominant varieties in the area. The crop becomes ready for harvest by about first week of May and the harvest will be over by the middle of the month. With the onset of pre-monsoon showers after the harvest, the fields are given two or three ploughings after which they are allowed to get submerged under the monsoon floods.

The second crop, mundakan, begins with the pumping out of water from the fields by about 15th of August, the operation continues till the middle of September. About 37 per cent of Kole areas is cultivated during mundakan season. After the completion of dewatering, the land is prepared as in the case of the punja crop and seedlings are transplanted. Medium duration varieties including Jaya, IR-8 and Triveni are used. The crops become mature for harvest by 15th of December. After harvest, the fields are ploughed twice or thrice and water is let in from surrounding canals. Thus the fields are again flooded and remains so till the commencement of punja season. The entire area is under water during the normal virippu season. Uplands are situated along the entire Kole region of Thrissur and Malappuram districts. Soil is laterite in origin with lesser amount of silt and clay. Coconut based cropping system is followed in uplands.

5.2 Physico-chemical properties of surface soil

Physical properties of surface soil samples collected from seven locations of Kole lands indicated that all these soils were clayey in texture except for soil of Muriyad kole where the soil was silty loam (Hameed, 1975). Water holding capacity ranged from 41.10 to 62.50, maximum being recorded in Pullazhy kole and minimum in Muriyad kole (Fig. 5.2.1).

Organic matter varied from 2.07 to 4.16 per cent and total nitrogen ranged from 0.30 to 0.43 per cent. Cation exchange capacity ranged from 12.60 to 38.36 cmol $(p^+) kg^{-1}$ of soil. Muriyad kole recorded the lowest value. pH of the surface soils ranged from 3.5 to 5.7, the lowest being recorded in Muthuvamural kole and highest in Pullazhy kole. Total nitrogen, P_2O_5 and K_2O varied from 0.30 to 0.43, 0.09 to 0.24 and 0.09 to 0.21 per cent respectively. CaO and MgO content ranged from 0.19 to 0.55 and 0.03 to 0.38 per cent respectively (Fig. 5.2.2).



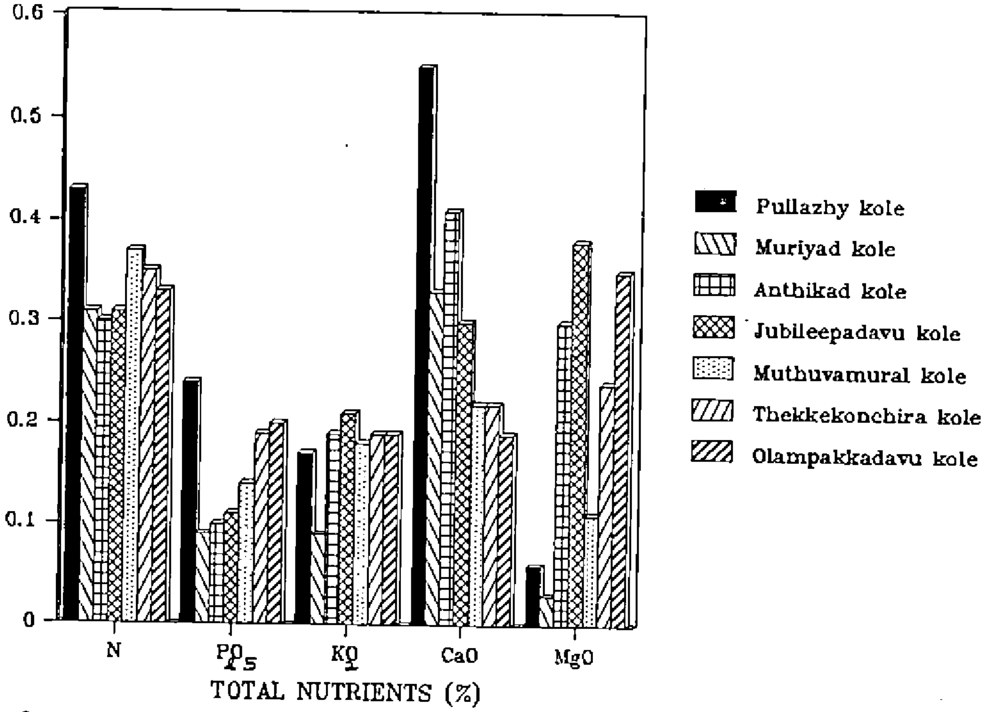
Source: Hameed, 1975

Fig. 5.2.1. Physical properties of surface soil (0-22 cm depth)

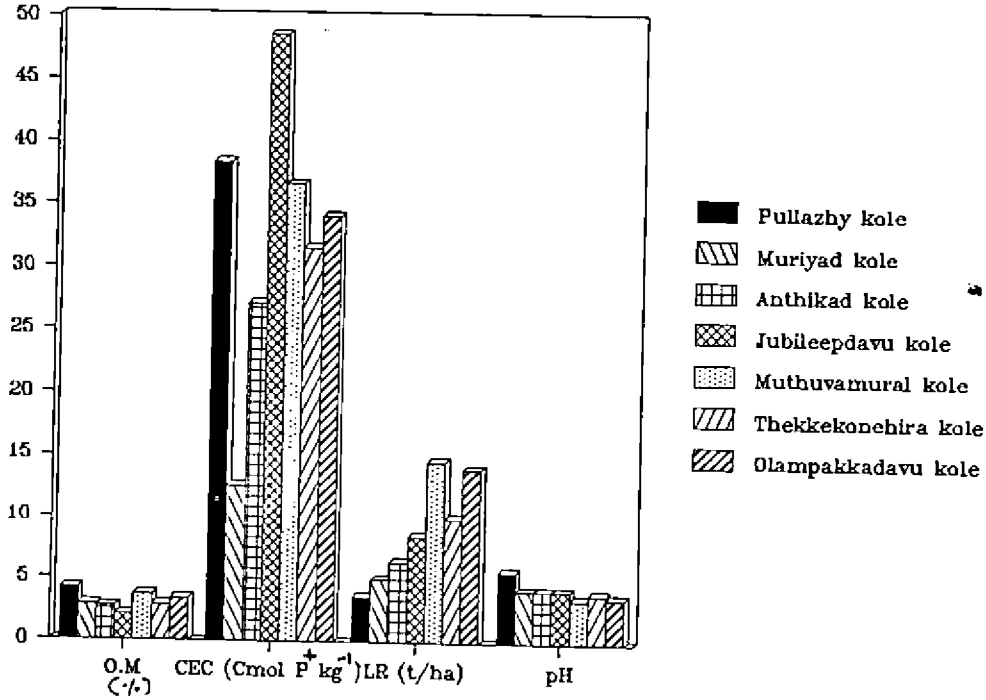
Table 5.2.1 Fertility status of surface soils

Location	pH	OC %	Rating	P (kg ha^{-1})	Rating	K (Kg ha^{-1})	Rating
Tholour	5.18	0.53	Low	45.8	High	81.0	Low
Adat	4.80	1.89	High	30.0	High	163.0	Medium
Chathan kole	4.60	0.92	Medium	18.6	Medium	61.0	Low
Chittilappally	4.61	0.63	Low	18.7	Medium	59.3	Low
Chalakkal	5.07	0.98	Medium	5.8	Low	158	Medium
Ayyanthole	5.40	0.85	Medium	7.0	Low	136	Low

Source: Agri. Electronics Project Report, 1992



Source: Hameed, 1975.



Source: Hameed, 1975

Fig. 5.2.2. Chemical properties of the surface soil (0 - 22 cm depth)

Fertility ratings of some Kole padavu in Thrissur district (Table 5.2.1) revealed that these soils were acidic in reaction. Available nitrogen as indicated by organic carbon content was medium to high.Most of these soils were medium to high in available phosphorus but low to medium in available potassium.

Surface soils of Kole lands are mostly clayey in texture with good water holding capacity. Soil is rich in organic matter and total nitrogen. Cation exchange capacity is found to range from 12.6 to 38.6 cmol (P^+) kg^{-1} and is found directly related to soil texture. Kole soils are found to be high to medium in available nitrogen, available phosphorus and low to medium in available potassium.

5.3 Profile characteristics

Seven typical soil profiles from Pullazhy, Muriyad, Anthikad, Jubileepadavu, Muthuvamural, Thekkekonchira and Olampakkadavu kole of Thrissur were investigated for their morphological, physical and chemical characteristics (Hameed,1975). Profile characteristics of the first four profiles resembled each other whereas that of the last three were similar. Profile characteristics of Muriyad kole and Muthuvamural kole being taken as representative profiles are given in Table 5.3.1.

5.3.1 Morphological properties

The soil of surface layers upto 44 cm depth was dark yellowish brown in colour in both Muriyad kole as well as in Muthuvamural kole. Surface layer of Muriyad kole was slightly plastic on wetting and hard on drying whereas it was plastic on wetting and very hard on drying in Muthuvamural kole. Below 44 cm, colour of the soil was dark brown in Muriyad kole whereas it was black in Muthuvamural kole. Decomposed or partially decomposed plant residues were seen in this layer in both profiles. Soil was loose and compost like with a foul smell of hydrogen sulphide (Hameed, 1975).

5.3.2 Physical properties

Physical properties of kole profiles are presented in Table 5.3.2.1. Texture of the profiles ranged from silty loam to clayey, but surface layers were mostly clayey. Apparent specific gravity ranged from 0.76 to 1.22 and absolute specific gravity from 1.30 to 2.83. A decrease in specific gravity was observed with increase in depth. Maximum water holding capacity ranged from 41.1 to 87.1 per cent and percentage pore space from 49.9 to 61.5 (Hameed, 1975). Fifteen surface (0-20 cm) and sub-surface (15-40 cm) soil samples collected from different parts of Thrissur. (Sheela, 1988) also analysed similarly for the above parameters.

Table 5.3.1 Profile description

A. Muriyad kole

I. General information of the site

a.	Topography	:	level and flat
b.	Vegetation	:	cultivated rice

II. Profile characteristics

Depth cm	Colour	Texture	Consistency	Presence of mots	pH	Special features
0	Moist -10 YR 4/4 dark yellowish brown Dry -10 YR 5/6 yellowish brown	Silt loam	Wet-sticky Moist-firm Dry-slightly hard	Abundant	4.8	Yellowish mottlings and pebbles
22	Moist-10 YR 3/4 dark yellowish brown Dry- 10 YR 5/6 yellowish brown	Massive clay	Wet-very sticky Moist - firm Dry - very hard	Few	4.8	Yellowish mottlings
44	Moist-7.5 YR 3/2 Dry-7.5 YR 4/2 brown	Massive clay	Wet-non sticky Moist-loose	Nil	4.6	Ressemble well rotten compost, very strong smell of hydrogen sulphide. Recent vegetable remains leaves and twigs

B Muthuvamural kole

I. General information of the site

a.	Topography	:	level and flat
b.	Vegetation	:	cultivated rice

II. Profile characteristics

Depth cm	Colour	Texture	Consistency	Presence of roots	pH	Special features
0	Moist-10 YR 4/4 dark yellowish brown Dry-10 YR 5/4 yellowish brown	Massive clay	Wet-sticky Moist-firm Dry-very hard	Abundant	3.7	Yellowish mottlings
22	Moist-10 YR 4/4 dark yellowish brown Dry-10 YR 5/4 yellowish brown	Massive clay	Wet-very sticky Moist - firm Dry - very hard	Few	3.7	Yellowish mottlings
44	Moist-10 YR 2/1 black. Dry-10 YR 2/2 very dark brown	Massive clay	Wet-non sticky Moist-loose Dry-loose	Few	3.2	Decaying wood, twigs and vegetable residues

66

Source: Hameed, 1975

Table 5.3.2.1 Physical properties of soil profiles

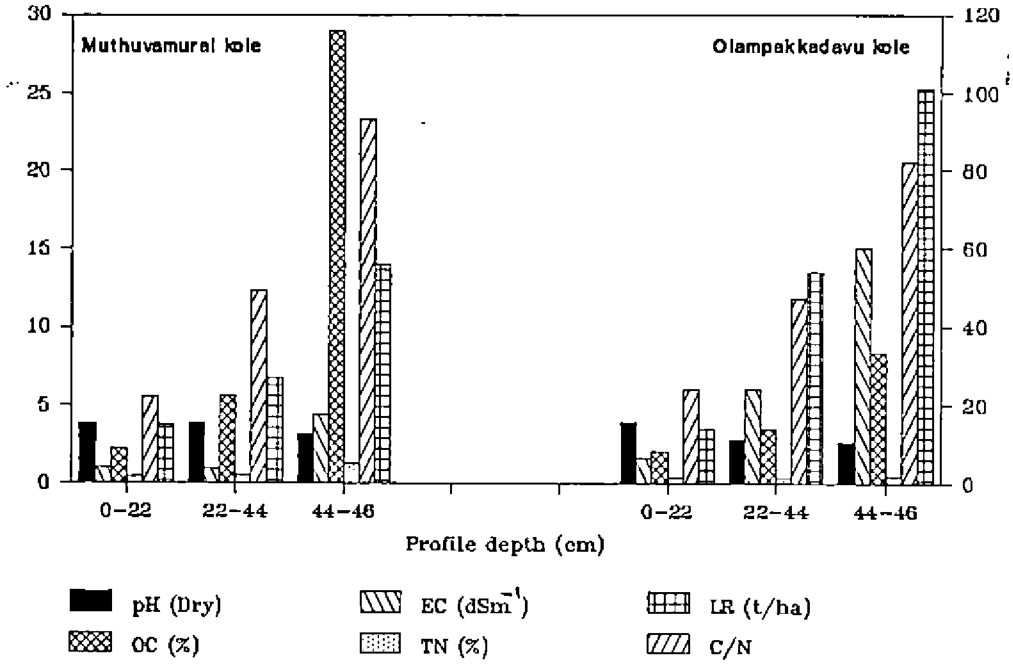
Name of field	Depth (cm)	Textural class gravity	Apparent specific gravity	Absolute specific holding capacity	Maximum water (per cent)	Porespace (%)	Volume expansion (%)
Pullazhy kole	0-22	Clay	1.12	2.61	62.50	59.50	10.40
Pullazhy kole	22-44	Clay	1.20	2.60	54.00	57.30	9.73
Pullazhy kole	44-66	-	0.76	1.30	84.10	59.60	8.88
Muriyad kole	0-22	Silt loam	1.21	2.47	41.10	49.90	5.23
Muriyad kole	22-44	Clay	1.20	2.61	49.00	55.70	6.51
Muriyad kole	44-66	Clay	0.86	2.05	75.10	60.40	6.41
Anthikad kole	0-22	Clay	1.16	2.55	56.80	50.10	10.10
Anthikad kole	24-44	Clay	1.19	2.58	51.20	56.90	7.60
Anthikad kole	44-66	Clay	1.17	2.59	66.10	62.50	23.20
Jubilee Padavu kole	0-22	Clay	1.19	2.77	55.10	60.40	8.80
Jubilee Padavu kole	22-44	Clay	1.22	2.69	57.60	958.4	14.10
Jubilee Padavu kole	44-66	Clay	1.18	2.70	63.10	63.00	18.40
Muthuvamural kole	0-22	Clay	1.22	2.56	50.60	56.70	10.40
Muthuvamural kole	22-44	Clay	1.05	2.47	65.20	61.50	11.40
Muthuvamural kole	44-66	-	0.76	1.76	87.10	60.70	9.89
Thekkekonchira kole	0-22	Clay	1.20	2.59	53.00	57.80	10.93
Thekkekonchira kole	23-37	Clay	1.12	2.46	58.40	58.90	11.70
Thekkekonchira kole	37-59	-	0.70	1.81	86.10	70.80	6.08
Olampakkadavu kole	0-22	Clay	1.18	2.83	54.20	60.70	6.18
Olampakkadavu kole	22-44	Clay	1.15	2.60	54.10	59.00	7.84
Olampakkadavu kole	44-66	Silt clay	1.06	2.31	53.30	56.70	6.20

* Oven dry basis

Source: Hameed, 1975

5.3.3 Chemical characteristics

Chemical characteristics of seven profiles are presented in Table 5.3.3.1 and Fig. 5.3.3.1 shows the chemical characteristics of two representative soil profiles viz. Muthuvamural kole and Olampakkadavu kole. Electrical conductivity of the different horizons increased with depth in all the profiles. In the three layers of depth, 0-22, 22-44 and 44-60 cm, electrical conductivity ranged from 0.58 to 1.59, 0.16 to 6.04 and 1.27 to 15.00 respectively. pH decreased with depth in all the profiles. Lime requirement was maximum in the lower most layer. It ranged from 3.6 to 14.6 t ha^{-1} in the surface layer to 11.8 to 100.0 t ha^{-1} in the lower most layer. Minimum lime requirement in the surface layer was recorded in Pullazhy kole and maximum in Muthuvamural kole. Minimum lime requirement in the lower most layer was recorded by Jubileepadavu kole and maximum in Olampakkadavu kole. Organic carbon content increased with depth. An organic carbon content of 40.54 per cent in the lower most layer was recorded in Thekkekonchira kole. Total nitrogen and C/N ratio also increased with depth in all the profiles. Total potassium, calcium and magnesium increased with depth in all the profiles whereas phosphorus decreased (Hameed, 1975). Surface (0-20 cm) and sub-surface (20-40 cm) soil samples of fifteen locations were collected from Thrissur district and studied for their physical and chemical properties and made similar



Source: Hameed, 1975.

Fig. 5.3.3.1. Chemical properties of soil profiles

Table 5.3.3.1 Chemical properties of soil profiles

Lab. No.	Name of field	Depth (cm)	pH (Dry)	Conductivity dSm^{-1}	Lime requirement $CaCO_3$ kg ha^{-1}	Organic carbon (%)	Total nitrogen (%)	Carbon nitrogen ratio	P_2O_5 (%)	K_2O (%)	CaO (%)	MgO (%)
1	Pullazhy kole	0-22	6.3	0.69	3640	2.41	0.43	5.56	0.24	0.17	0.55	0.06
2	Pullazhy kole	0-44	5.6	2.86	6170	4.73	0.39	12.18	0.22	0.15	0.80	0.11
3	Pullazhy kole	44-66	3.9	15.00	54930	27.78	0.82	33.79	0.11	0.19	2.08	0.30
4	Muriyad kole	0-22	4.6	0.64	5040	1.69	0.31	5.37	0.09	0.09	0.33	0.03
5	Muriyad kole	22-44	4.2	0.16	15130	2.54	0.29	8.81	0.05	0.10	0.33	0.05
6	Muriyad kole	44-66	3.5	1.27	36300	16.80	0.57	29.47	0.05	0.24	1.89	0.36
7	Anthikad kole	0-22	4.7	0.58	8480	1.55	0.30	5.15	0.10	0.19	0.41	0.30
8	Anthikad kole	22-44	1.7	0.48	9530	0.90	0.14	6.62	0.03	0.16	1.05	0.32
9	Anthikad kole	44-66	4.1	3.13	19060	2.77	0.30	9.16	0.02	0.60	0.30	0.90
10	Jubileepadavu kole	0-22	4.5	0.95	8480	1.20	0.31	3.85	0.11	0.21	0.35	0.38
11	Jubileepadavu kole	22-44	4.3	0.85	10090	0.79	0.14	5.51	0.04	0.34	0.39	0.58
12	Jubileepadavu	44-66	4.6	1.38	11780	1.26	0.23	5.53	0.03	0.57	0.22	0.67
13	Muthuvamural kole	0-22	3.8	1.01	14570	2.15	0.37	5.53	0.14	0.18	0.22	0.11
14	Muthuvamural kole	22-44	3.8	0.90	26900	5.63	0.46	12.28	0.08	0.30	0.34	0.16
15	Muthuvamural kole	44-66	3.1	4.35	56050	29.23	1.25	23.24	0.04	0.24	0.66	0.18
16	Thekkekonchira kole	0-22	4.3	1.06	10090	1.66	0.35	4.76	0.10	0.19	0.22	0.24
17	Thekkekonchira kole	22-37	4.2	0.85	14570	4.40	0.47	9.46	0.09	0.17	1.27	0.22
18	Thekkekonchira kole	37-59	3.0	15.00	92480	40.54	0.48	84.64	0.05	0.12	1.06	0.38
19	Olampakkadavu kole	0-22	3.9	1.59	14010	1.95	0.33	5.95	0.13	0.20	0.19	0.35
20	Olampakkadavu kole	22-44	2.8	6.04	54370	3.52	0.30	11.80	0.12	0.36	0.38	0.50
21	Olampakkadavu kole	44-66	2.6	15.00	100900	8.43	0.41	20.52	0.05	0.44	0.58	0.81

Source: Hameed, 1975

observations. Total Al ranged from 9.7 to 94.10 and Fe ranged from 4.48 to 74.10 mg g^{-1} of soil. Phosphorus fixing capacity ranging from 15 to 88 per cent showed positive relationship with sesquioxide, total Fe, Al, organic matter, clay and silt content of soil (Table 5.3.3.2).

Table 5.3.3.2 Relationship between PFC(*) and other soil characters

Sl. No.	Variables	Correlation coefficient
1	Coarse sand (30)	-0.7135**
2	Fine sand (30)	-0.1631
3	Salt (30)	0.4301*
4	Clay (30)	0.5286**
5	pH (30)	-0.2765
6	Organic carbon (15)	0.5944*
7	Sesquioxides (30)	0.2811**
8	Aluminium (30)	0.3300*
9	Iron (30)	0.5964**
10	CaO (30)	-0.3800*

* Significant at 5% level

** Significant at 1% level

Figures in paranthesis indicate number of samples

(*) PFC Phosphorus fixing capacity

Source: Sheela, 1988

Surface layers of Kole profiles are dark yellowish brown in colour and clayey in texture. Lower most layer is darker in colour with plenty of organic matter. Electrical conductivity as well as pH of the soil of different layers decrease with depth. Lime requirement is maximum in the lower most layer. Total nitrogen, potassium, calcium and magnesium increase with depth in the profile whereas phosphorus decreased. Phosphorus fixing capacity of the soil is found to be very high.

5.4 Management of Kole lands for rice cultivation

A replicated trial was carried out to compare the efficiency of different methods of application of nitrogenous fertilizer for increasing grain yield of dry sown rice in Kole lands. Urea in split doses (KAU Package recommendations 1982) was compared with complete basal incorporation of urea, application of urea either in plough furrows or alternate furrows along with seeds and application of urea after first weeding. The above treatments were also compared with urea super granules instead of urea. Urea super granules in plough furrows after broadcasting seeds, neem coated urea in plough furrows, enriched farm yard manure in plough furrows and an unfertilized control were also included for comparison. Results of the study indicated that the treatments, urea super granules and seeds in alternate furrows, urea super granules supplied after first weeding and unfertilized control were statistically inferior to all other treatments which were on a par with each other (Table 5.4.1).

Table 5.4.1. Nitrogen management for dry sown low land rice

Treatments	Grain yield kg ha^{-1}	Straw yield kg ha^{-1}
Ordinary urea in split as per package of practices	3789	6100
Ordinary urea full basal incorporation	3522	6433
Ordinary urea in plough furrow with seeds in same furrow	3328	4567
Ordinary urea with seeds in alternate furrows	3545	6233
Ordinary urea applied after first weeding	4122	6433
USG & seeds in same furrow	4445	6000
USG & seeds in alternate furrow	3156	5767
USG & seeds placement after first weeding	3167	6000
USG & seeds in plough furrow after broadcasting seeds	3745	5567
NCU in plough furrow	3689	5767
Enriched FYM in plough furrow	3956	5667
Unfertilised control	2751	4333
CD (0.05)	1120	NS

USG - Urea super granules
NCU - Neem coated urea

Source: KAU Annual Report, 1984-85

Table 5.4.2 Effect of NPK on grain and straw yield of short and medium duration variety

Sl. no.	Short duration variety: Treatments N kg ha^{-1}	P kg ha^{-1}	K kg ha^{-1}	Grain (Yield kg ha^{-1})	Straw (Yield kg ha^{-1})	Medium duration variety: Treatments N kg ha^{-1}	P kg ha^{-1}	K kg ha^{-1}	Grain (Yield kg ha^{-1})	Straw (Yield kg ha^{-1})
1	50	25	25	4063	5019	70	35	35	5120	6330
2	70	35	35	4788	5950	90	45	45	5240	5600
3	90	35	35	5025	6216	110	45	45	5600	6830
4	90	35	45	5188	5950	110	45	45	5660	6500
5	110	35	35	5413	5775	130	45	45	5920	7170
6	110	35	35	5500	6419	130	45	65	5920	8000
7	130	35	35	5413	6181	150	45	45	5800	8000
8	130	35	35	5288	589	150	45	75	5740	7330
9	Control -	no fertilizer		3062	3675	Control -	no fertilizer		3820	3675
C.D. (0.05)				594					780	1324

Source: KAU Annual report, 1984-85

The optimum dose of NPK for short and medium duration rice varieties were determined in experiments conducted in farmers field in Kole lands. There was positive response to nitrogen upto 130 kg ha^{-1} for the medium duration variety. But it was statistically on a par with the present recommendation of 90-45-45 kg N, P_2O_5 and K_2O ha^{-1} (Table 5.4.2). Maximum grain yield was obtained for 90-35-55 kg NPK ha^{-1} for short duration variety which was on a par with yields realised for 110-35-35, 90-35-45 and 90-35-35 kg, N, P_2O_5, K_2O ha^{-1}.

Different methods of application of urea are found to have no effect for dry sown rice in Kole lands. Present mode of application of fertilizers as recommended by KAU is ideal for the rice varieties being grown in this tract. A dose of 90:35:45 kg NPK ha^{-1} for the short duration varieties and 90:45:45 for the medium duration varieties (the present package of recommendations) are sufficient for rice.

6 POONTHALPADOMS

6.1 General characteristics

Poonthalpadoms are located in patches in Chittoor taluk of Palghat district and in some parts of Wynad district. These soils are locally known as Poonthalpadoms due to the deep slushy nature of the soil in major part of the year. These soils spread over an area of 2000 ha in Chittoor taluk and is mainly located in the Palghat gap of Western ghats.

The soil of Chittoor taluk is black in colour which may be due to the extension of black cotton soil of Deccan plateau through the Palghat gap. Even in summer months of the year, the soil remains in a semi dry slushy state but in extremely dry weather, some times they dry up forming deep crevices on the surface. These soils cause problems for cultivation due to impeded drainage and poor hydraulic conductivity. Though these soils are grouped under problem soils, the nature of problems are entirely different, being more of a physical rather than of a chemical.

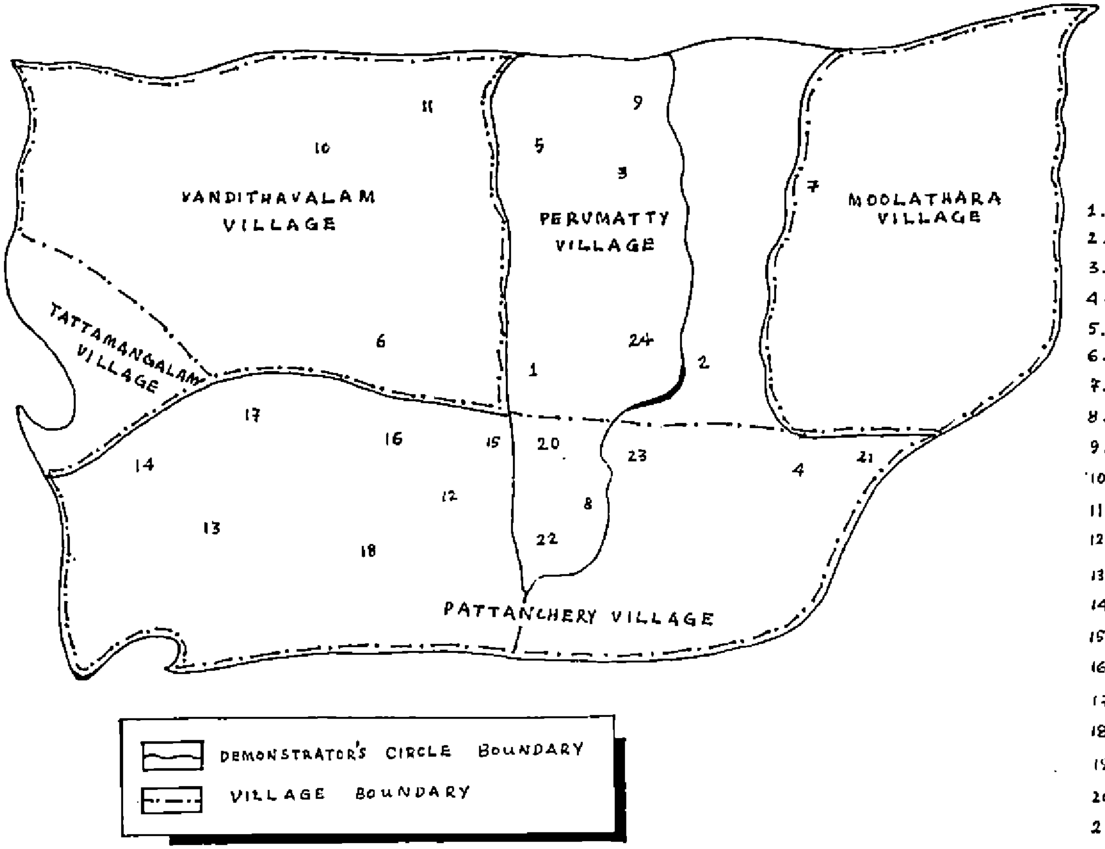
6.2 Physico-chemical properties of surface and sub-surface soil

Surface soils were clayey to sandy loam in texture with a pH ranging from 6.3 to 8.3 (Krishnakumar, 1978). Organic carbon ranged from 1.51 to 3.54 per cent. Soils were low to medium in available nitrogen and phosphorus but rich in available potassium. Among the exchangeable cations, calcium was found to be the most dominant. Sumam (1981) collected 38 samples each of surface and sub-surface soils and made similar observations regarding soil reaction and fertility status of surface soils. Average calcium content of the surface soils ranged from 0.11 to 0.96 per cent and exchangeable calcium ranged from 2.03 to 5.33 cmol (p^+) kg^{-1}. Sodium content of the surface soils ranged from 0.02 to 0.06 per cent and exchangeable sodium ranged from 0.33 to 0.62 cmol (p^+) kg^{-1}. Calcium dominated among the exchangeable cations, saturating about 20 per cent of the exchange complex whereas, average exchangeable sodium was 2.56 per cent (Table 6.2.1 a and b).

pH of the sub-surface soil was not found to vary much from surface soil samples. Organic carbon content of sub-surface soils were higher when compared to surface soils in some locations like Chittoor, Kuttipalam and Perumatti. Available nitrogen content of the sub-surface soils ranged from 0.012 to 0.016 per cent. Total as well as available phosphorus were found to be higher in the surface layers when compared to sub-surface layers. Soil of Valiyavallampathy showed maximum available phosphorus content in both surface and sub-surface layers (Table 6.2.2).

POONTHALPADOM SOIL

(Chittoor taluk ; Palakkad district)



1. KAITHARAVU
2. VEMBRA
3. MUTALAMTHODU
4. KANNIMARI
5. PUTHUSSERY
6. ORAVU.
7. PLACHIMADA.
8. KAVARATHODU
9. MALLANCHALLA
10. PARAKKALAM.
11. IRULAMPULLY.
12. CHENTHONY
13. MUTTUCHIRA
14. KARIPPALI
15. CHORAKODU
16. KOOTHUMADAM
17. CHENGAZHI
18. NAVUKODU
19. EDAYAMKOLAMBU
20. PAPPAMPALLAM
21. KUTTICKAL CHALLA
22. THUPPIALA CHALLA
23. NANNIODE
24. THARAKAN CHALLA.

Bijulal.

Table 6.2.1 (a) Properties of surface soil

	pH	EC dSm^{-1}	OC (%)	Total N (%)	Avail. N (%)	Total P_2O_5 (%)	Avail. P (ppm)	K (%)	Ca (%)	Mg (%)	Mn (%)	Na (%)
Chittoor	7.29	0.20	0.61	0.09	0.012	0.16	5.14	0.11	0.96	0.60	0.03	0.027
Kuttipalam	7.45	0.36	0.99	0.12	0.016	0.16	5.07	0.11	0.71	0.50	0.06	0.040
Thamarachira	6.17	0.16	1.20	0.15	0.015	0.11	6.00	0.12	0.32	0.44	0.04	0.026
Thekkedesam	6.92	0.22	0.93	0.13	0.013	0.15	5.57	0.12	0.45	0.35	0.03	0.024
Valiyavallampathy	6.89	0.13	1.98	0.15	0.012	0.20	11.8	0.08	0.11	0.15	0.03	0.018
Perumatty	7.06	0.20	0.85	0.18	0.012	0.16	4.0	0.10	0.17	0.24	0.02	0.037

Source: Sumam, 1981

Table 6.2.1 (b) Cation exchange capacity and exchangeable cations in surface soil samples

Location	K	Ca	Mg	Na	CEC
	←		cmol (P+) kg^{-1}		→
Chittoor	0.06	3.54	2.75	0.40	14.65
Kuttipalam	0.04	3.21	2.74	0.62	16.70
Thamarachira	0.05	5.33	3.41	0.41	19.82
Thekkedesam	0.03	3.10	2.93	0.44	17.92
Valiyavallampathy	0.03	2.03	1.92	0.33	14.17
Perumatty	0.02	2.83	2.54	0.53	22.50

Source: Sumam, 1981

Table 6.2.2 Properties of sub-surface soil

Location	pH	EC dSm^{-1}	OC (%)	Total N (%)	Avail. N (%)	Total P_2O_5 (%)	Avail. P (ppm)	K (%)	Ca (%)	Mg (%)	Mn (%)	Na (%)
Chittoor	7.28	0.14	0.73	0.12	0.009	0.13	4.42	0.11	0.83	0.52	0.04	0.03
Kuttipalam	7.51	0.18	1.23	0.12	0.015	0.12	4.14	0.10	0.59	0.44	0.04	0.05
Thamarachira	6.90	0.19	0.97	0.16	0.009	0.05	4.79	0.12	0.23	0.34	0.07	0.02
Thekkedesam	6.94	0.18	0.78	0.12	0.014	0.07	5.96	0.12	0.22	0.42	0.03	0.03
Valiyavallampathy	6.95	0.11	0.69	0.14	0.010	0.11	14.4	0.09	0.16	0.20	0.02	0.02
Perumatty	6.95	0.11	1.08	0.13	0.011	0.12	4.0	0.11	0.18	0.03	0.03	0.03

Source: Sunam, 1981

Surface soils are clayey to sandyloam in texture and are neutral to alkaline in reaction. pH of sub-surface soil is almost similar to that of surface soil. Available potassium status is high and among the exchangeable cations, Ca dominates.

6.3 Profile characteristics

6.3.1 Morphological properties

Profile descriptions of soil from six locations are given in Table 6.3.1.1. pH of all profiles except that of Kuttipalam of Chittoor taluk showed increasing trend with depth and was found to range from 6.7 to 8.4. Different horizons were uniformly grey to dark grey in colour and clay loam in texture. Ground water table was at the surface of the profile during most periods of the year (Krishnakumar, 1978).

Table 6.3.1.1 Characteristics of Poonthalpadom profiles

Profile No:	I	II	III
Date:	14.1.1978	13.1.1978	13.1.1978
Location:	Perumatty, 5 km south of Chittoor town, Palghat district.	Kuttipalam, 25 km from Palghat town on Pollachi route	Chittoor (Thamarachirra) 3km from Chittoor town
Topography :	Level to gently slopping	Level to gently sloppy land	Level and gently slopping
Drainage :	Imperfectly drained	Imperfectly drained	Imperfectly drained
Ground water table:	At surface during most periods of the year	At surface during most periods of the year	At surface during most periods of the year
Depth	**Description**		
0-30 cm	Dark grey (10 YR 4/1) when dry and very dark grey (10YR 3/1) when moist, loamy texture, coarse blocky structures, slightly sticky and plastic when wet, few fine roots, moderately slow permeability, pH 8.0, diffuse boundary, consistence hard when dry, firm when moist.	Dark greyish brown (10 YR 4/2) when dry, very dark grey (10 YR 3/1) when moist, clay loam texture, coarse blocky structure, hard when dry, firm when moist and sticky and plastic when wet plentiful fine roots, pH 7.7, gradual wavy boundary, moderately slow permeability.	Dark grey (10 YR 4/1) when dry very dark grey (10YR3/1) when moist, loamy texture, blocky structure, hard, firm, slightly sticky and slightly plastic, calcareous, pH 7.9, diffuse boundary, moderate permeability.
30-60 cm	Dark grey (10 YR 4/1) when dry and black (10 YR 2/1) when moist, silty loam texture, massive structure, firm, sticky and plastic, moderately slow permeability, pH 8.25, diffuse boundary.	Dark greyish brown (10 YR 4/2) when dry, dark brown (10 YR 3/3) when moist, clay loam texture, massive structure, compact, sticky and plastic when wet, roots absent, pH 6.8, gradual wavy boundary, slow permeability.	Dark greyish brown (10 YR 4/2) when dry very dark grey (10 YR 3/1) when moist, clay loam texture, massive structure, sticky and plastic, calcareous, pH 8.0, gradual wavy boundary, moderately slow permeability.
60-80 cm	Dark grey (10 YR 4/1) when dry, very dark grey (10 YR 3/1) when moist, loamy texture, massive structure, compact, wet sticky and plastic, very slow permeability, pH 8.25.	Grey (10 YR 5/1) when dry very dark grey (10 YR 3/1) when moist, clay loam texture, massive structure, slightly sticky and slightly plastic, pH 6.5, moderate permeability.	Dark grey (10 YR 4/1) when dry, very dark greyish brown (10 YR 3/2) when moist, clayey texture, massive structure, hard, firm, very sticky and very plastic, pH 8.4, slow permeability.

Table 6.3.1.1. Contd...

Profile No:	IV	V	VI
Date:	12.1.1978	11.1.1978	12.1.1978
Location:	Thekkedesam, 15 km from Chittoor town	Valiavallampathy, about 17 km from Chittoor town	Perumatty, 11 km from Chittoor town
Topography :	Level and gently slopping	Level to gently sloping	Level and gently slopping
Drainage :	Imperfectly drained	Imperfectly drained	Imperfectly drained
Ground water table:	At surface during most parts of the year	At surface during most periods of the year	At surface during most parts of the year
Depth	**Description**		
0-30 cm	Grey (10 YR 5/1) when dry very dark grey (10YR 3/1) when moist, clay loam texture, coarse blocky hard on dry firm on moist sticky, moderately permeable, pH 6.8, few fine roots present, calcium carbonate nodules.	Greyish brown (10YR5/2) when dry, very dark greyish brown (10 YR3/2) when moist, clay loam texture, coarse blocky structure, slightly hard, frim, slightly sticky and plastic, fine roots, calcium carbonate nodules present. pH 8.2, moderate permeability, gradual wavy boundary.	Very dark greyish brown (10 YR 3/2), when dry very dark brown when moist, texture, coarse sub angular blocky, hard, firm, slightly sticky and slightly plastic, pH 6.7, few fine roots present, moderately slow permeability.
30-60 cm	Dark grey (10 YR 4/1) when dry, dark grey (10 YR 3/1) when moist, clay loam texture, massive structure, sticky, firm and slightly plastic, pH 8.4, moderate permeability, few calcium carbonate nodules.	Dark greyish brown (10 YR 4/2) when dry, very dark greyish brown (10 YR 3/2) when moist, loamy texture, massive structure, slightly sticky and slightly plastic, moderately slow permeability, pH 8.4, boundary gradual.	Dark greyish brown (10 YR 4/2) when dry, very dark grey (10 YR 3/1) when moist, loamy texture, massive structure, slightly sticky and plastic, pH 7.1, slow permeability.
60-80 cm	Dark grey (10 YR 4/1) when dry, very dark greyish brown (10YR3/2) when moist, clayey in texture, massive structure, hard when dry and firm when wet, very sticky and plastic, pH 8.4,slow permeability.	Greyish brown (10YR5/2) when dry, very dark greyish brown (10 YR 3/2) when moist, clay loam texture, massive structure, sticky and plastic, pH 8.4, slow permeability.	Very dark greyish brown (10 YR 3/2) when dry, very dark brown (10 YR 2/2) when moist, loamy texture, massive structure, hard when dry and firm when wet, slightly sticky and plastic, pH 7.1, slow permeability.

6.3.2 Physico-chemical properties

Data on physical properties of the soil profiles are presented in Table 6.3.2.1. Texture of the different horizons of the profiles varied from sandy clay to clay. Organic carbon, total as well as available nitrogen were more in the surface layers of Chittoor, Kuttipalam, Thamarachira and Thekkedesam profiles,whereas in Valiyavallampathy and Perumatty profiles, total nitrogen was more concentrated in the lower layers (Table 6.3.2.2 a). Cation exchange capacity and exchangeable cations of soils at different depths are presented in Table 6.3.2.2 (b) and was found to range from 7.17 at 60-80 cm depth in Chittoor soil to 17.30 in the surface soil of Perumatty. Among the different soils, Chittoor soil was found to have minimum CEC, whereas Perumatty soil was found to have maximum. At all depths in different locations, calcium was found to be the most dominant exchangeable cation and potassium, the least dominant.

Table 6.3.2.1 Mechanical composition of profile samples

Location	Depth (cm)	Coarse sand (%)	Fine sand (%)	Silt (%)	Clay (%)	Textural class	soil reaction
Chittoor	0-30	48.30	15.93	14.07	20.00	Loam	8.0
	30-60	34.99	18.83	25.98	18.75	Silty loam	8.3
	60-80	56.33	13.25	10.36	18.75	Loam	8.3
Kuttipalam	0-30	48.50	18.07	7.78	23.75	Clay loam	7.7
	30-60	48.82	19.72	4.02	25.00	Clay loam	6.8
	60-80	54.05	22.82	5.35	16.25	Sandy loam	6.5
Thamarachira	0-30	47.21	15.00	13.39	21.70	Loam	7.9
	30-60	48.25	16.10	10.19	24.00	Clay loam	8.0
	60-80	49.00	20.00	8.64	21.00	Sandy loam	8.0
Thekkedesam	0-30	26.85	10.37	16.64	43.75	Clay	8.0
	30-60	39.95	20.46	14.02	23.75	Clay loam	8.4
	60-80	30.75	11.22	18.09	37.50	Clay	8.4
Valiyavallampathy	0-30	42.50	12.37	11.47	31.25	Clay loam	8.2
	30-60	51.10	10.36	17.90	18.75	Loam	8.4
	60-80	44.25	14.08	8.06	32.05	Clay loam	8.4
Perumatty	0-30	38.25	14.98	19.36	25.28	Loam	6.7
	30-60	46.15	15.80	16.86	19.15	Loam	7.1
	60-80	43.50	14.20	16.78	24.10	Loam	7.1

Source: Krishnakumar, 1978

Table 6.3.2.2 (a) Chemical properties of the profile

Locations	Depth (cm)	Organic carbon (%)	Total nitrogen (%)	Available nitrogen (%)	Carbon nitrogen ratio
Chittoor	0-30	1.01	0.04	0.005	28.40
	30-60	0.84	0.02	0.005	35.41
	60-80	0.76	0.01	0.004	59.27
Kuttipalam	0-30	1.12	0.06	0.005	17.67
	30-60	1.41	0.05	0.004	26.40
	60-80	0.89	0.03	0.004	34.09
Thamarachira	0-30	1.56	0.07	0.010	23.63
	30-60	0.85	0.06	0.009	14.07
	60-80	0.79	0.04	0.006	22.57
Thekkedesam	0-30	1.33	0.08	0.010	13.90
	30-60	1.05	0.04	0.007	17.27
	60-80	1.41	0.06	0.009	26.25
Valiyavallampathy	0-30	1.40	0.05	0.020	28.00
	30-60	1.10	0.09	0.016	12.70
	60-80	0.90	0.07	0.010	12.80
Perumatty	0-30	1.24	0.12	0.020	10.75
	30-60	1.53	0.11	0.020	13.50
	60-80	0.82	0.13	0.020	06.83

Source: Krishnakumar, 1978

Table 6.3.2.2 (b) Chemical properties of soil profiles (Cation exchange capacity and exchangeable cations)

Locations	Lab. No	Depth (cm)	Exchangeable cations (cmol(P^+) kg^{-1})				C.E.C. cmol (P^+kg^{-1})	Exchangeable Na (%)
			Ca	Mg	K	Na		
Chittoor	1	0-30	3.20	0.45	0.23	1.09	7.70	14.15
	2	30-60	4.00	0.75	0.10	0.70	7.80	8.90
	3	60-80	3.10	0.75	0.08	0.76	7.17	10.50
Kuttipalam	17	0-30	4.80	0.60	0.10	1.83	9.70	18.80
	18	30-60	4.00	0.50	0.12	1.13	8.30	9.70
	19	60-80	4.50	0.70	0.11	1.02	9.40	11.01
Thamarachira	21	0-30	6.00	0.80	0.08	0.73	10.50	6.90
	22	30-60	5.50	0.70	0.13	1.83	12.50	14.64
	23	60-80	5.60	0.70	0.15	1.13	12.50	9.04
Thekkedesam	37	0-30	9.21	2.00	2.00	0.20	1.74	13.60
	38	30-60	11.00	1.96	0.18	1.04	14.30	7.27
	39	60-80	6.05	0.80	0.28	1.02	11.50	8.80
Valiyavallampathy	49	0-30	11.60	0.80	0.24	1.00	13.65	7.32
	50	30-60	12.90	1.50	0.19	1.28	16.00	7.57
	51	60-80	12.10	2.30	0.19	1.26	15.50	8.12
Perumatty	61	0-30	9.40	1.60	0.19	0.96	17.30	5.50
	62	30-60	9.25	1.70	0.17	0.96	13.25	7.20
	63	60-80	4.98	1.20	0.20	0.78	9.10	8.57

Source: Krishnakumar, 1978

Ammonium, phosphorus and potassium fixing capacities of these soils were found to range from 1.12 to 7.24 cmol (p^+) kg^{-1} soil, 22 to 70 per cent and 1.04 to 7.93 cmol (p^+) kg^{-1} soil respectively (Sumam, 1981).

High water table due to seepage from canals and rivers and consequent slushy nature of soil during major part of the year is the main problem of Poonthalpadom soil. High exchangeable sodium percentage coupled with high water table resulted in poor physical condition. Productivity of these soils can be increased by improving the hydrological properties of soils by installing proper drainage systems.

FUTURE LINE OF WORK

Lime requirement being very high in Kari land, liming to bring the pH to the desired level is not economical. Standardising the time and method of application for arriving at the economic dose of lime has to be prioritised. Rather than incorporating heavy dose as basal, it may be economical to broadcast small doses of lime at intervals to mitigate the deleterious effects of acidity in the surface soil.

Application of more than 600 kg lime ha^{-1} in Karappadom lands and more than 1000 kg lime ha^{-1} in Pokkali lands are found to reduce grain yield of rice. Detailed investigations are warranted to assess the reasons for this low productivity.

Kari lands, being deficient in copper and zinc, optimum concentrations of these micronutrients for seed treatment and foliar application for rice have to be determined.

So also appropriate doses and time of foliar application of copper and zinc needs further research in Kayal lands for coconut.

Rockphosphate serve as an efficient source of phosphorus in Karappadom lands. Optimum levels of various locally available rockphosphates viz. Mussorie rockphosphate, Rajasthan rockphosphate etc. should be fixed for rice in comparison to superphosphate.

The dose of ammonium phosphate for foliar application for rice in Pokkali lands need standardisation.

Varietal screening for different physiological diseases prevalent in problem soil is another field that demand more research, since reclammation of these lands is not economical.

Economic doses of nitrogen, phosphorus and potash for the most popular high yielding varieties of each locality have to be assessed since nutrient requirement vary with varieties as well as soil type.

REFERENCES

Aiyer, R.S., Rajagopal, C.K. and Money, N.S. (1975). Available zinc, copper, boron and manganese status of the acid rice soils of Kuttanad. *Agric. Res, J. Kerala* 13(1): 15-19.

Amma, P.A, Aiyer., R.S. and Subramoney, N. (1966). Occurrence of blue green algae in the acid soils of Kerala. *Agric. Res. J. Kerala* 4(2): 141-143.

Annual Report (1966). CMA scheme, College of Agriculture, Vellayani.

Annual Research Report (1983-87) Published by the Directorate of Extension, Kerala Agricultural University.

Annual Research Report (1989-92). AICRIP on Agricultural Drainage, Karumady.

Brito Muthunayagam, A.P.A. and Koshy, M.M. (1961). Chemical nature and distribution of phosphorus in soils of Travancore - Cochin. *Bull. Cent. Res. Inst. Univ. Travancore* 2(1) A: 63-76.

Brito Muthunayagam, A.P.A. and Nambiar, P.S.N. (1948). Base exchange studies in Travancore rice soils. *Trav. Univ. Dept. Res. Bull:* 153-154.

Gopalaswamy, V. (1958). Studies on the fertility status of some peaty, marshy and swampy soils. M.Sc. (Ag.) thesis, Kerala Agricultural University.

Gopalaswamy, V. (1961). Studies on the soils of Kuttanad. The nature of clay minerals present. *Agric. Res. J. Kerala* 1(1):65-69.

Gopalaswamy, V. and Raychaudhari, S.P. (1969). Studies on the physical properties of some peaty soils of Kerala. *Indian J. agric. Chem.* 2(1): 1-5.

Gopalaswamy, V. and Raychaudhari, S.P. (1971). The qualitative mineralogical investigation on the fine sand fractions of some peaty, marshy and swampy soils. *Indian J. agric. Chem.* 4(1): 9-12.

Gopinath, V. (1973). Distribution of copper and zinc in the acid peat (Kari) soils of Kerala. M.Sc. (Ag.) thesis, Kerala Agricultural University.

Hameed, A. (1975). Fertility investigations on the Kole soils of Kerala. M.Sc. (Ag.) thesis, Kerala Agricultural University.

Iyer, K.R.C.N. (1928). *Dept. Agr. Travancore Bull.* 123, 126 and 130.

Jacob, C.I. (1966). Sulphur status of Kerala soils. M.Sc. (Ag.) thesis, Kerala Agricultural University.

Kabeerathumma, S. and Money, N.S. (1974). Effect of liming on available nutrients and yield of paddy in the acid soils of Kuttanad. *Agric. Res. J. Kerala* **12**(2): 190-193.

Kabeerathumma, S. and Patnaik, S. (1978). Effect of submergence on the availability of toxic and deficient nutrients in acid sulphate soils of Kerala. *Agric. Res. J. Kerala.* **16**(2): 181-187.

Koshy, M.M. (1970). The chemical nature of organic complexes in Kerala soils. *Curr. Sci.* **39**(15): 353-354.

Koshy, M.M. (1970). A comparative study of the different groups of organic compounds in plants and soil. *J. Kir. Acad. Biol.* **2**(2): 32-38.

Krishnakumar, A.K. (1978). Study of the physico-chemical characteristics of the Poonthalpadom soils of Kerala. M.Sc. (Ag) thesis, Kerala Agricultural University.

Kurup, T.K.B. (1967). Fertility investigations on rice soils of Kuttanad. M.Sc. (Ag) thesis, University of Kerala.

Kurup, T.K.B. and Aiyer, R.S. (1973). Seasonal variations in soil reaction and soluble salt content of Kuttanad rice soils. *Agric. Res. J. Kerala* **11**(1): 57-60.

Kuruvila, V.O.(1974). Chemistry of low productive acid sulphate soils of Kerala and their amelioration for growing rice. Ph.D. thesis, Orissa University of Agriculture and Technology.

Kuruvila, V.O. and Patnaik, S. 1973. Problems of acid sulphate soils of Kerala and their amelioration. Acid sulphate soil symposium held at Trivandrum.

Money, N.S. (1950). A new species of Azotobacter isolated from the acid peats (Kari) of Travancore. *Bull. Cent. Res. Inst., Univ. Travancore.* **2**A: 1-16.

Money, N.S. (1951). Fertility investigations on the acid peats (Kari) of Travancore. *Bull. Cent. Res. Inst., Univ. Travancore.* **2A**: 1-16.

Money, N.S. (1961). Studies on the soils of Kuttanad. Microbial nitrogen transformations in acid peat soils of Kuttanad. *Agric. Res. J. Kerala* **1**(1): 59-64.

Money, N.S. and Sukumaran, K.M. (1973). Chemical, microbiological and agronomic aspects of the acid saline waterlogged soils of Kerala. *Tech. Bull. 1.* Directorate of Extension Education, KAU.

Menon, P.K.G. (1975). Morphological and physico-chemical properties of the Kayal soils of Kuttanad, Kerala State. M.Sc. (Ag.) thesis, Kerala Agricultural University.

Nair, P.K. (1966). Status of available silica in the rice soils of Kerala state. M.Sc. (Ag) thesis, Kerala University.

Nair, C.K.N. and Iyer, S.N. (1948). Studies on Kari soils. *Univ.Trav. Dept. Res. Rep.* pp 148-150.

Nair, P.G. and Money, N.S. (1968). Studies on some chemical and mechanical properties of salt affected rice soils of Kerala. *Agric. Res. J. Kerala* **10**(1): 51-53.

Namboodiri, K.N. (1980). Studies on the effect of varying levels of zinc on growth and yield of rice. M.Sc. (Ag.) thesis, Kerala Agricultural University.

Pillai, K.P. (1928). Dept. of Agr. Travancore Bull. 9.

Pillai, S.V. (1964). Physico-chemical and microbiological studies of some Kari soils of Kerala. M.Sc. (Ag.) thesis, Kerala Agricultural University.

Pillai, T.R.N. and Subramaniyan, V. (1931). The origin and nature of the peaty soils of Travancore. *J. Indian Inst. Sci.* **14**: 99-117.

Praseedom, R. (1970). Distribution of copper and zinc in the soils of Kerala. M.Sc. (Ag.) thesis, Kerala Agricultural University.

Praseedom, R. and Koshy, M.M. (1975). Zinc status of Kerala soils. *Agric. Res. J. Kerala.* **13**(1): 1-4.

Rajendran, P. (1981). Manganese and zinc status of rice soils of Kerala. M.Sc. (Ag.) thesis, Kerala Agricultual University.

Samikutty, V. (1977). Investigations on the salinity problems of Pokkali and Kaipad areas of Kerala state. M.Sc. (Ag.) thesis, Kerala Agricultural University.

Santhakumari, G. (1975). Morphological and physico-chemical properties of Karappadom soils of Kuttanad region of Kerala state. M.Sc. (Ag.) thesis, Kerala Agricultural University.

Sheela, S. (1988). Distribution, fixation and availability of phosphorus in the Kole soil of Kerala. M.Sc. (Ag.) thesis, Kerala Agricultural University.

Soils of Kerala (1978). Bulletin published by Soil Survey Branch, Department of Agriculture.

Sreedevi, S., Varghese Thomas and Aiyer, R.S. (1975). Potassium status of the major rice soils of Kerala state in relation to their granulometric composition. *Agric. Res. J. Kerala* 13(1): 5-8.

Subramoney, N. (1958). Chemical and mineralogical studies on the acid peats of Kerala. Ph.D. thesis, University of Travancore.

Sudhansu, K., Ghosh, D.K., Das and D.L. Deb (1973). Minerological characterization of Kari soils from Kerala. Acid sulphate and other acid soils of India. Conducted in Kerala Agricultural University, Trivandrum, Kerala.

Sumam George (1981). Fertility investigations in the Poonthalpadom soils of Kerala. M.Sc. (Ag.) thesis, Kerala Agricultural University.

Varghese, M.P. (1973). Studies on the lime potential and aluminium hydroxide potential of the acid soils of Kerala state. M.Sc. (Ag.) thesis, Kerala Agricultural University.

Varghese T. and Aiyer, R.S. (1973). Influence of geomorphological and climatic factors on the soil formation of Kerala. *Geological survey of India,* 5: 69-71.

Varghese, T., Thampi, P.S. and Money, N.S. (1970). Some preliminary studies on the Pokkali saline soils of Kerala. *J. Indian Soc. Soil Sci.* 18: 65-70.

ANNEXURE

1. Krishithottam Thottappally
2. Puthenkari
3. Illichira G Block
4. Mundar IV Block
5. Mundar VI Block
6. Kothuputhenkari, Purakkad
7. Purakkad kari
8. Irandachira, Thottappally
9. Vanamkari
10. Kavilbhagom Munnor Purakkad
11. Valiyathuruthu Karumady
12. Ullala kari