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**GPS and GIS based Model Soil Fertility Maps for Precise Fertilizer
Recommendations to the Farmers of Kerala**



**AICRP on STCR
Indian Institute of Soil Science
Nabibagh, Berasia Road, Bhopal-462038**



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**Kerala Agricultural University
College of Horticulture
Department of Soil Science and Agricultural Chemistry
Vellanikkara Thrissur – 680 656, Kerala
2014**

GPS and GIS based Model Soil Fertility Maps for Precise Fertilizer Recommendations to the Farmers of Kerala

Betty Bastin, Beena, V. I., Sreelatha, A.K. and Pradip Dey

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**Dedicated to the fond memory of our
beloved Professor, Dr. M.A. Hassan**



KERALA AGRICULTURAL UNIVERSITY

Main Campus, Vellanikkara, Thrissur-680656

Prof. (Dr.).P.Rajendran
Vice Chancellor

Foreword

In Kerala, which is blessed with a high degree of spatial variability, soil test – based fertility management is the need of the hour. However, a more precise, micro-level understanding of this variability as a viable decision support system for more effective nutrient management will enable us to achieve food and nutritional security without compromising sustainability. With the growing recognition for “precision agriculture” practices, geo-referenced soil fertility maps that will enable site-specific nutrient applications have come to stay.

This technical bulletin presents the results from the project “GPS and GIS based Model Soil Fertility Maps for selected districts for precise Fertilizer Recommendations to the farmers of India” during the period 2010-2013 conducted for Kerala state by AICRP on STCR. The spatial distribution of different soil nutrients and soil chemical characteristics such as soil pH, EC, organic C and available nutrients including micronutrients for the nine districts of our state, are presented in different chapters. The soil fertility maps use data based on geographical information system (GIS).

The Government of Kerala is actively elaborating and upgrading the services of soil testing laboratories over the last few years. The researchers and the soil testing personnel have to get acquainted with the latest technologies followed in soil testing. The information generated from soil testing should not be used in isolation, but linked to other sources of spatial data such as soil maps, crop yield maps and topographic maps to assist in farm planning and decision making. The information generated can be transferred to farmers through the state department of agriculture to address specific issues related to nutrient deficiencies, excesses and soil test based agrotechnology transfer.

I appreciate the efforts of Dr. Betty Bastin and her team for bringing out this excellent publication on soil testing and fertilizer recommendation. The geo-referenced data base related to nutrient status and the recommendations formulated will be highly useful to the farming community as a whole and to all soil professionals in particular. I hope this publication will further serve as a guide to strengthen and improve the soil nutrient management programmes in Keralam.

Dr. P. Rajendran
Vice Chancellor

Fax No. : 91-487-2370019 Phone : 91-487-2371302 (Off.)
E-mail : dr@kau.in 0487-2371917 (Res.)
drtrgk@gmail.com (personal) 9446071917 (Mob)



KERALA AGRICULTURAL UNIVERSITY

DIRECTORATE OF RESEARCH

Dr. T.R. GOPALAKRISHNAN, Ph.D, FISVS
Director of Research

Main Campus, Vellanikkara
KAU (P.O.)-680 656, Thrissur-Kerala

Preface

Agricultural production is the driving force for the development of our country. Sustainable agricultural production and food security are ensured by promoting natural resource management. Thus, the need of the hour is to maintain soil fertility at a level high enough for sustained food production. In this context, a comprehensive research programme involving the assessment of soil health of different districts of Kerala using modern decision support tools like GPS-GIS and formulating district wise nutrient recommendations is highly relevant.

The technical bulletin on "GPS and GIS based model soil fertility maps for precise fertilizer recommendations to the farmers of Kerala" is the outcome of the systematic analyses and compilation of results of physicochemical characterisation of soils collected from farmers' holdings in the nine selected districts of the state. Preliminary surveys (village and farmer oriented) were conducted to generate data on resource base, crops cultivated and fertilizer use adopted by farmers. Farmers were identified from three categories viz., small, medium and large based on the size of land holdings and geo referenced soil samples were collected from their fields.

The bulletin elaborately describes taluk wise and district wise fertility status with respect to pH, EC, organic carbon, and major, secondary and micronutrients in soil. In addition, the nine chapters also vividly present the soil fertility status through soil fertility maps followed by the recommendations to be adopted including training requirements of farmers.

The GIS-GPS project team attached to the AICRP on STCR in the Department of Soil Science and Agricultural Chemistry has done a commendable service. I am sure that the research outcome published as a bulletin will be a valuable asset to the farming community, officers of the Department of Agriculture, researchers, students, administrators and policy makers.

Dr. T.R. Gopalakrishnan
Director of Research

Acknowledgement

It gives us immense pleasure to acknowledge our deep sense of gratitude and indebtedness to our Honourable Vice Chancellor, Dr. P. Rajendran, Kerala Agricultural University for the inspiration instilled in us and for providing guidance and facilities for effectively carrying out the research activities.

We are thankful to Department of Agriculture and Cooperation and Indian Council of Agricultural Research for providing financial and technical support for the conduct of the research work.

We wish to express our profound gratitude to Dr. T.R. Gopalakrishnan, Director of Research, Kerala Agricultural University for the keen interest and support extended to us during the project period.

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We acknowledge our sincere gratitude to Dr. Koshy Abraham, Associate Dean, College of Horticulture, Dr. P.K. Valsalakumari and Dr. C.T. Abraham Former Associate Deans for their constant encouragement, support and guidance.

The sincere efforts and unfailing encouragement offered to us by late Dr. M.A. Hassan, Former Principal Investigator, AICRP on STCR from the inception of the project and through out the project period had contributed much to the successful completion of the project. We gratefully remember him and acknowledge his valuable services.

We are quite indebted to Dr. P.K. Sushama, Professor and Head, Department of Soil Science and Agricultural Chemistry for her whole hearted support. The good will and help extended to us by all the staff members of the department of Soil Science and Agricultural Chemistry is gratefully remembered.

We express our sincere gratitude to Dr. Sujatha M.P. Head, Soil Science Division, Kerala Forest Research Institute for the valuable assistance extended to us.

With great pleasure, we acknowledge the cooperation and assistance received from the Principal Agricultural Officers, Assistant Directors of Agriculture, Agricultural Officers and Assistants of different districts throughout the implementation of the programme. Our heartfelt gratitude goes with the farmers who had sincerely cooperated with our efforts.

We extend our sincere thanks to all the staff members of the AICRP on STCR and Research fellows and Skilled assistant of GPS – GIS project. Our gratefulness and obligation go without any reservation to all individuals who had co-operated for the successful completion of this project.

Authors

Abbreviations

Abbreviations	Expansions
AEZ	: Agro ecological zone
AEU	: Agro ecological unit
AICRP	: All India Coordinated Research Project
ATMA	: Agriculture Technology Management Agency
DAC	: Department of Agriculture and Cooperation
DTPA	: Diethylene triamine penta acetic acid
EC	: Electrical conductivity
FYM	: Farm yard manure
GIS	: Geographic information system
GPS	: Global positioning system
GRD	: General recommendations of KAU
ha	: Hectare
ICAR	: Indian Council of Agricultural Research
IISS	: Indian Institute of Soil Science
IPNS	: Integrated Plant Nutrition System
KAU	: Kerala Agricultural University
MOP	: Muriate of potash
NGO	: Non-governmental organization
NIV	: Nutrient index value
OC	: Organic carbon
SOP	: Sulfate of potash
SSP	: Single super phosphate
STCR	: Soil test crop response
STL	: Soil testing laboratory
VAM	: Vesicular arbuscular mycorrhiza

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Chapter 1

1.1 Introduction

The soil test data generated by the soil test laboratories have not been systematically consolidated so far. Collection of soil samples was not geo-referenced. Data base on the status of primary, secondary and micronutrients of the farmers' fields are also not available. So, in order to collect precise and reliable agricultural information as well as to develop a nutrient recommendation system on the basis of geo referenced map of soil nutrient status, this project was started. Most of the farmers are not applying fertilizers to the crops as per soil tests due to lack of confidence. Hence, there is every necessity to develop the confidence in them about soil testing. Moreover, there is a need to cross check these prepared maps through generating actual soil test databased on systematic and scientific soil sampling.

1.2 Objectives

The main objectives of the project are the following

1. To develop database related to soils, organic manures, crops and cropping systems and primary, secondary and micronutrient fertility status.
2. To prepare soil fertility maps using GIS for N, P, K, S, Fe, Mn, Cu, Zn and B.
3. To interlink the soil fertility status with soil test crop response data and to generate site-specific IPNS recommendations.
4. Validation of geo referenced fertility maps and their refinement for farmer friendly fertilizer recommendations.
5. To prepare policy guidelines for the planners, administrators for allocation, distribution of all required plant nutrients carriers for improved nutrient use efficiency, which helps in larger savings of the economy of the country.
6. Transfer of generated technology to the farmers through government agencies and non-governmental agencies (NGOs).

1.3 Methodology

It will not be possible to collect and analyse soil samples from every field of farmer in each village for preparation of soil fertility map. The best alternative approach for the preparation of reliable soil fertility map is the use of systematic sampling methodology in collecting soil samples. Hence, to prepare soil fertility map of India, random sampling (villages are selected as locations of sampling) was carried out in selected districts of Kerala state with specific cropping systems.

Global positioning system (GPS) was used to identify the actual locations (latitude, longitude and altitude data) of samples collected for the work.

Using stratified random sampling method, Indian Institute of Soil Science (IISS), Bhopal has selected villages from different taluks of selected districts of State (9 districts). In connection with the above-mentioned objectives, survey works were started and the Principal Agricultural Officers of the concerned districts (9) and Agricultural Officers of the respective villages were contacted. Details regarding the villages including total geographical area, cultivated area, irrigated area, rainfed area etc were collected as per the proforma (Appendix IV) obtained from IISS, Bhopal. A detailed survey of soil types in the village, major crops and cropping systems, types of fertilizers used by the farmers, and per cent of area under each cropping system was also carried out as per the proforma provided.

Soil samples were taken from six selected farmers from each village by following the random sampling procedure as directed. The location of sampling was geo referenced using GPS. The depth of sampling was 15 cm. The farmers were classified into the following categories and from each group two farmers were selected.

1. Large - Farmers with land area more than 2 acres
2. Medium - Farmers with land area between 1 and 2 acres
3. Small - Farmers with land area less than 1 acre

Details collected from the farmers included the name of the crop, cultivated area, type of soil, type of fertilizer and type of irrigation as per the proforma (Appendix V). Soil samples collected from different locations were processed and analysed for pH, electrical conductivity, organic carbon, available nitrogen, phosphorus, potassium, sulphur, zinc, copper, iron, manganese and boron. The analytical data of soils for these parameters were processed and range, mean, number of samples and per cent samples falling under different categories were found out. The samples were then classified based on the nutrient index value into different fertility groups. Soil fertility map for each parameter was prepared by using GPS values of sampling points and GIS software.

The data generated can be used to know the fertility status of the farmers' fields even at the block level. The results of the study can provide the information of soil fertility status and suitable integrated nutrient fertilizer recommendation based on the desired target yields and available resources of the farmers even at the block level of each districts.

1.4 General information of Kerala

Kerala state stretches as a narrow belt along the south eastern portion of India and is guarded by the Western Ghats in the east and the Lakshadweep Sea in the west. Kerala lies between 8°8' to 12°48' N latitude and 74°52' to 77°22' E longitude. The geographical area of Kerala is 38863 sq. km accounting to 1.18 per cent of India's total areas supporting 3.4 per cent of the national population. Kerala is bounded by the state of Karnataka on the north and north east, Tamil Nadu on the east and the Arabian Sea on the west. Administratively, the state is divided into 14 districts, 63 taluks and has 1452 revenue villages.

Kerala State has been divided into five agro-ecological zones and twenty three agro-ecological units and ninety eight agro-ecological subunits based primarily on climate, geomorphology, land use and soil variability (Fig. 1). The agro ecological zones (AEZ) are coastal plains (AEZ I), midland laterites (AEZ II), foothills (AEZ III), high hills (AEZ IV and Palakkad plains (AEZ V).

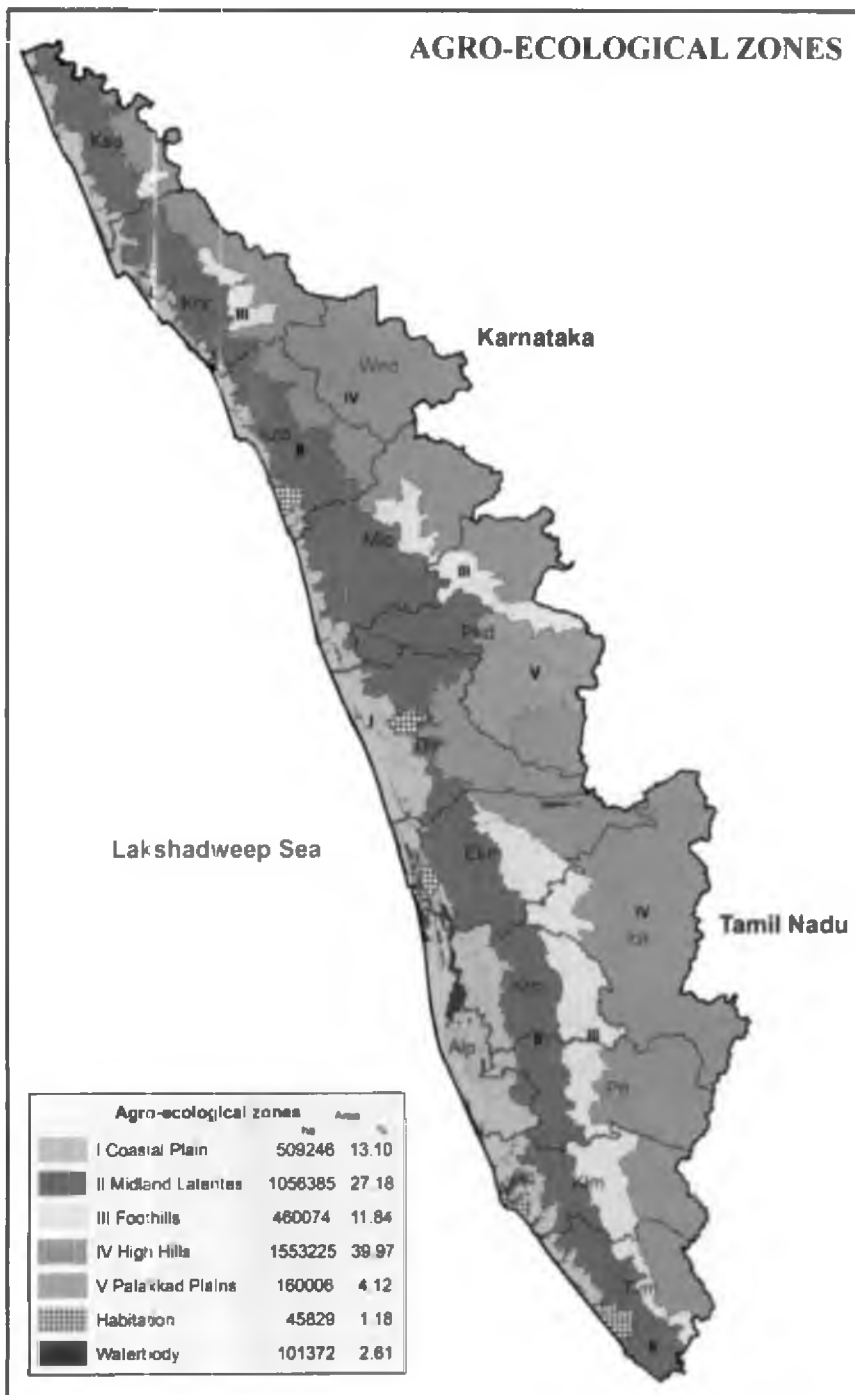
Under the project entitled, "Preparation of GPS-GIS based soil fertility maps for selected districts of the country", nine districts have been identified viz., Kannur, Wayanad, Kozhikode, Malappuram, Palakkad, Thrissur, Ernakulam, Alappuzha and Thiruvananthapuram. The districts Kannur, Malappuram, Ernakulam and Trivandrum comes under agro ecological zones I, II, III and IV; Kozhikode and Thrissur districts come under AEZ I,II and IV; Alappuzha district comes under AEZ I and II; Palakkad district comes under AEZ II, III, IV and V. The whole area of Wayanad district comes under the AEZ IV (High hills). Majority of the area under these five zones are acidic and about 60 %per cent of soils are laterites and lateritic. The main soil orders of the state are Ultisols, Inceptisols, Entisols, Alfisols and Mollisols.

Predominant cropping system prevailing in all the above districts is rice based. The pattern of cropping systems adopted by the farmers are rice – rice, rice – rice – fallow, rice – rice – rice and rice – rice – vegetables. Plantation crops like rubber, coconut, arecanut, pepper, cardamom, coffee, tea, cocoa, cashew and spices like ginger, turmeric, nutmeg etc. are grown in the different agro ecological regions of the state.

Tuber crops like cassava, sweet potato, yam and colocasia are cultivated both as food crops and vegetables. Fruit crops like banana and pineapple are also cultivated in large scale depending on soil type and climate. Sugar cane is cultivated only in a few districts. Tree crops like mango and jack are widely grown throughout the different districts.

Organic sources of nutrients like farm yard manure, poultry manure, wood ash, coir pith, vermi compost and green manures like glyricidia and daincha are also used by farmers in addition to lime and fertilizers. Farmers depend on canals, wells and tube wells for irrigation.

Fig. 1 Agro-ecological map of Kerala state



Chapter 2

Soil fertility status of Kannur

Kannur, with a sandy coastal area lies between latitudes 11° 40' to 12° 18' north and longitudes 75° 10' to 75° 57' east and elevation of 1.02 metres above msl. The district is bound by the Western Ghats in the east (Coorg district of Karnataka State), Kozhikode and Wayanad districts in the south, Lakshadweep sea in the west and Kasaragod in the north. The district can be divided into three geographical regions ie. highlands, midlands and lowlands. The highland region comprises mainly of mountains. This is the area of major plantations like coffee, rubber and tea. Timber trees like teak, rosewood, etc are grown in plenty in this region. The midland region, lying between the mountains and the low lands, is made up of undulating hills and valleys. The lowland is comparatively narrow and comprises of rivers, deltas and seashore. This is a region of coconut and paddy cultivation. The agro-ecological zones of the district are depicted in Fig.2. The main crops cultivated in Kannur district are banana, pepper and plantation crops like coconut and arecanut (Table1).

Table 1. Major crops, fertilizers, organic nutrient sources and sources of irrigation in Kannur

Crops	Chemical fertilizers	Organic sources	Sources of irrigation
Banana	Urea	Cow dung	Wells
Pepper	Factomphos	Green leaves	
Coconut	MOP	Neem cake	
Arecanut		Groundnut cake	
Rubber		Bone meal	
Cashew		Wood ash	
Cocoa			

The district is divided into three taluks (tehsils) namely Thaliparambu, Kannur and Thalassery. A total of 16 villages were selected based on stratified multistage random sampling method covering all the three taluks and a total of 96 surface soil samples (six from each village) were collected using GPS representing small, medium and large farmer category (Tables 2 and 3). The samples were processed and were analysed for 12 chemical parameters viz., pH, electrical conductivity, organic carbon, available nitrogen, phosphorus, potassium, sulphur, zinc, copper, iron, manganese and boron.

Fig. 2 Agro ecological map of Kannur

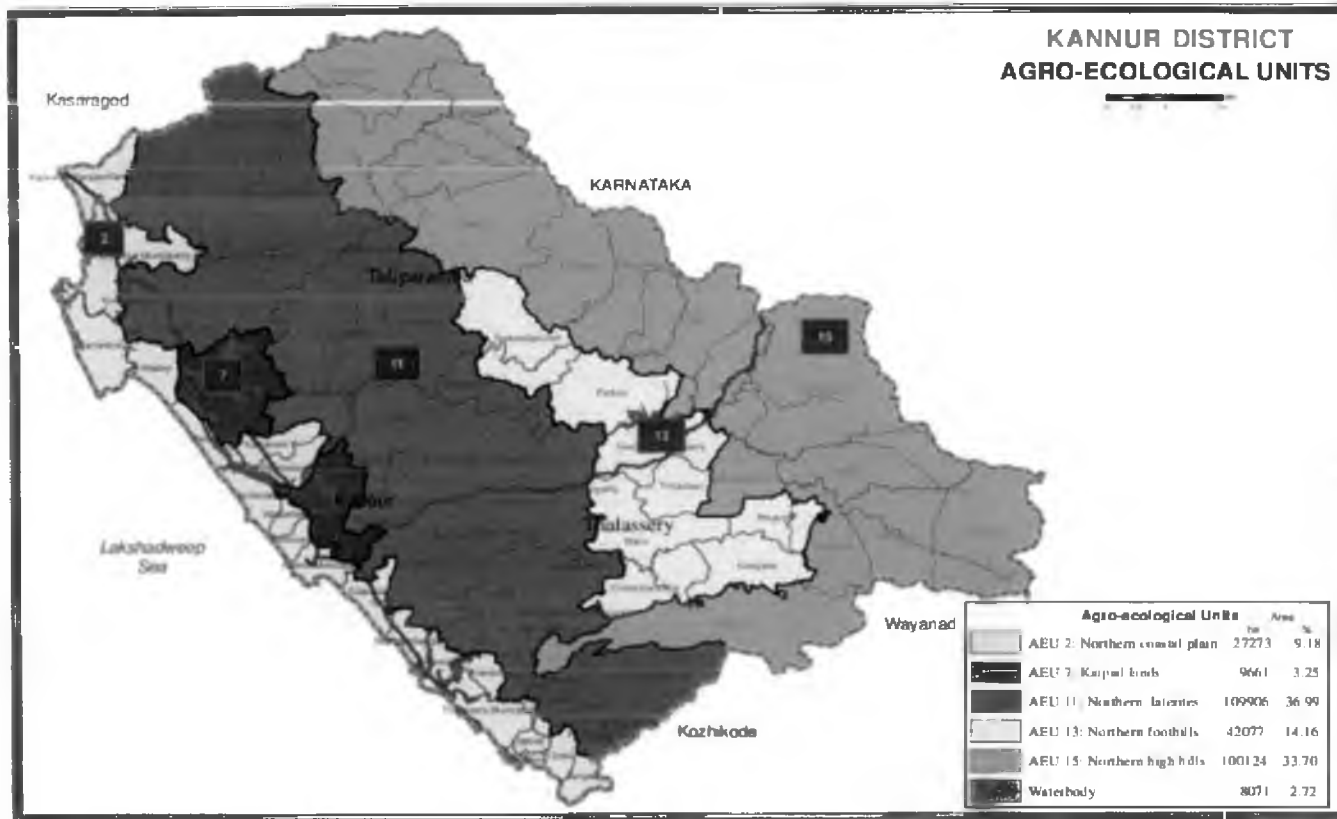


Table 2. Number of villages selected in different taluks of Kannur

Sl. No.	Name of taluk	Number of villages selected
1	Thaliparambu	9
2	Kannur	2
3	Thalassery	5

Table 3. Selected villages in different taluks of Kannur

Thaliparambu	Kannur	Thalassery
Peralam	Kunjimagalam	Chavassery
Thimiri	Cherukunnu	Koodaly
Kurumathur		Shivapuram
Vellad		Muzhakunnu
Keezhallur		Kannavam
Irikkur		
Chelery		
Maniyoor, Padiyoor		

Soil fertility status

The results of soil analysis are listed in the following tables. The soil fertility maps generated from the analytical data are presented in figures, 3 to 14. These fertility maps reveal the per cent area under different categories with respect to each parameter in the total geographic area of 2,966 sq. km in the Kannur district.

2.1 pH and electrical conductivity

The pH of the surface soil ranged from 4.60 to 7.50. It was observed that 93.21, 5.06 and 1.73 per cent of the samples analysed were acidic, neutral and alkaline respectively. In the taluks of Thaliparambu, Thalassery, and Kannur, 96.30, 83.33 and 100 per cent were found to be acidic respectively.

Table 4. Status of pH in different taluks of Kannur

Sl. No	Taluks	No. of samples	Range	Mean	Per cent sample category		
					Acidic	Neutral	Alkaline
1	Thaliparambu	54	4.60-7.50	5.58	96.30	1.85	1.85
2	Thalassery	30	5.20-7.50	5.90	83.33	13.34	3.33
3	Kannur	12	5.20-6.20	5.73	100.00	0.00	0.00
# Range /Mean		96	4.60-7.50	5.74	93.21	5.06	1.73

Over all Range/Mean

The electrical conductivity of the soil ranged from 0.02 to 0.93 dS m⁻¹ with a mean of 0.14 dS m⁻¹.

Table 5. Status of EC (dS m⁻¹) in different taluks of Kannur

Sl. No.	Taluks	Range	Mean
1	Thaliparambu	0.02 - 0.93	0.18
2	Thalassery	0.04 - 0.77	0.17
3	Kannur	0.02 - 0.15	0.06
# Range/Mean		0.02 - 0.93	0.14

2.2 Organic carbon

The organic carbon status of the soil ranged from 0.23 to 3.53 per cent with a mean value of 0.95 per cent. Thaliparambu taluk recorded the highest mean organic carbon content of 1.41 per cent followed by Thalassery taluk (0.97 per cent). The per cent of soils coming under low, medium and high categories were 26.98, 60.80 and 12.22 respectively.

Table 6. Status of organic carbon (per cent) in different taluks of Kannur

Sl. No.	Taluks	No. of samples	Range	Mean	Per cent sample category			NIV	Fertility rating
					Low	Medium	High		
1	Thaliparambu	54	0.23 - 3.53	1.41	9.26	57.40	33.34	2.26	Medium
2	Thalassery	30	0.43 - 1.53	0.97	13.34	83.33	3.33	3.60	High
3	Kannur	12	0.24 - 0.67	0.47	58.33	41.67	0.00	1.42	Medium
# Range/Mean		96	0.23 - 3.53	0.95	26.98	60.80	12.22	2.42	High

2.3 Available nitrogen

The available N status in the surface soils ranged from 151.12 to 1090.07 kg ha⁻¹ with mean value of 521.38 kg ha⁻¹. The per cent samples under low, medium and high categories were 17.90, 41.73 and 40.37 respectively. Among the three taluks, Thaliparambu recorded the highest (61.11) per cent of samples under high available N; the highest per cent of samples under low available N was observed in Kannur (50 per cent). The mean value of nutrient index for available nitrogen was 2.25. The fertility rating was medium for available nitrogen.

Table 7. Status of available nitrogen (kg ha^{-1}) in different taluks of Kannur

Sl. No	Taluks	No. of samples	Range	Mean	Per cent sample category			NIV	Fertility rating
					Low	Medium	High		
1	Thaliparambu	54	185.53-1090.07	638.92	3.70	35.19	61.11	2.57	High
2	Thalassery	30	375.38-984.00	634.95	0.00	40.00	60.00	2.70	High
3	Kannur	12	151.12-445.94	290.28	50.00	50.00	0.00	1.50	Medium
# Range/Mean		96	151.12-1090.07	521.38	17.90	41.73	40.37	2.25	Medium

2.4 Available phosphorus

The available Bray-P content ranged from 3.95 to 311.35 kg ha^{-1} with a mean value of 71.50 kg ha^{-1} . The per cent of soils under low, medium and high categories were 1.85, 22.72 and 75.43 respectively. Among the three taluks, Kannur recorded the highest per cent of samples under high available P (100 per cent); the highest per cent of samples under low available P was observed in Thaliparambu taluk (5.55 per cent). The mean value of nutrient index for available phosphorus was 2.71. The fertility rating for available phosphorus was high.

Table 8. Status of available phosphorus (kg ha^{-1}) in different taluks of Kannur

Sl. No.	Taluks	No. of samples	Range	Mean	Per cent sample category			NIV	Fertility rating
					Low	Medium	High		
1	Thaliparambu	54	3.95 – 311.35	50.77	5.55	31.49	62.96	2.57	High
2	Thalassery	30	12.92 – 103.34	36.02	0.00	36.67	63.33	2.57	High
3	Kannur	12	42.16 – 241.13	127.70	0.00	0.00	100.00	3.00	High
# Range/Mean		96	3.95 – 311.35	71.50	1.85	22.72	75.43	2.71	High

2.5 Available potassium

The available K status in surface soils of different taluks ranged from 56.00 to 924.00 kg ha^{-1} . Considering the mean values, the highest value of 273.52 kg ha^{-1} was recorded in Thaliparambu taluk; the lowest mean value of 114.33 kg ha^{-1} in Kannur taluk. The per cent of samples under low, medium and high categories were 35.24, 39.57 and 25.19 respectively. The mean value of nutrient index for available K was 1.90. The fertility rating for available K was medium.

Table 9. Status of available potassium (kg ha⁻¹) in different taluks of Kannur

Sl. No	Taluku	No. of samples	Range	Mean	Per cent sample category			NIV	Fertility rating
					Low	Medium	High		
1	Thaliparambu	54	84.00 - 924.00	273.52	7.40	53.70	38.90	2.32	Medium
2	Thalassery	30	70.00 - 630.00	231.00	23.33	40.00	36.67	2.13	Medium
3	Kannur	12	56.00 - 224.00	114.33	75.00	25.00	0.00	1.25	Low
# Range/Mean		96	56.00 - 924.00	206.28	35.24	39.57	25.19	1.90	Medium

2.6 Available sulphur

The available S content ranged from 2.91 to 471.89 mg kg⁻¹ with a mean value of 65.11 mg kg⁻¹. The mean available S status was found to be low in Thalassery taluk (55.24 mg kg⁻¹) and high in Thaliparambu taluk (74.32 mg kg⁻¹). Available S content was deficient in 10.25 per cent of samples and adequate in 89.75 per cent samples.

Table 10. Status of available sulphur (mg kg⁻¹) in different taluks of Kannur

Sl. No.	Taluku	No. of samples	Range	Mean	Per cent sample category	
					Deficient	Adequate
1	Thaliparambu	54	7.27 - 471.89	74.32	7.41	92.59
2	Thalassery	30	4.57 - 171.29	55.24	6.67	93.33
3	Kannur	12	2.91 - 248.72	65.76	16.67	83.33
# Range/Mean		96	2.91 - 471.89	65.11	10.25	89.75

2.7 Available micronutrients

The DTPA-Zn content ranged from 0.01 to 12.51 mg kg⁻¹ with a mean value of 1.74 mg kg⁻¹. The DTPA-Fe content varied from 5.85 to 125.60 mg kg⁻¹ with a mean value of 30.34 mg kg⁻¹. In all the taluks, Fe was found to be sufficient. The availability of Cu ranged from 0.10 to 12.05 mg kg⁻¹ with a mean value of 2.09 mg kg⁻¹. The Mn availability in the soils ranged from 0.65 to 22.90 mg kg⁻¹ with a mean of 5.10 mg kg⁻¹. The boron content ranged from 0.07 to 8.77 mg kg⁻¹ with a mean value of 1.41 mg kg⁻¹. The nutrient index value ranged from 1.57 to 1.83 for Zn, 1.97 to 2.00 for Cu, 1.83 to 2.00 for Mn and 1.53 to 1.80 for B. The value for iron was 2.00. Low to medium fertility rating was recorded for Zn and B, medium for Fe, Cu and Mn in most of the taluks (Appendix III).

Table 11. Status of available micronutrients (mg kg⁻¹) in different taluks of Kannur

Sl. No.	Taluku	No. of samples	Micronutrient status (Range)				
			Zn	Fe	Cu	Mn	B
1	Thaliparambu	54	0.01-7.61 (1.50)	6.25-101.20 (30.64)	0.25-12.05 (2.13)	1.25-22.90 (5.67)	0.07-8.21 (1.38)
2	Thalassery	30	0.26-12.51 (1.76)	11.70-125.60 (23.25)	0.15-6.45 (2.18)	0.85-3.80 (5.31)	0.11-3.02 (1.57)
3	Kannur	12	0.10-4.34 (2.76)	5.85-42.85 (46.68)	0.10-4.05 (1.63)	0.65-10.30 (2.00)	0.22-8.77 (1.13)
# Range/Mean		96	0.01-2.51 (1.74)	5.85-125.60 (30.34)	0.10-2.05 (2.09)	0.65-2.90 (5.10)	0.07- 8.77 (1.41)

* Values in parenthesis indicate mean

Table 12. Per cent sample category of available micronutrients in different taluks of Kannur

Taluk	No. of samples	Zn		Fe		Cu		Mn		B	
		D (%)	A (%)	D (%)	A (%)	D (%)	A (%)	D (%)	A (%)	D (%)	A (%)
Thaliparambu	54	37.03	62.97	0.00	100	0.00	100	0.00	100	20.38	79.62
Thalassery	30	43.33	56.67	0.00	100	3.33	96.67	6.67	93.33	46.67	53.33
Kannur	12	16.67	83.33	0.00	100	0.00	100	16.67	83.33	33.33	66.67
Mean	96	32.34	67.66	0.00	100	1.11	98.89	7.78	92.22	33.46	66.54

D = Deficient, A = Adequate

Fig. 3 Status of pH in the soils of Kannur

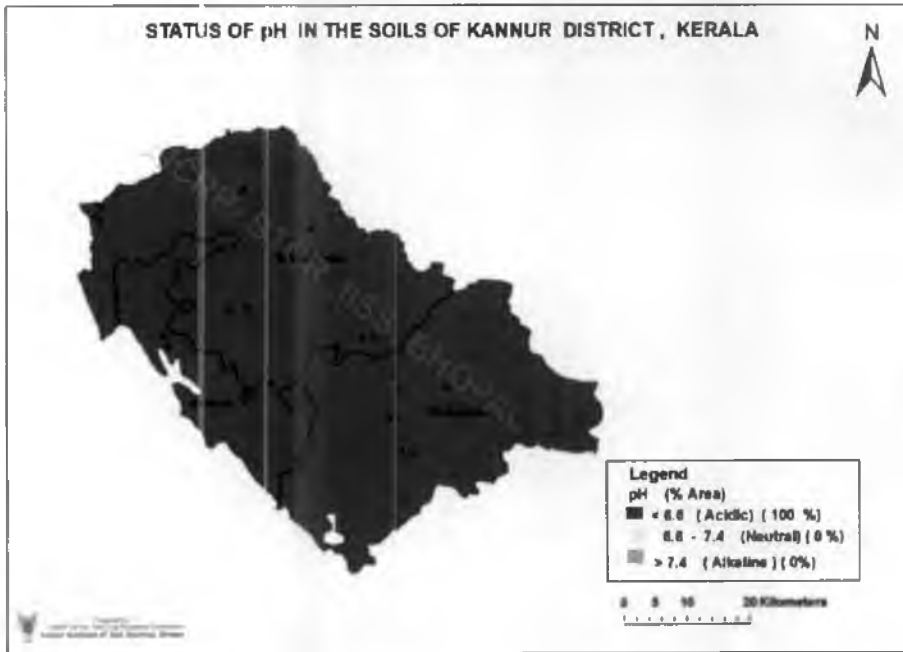


Fig. 4 Status of electrical conductivity in the soils

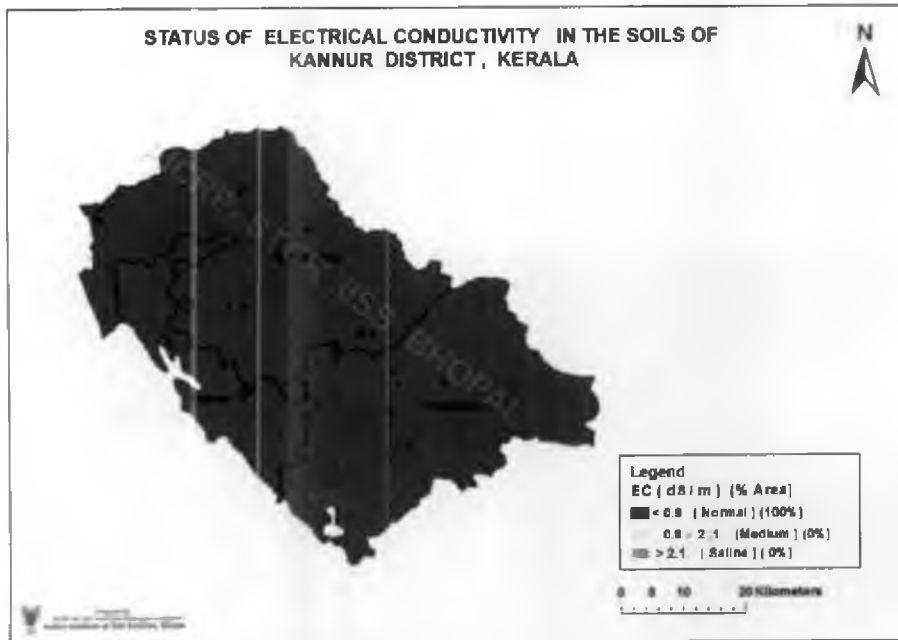


Fig. 5 Status of organic carbon in the soils of Kannur

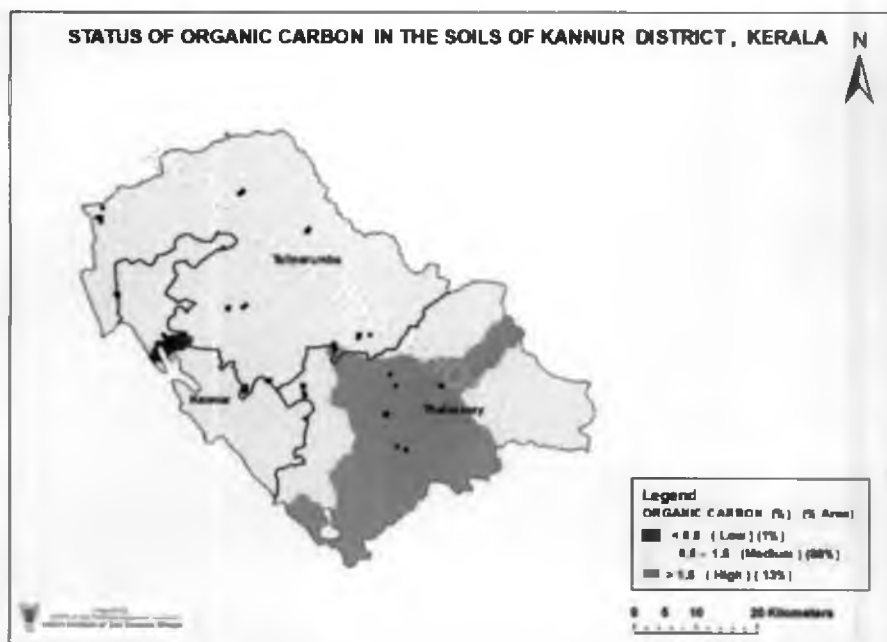


Fig. 6 Status of nitrogen in the soils of Kannur

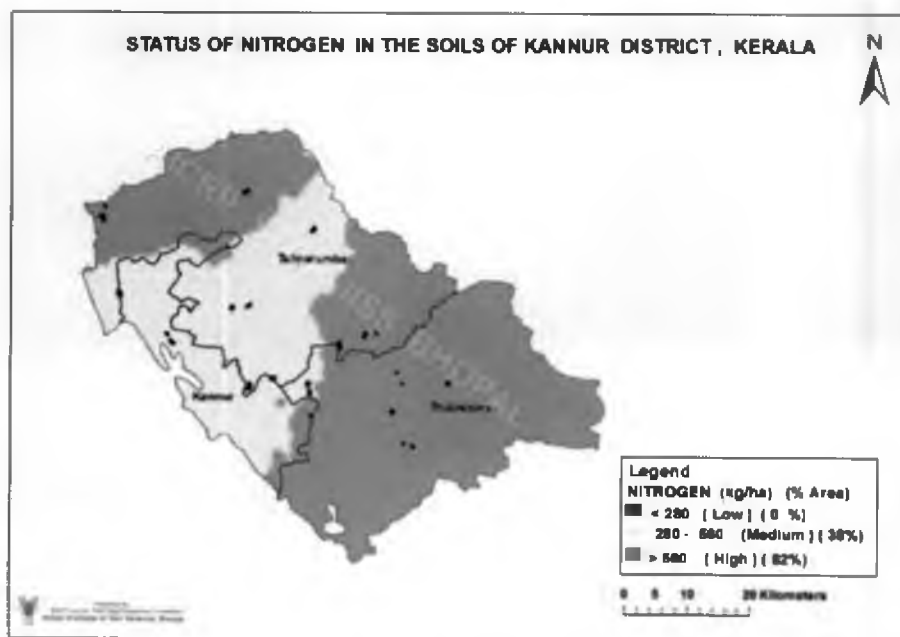


Fig. 7 Status of phosphorus in the soils of Kannur

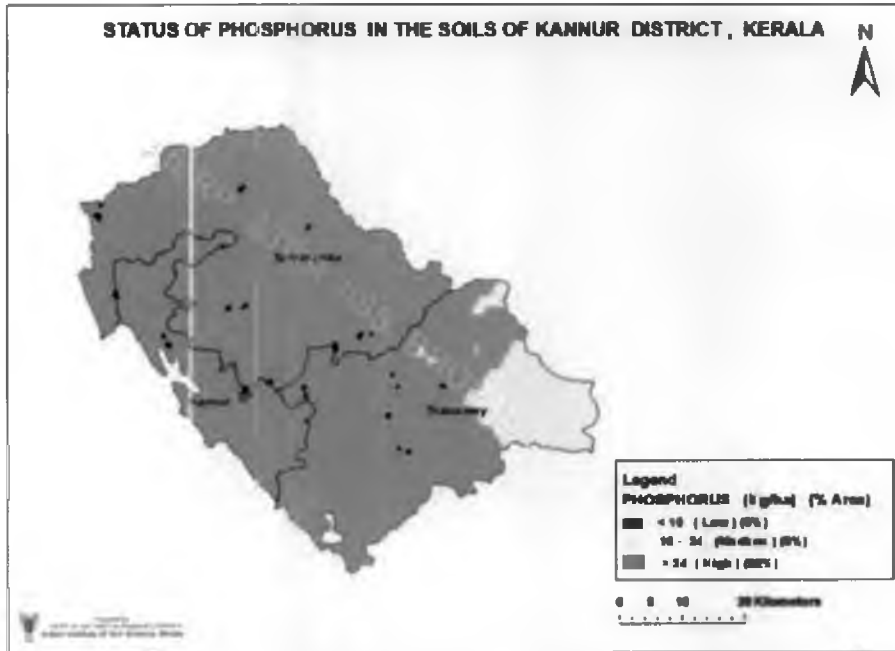


Fig. 8 Status of potassium in the soils of Kannur

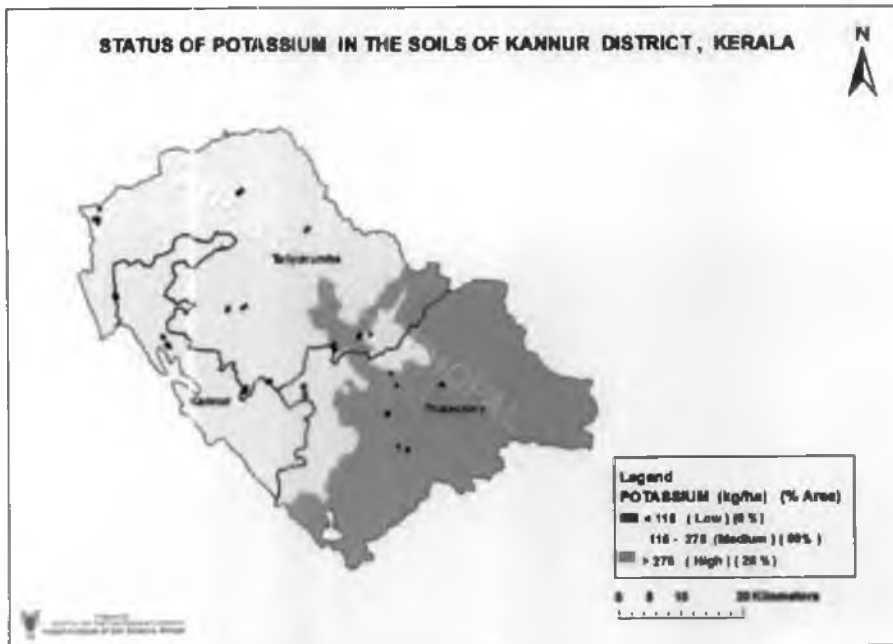


Fig. 9 Status of sulphur in the soils of Kannur

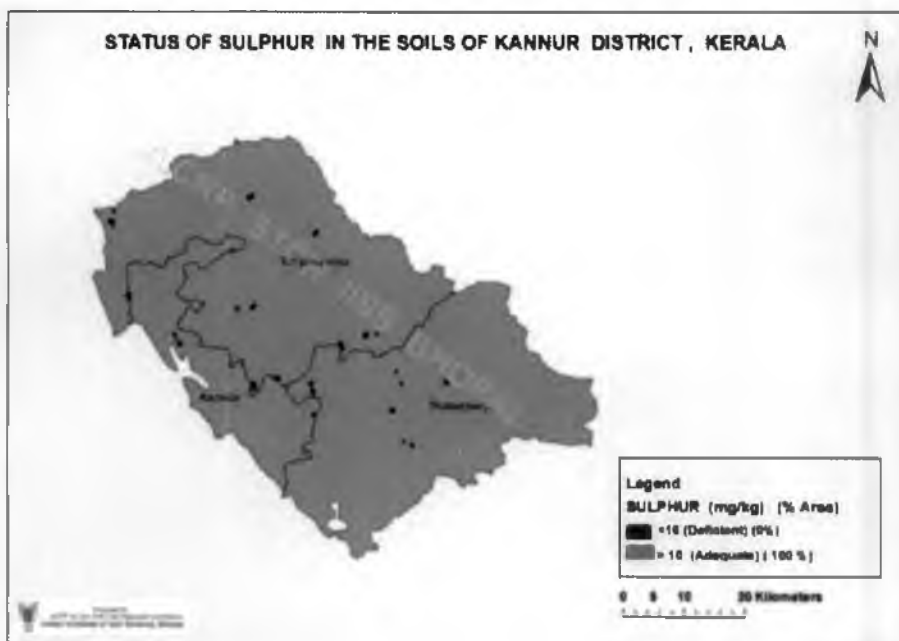


Fig. 10 Status of iron in the soils of Kannur

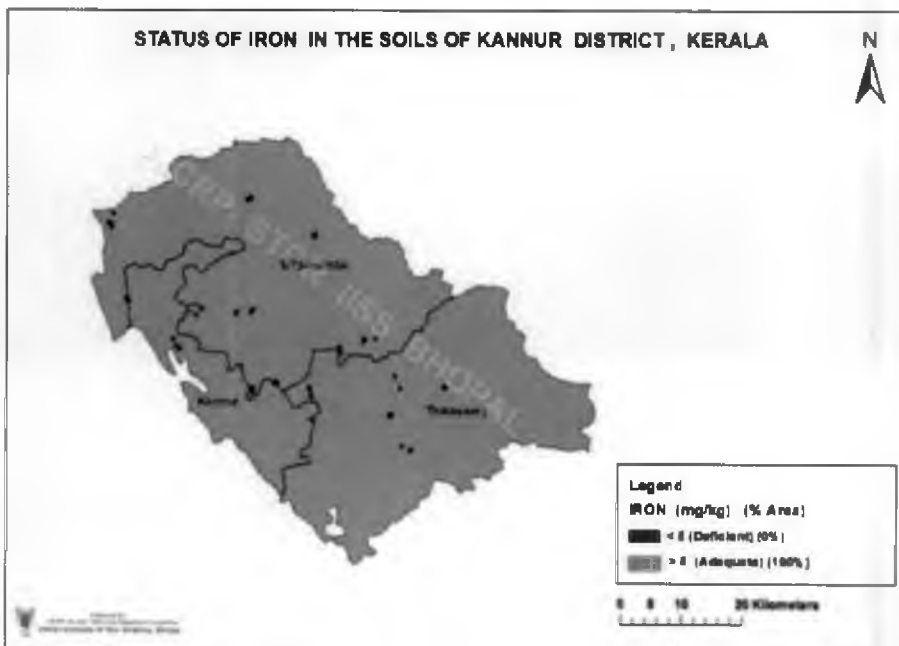


Fig. 11 Status of manganese in the soils of Kannur

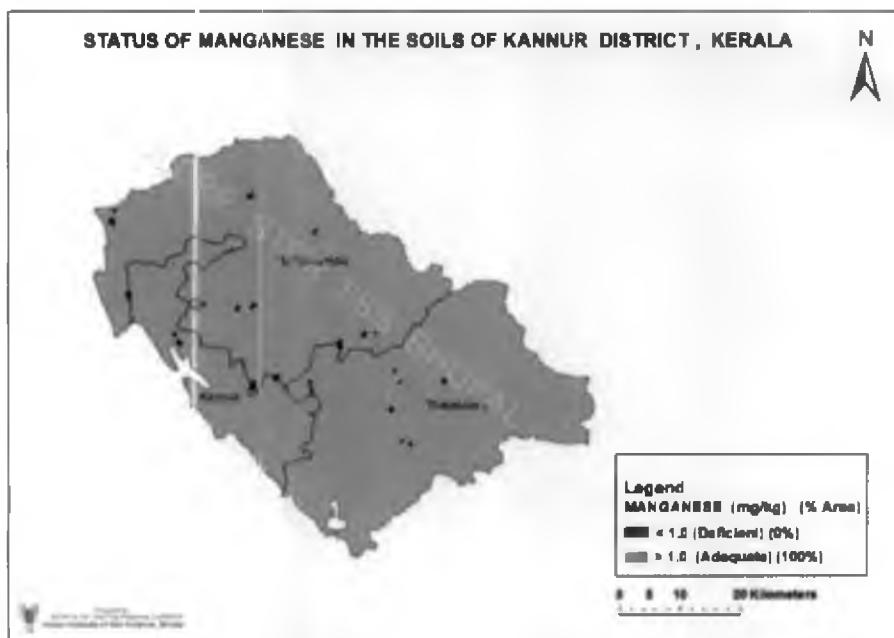


Fig. 12 Status of copper in the soils of Kannur

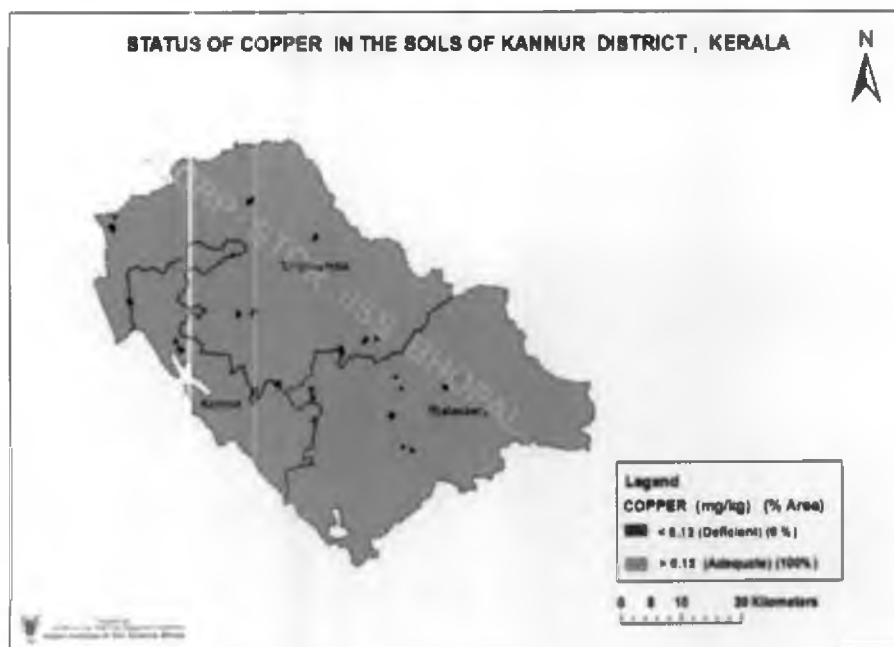


Fig. 13 Status of zinc in the soils of Kannur

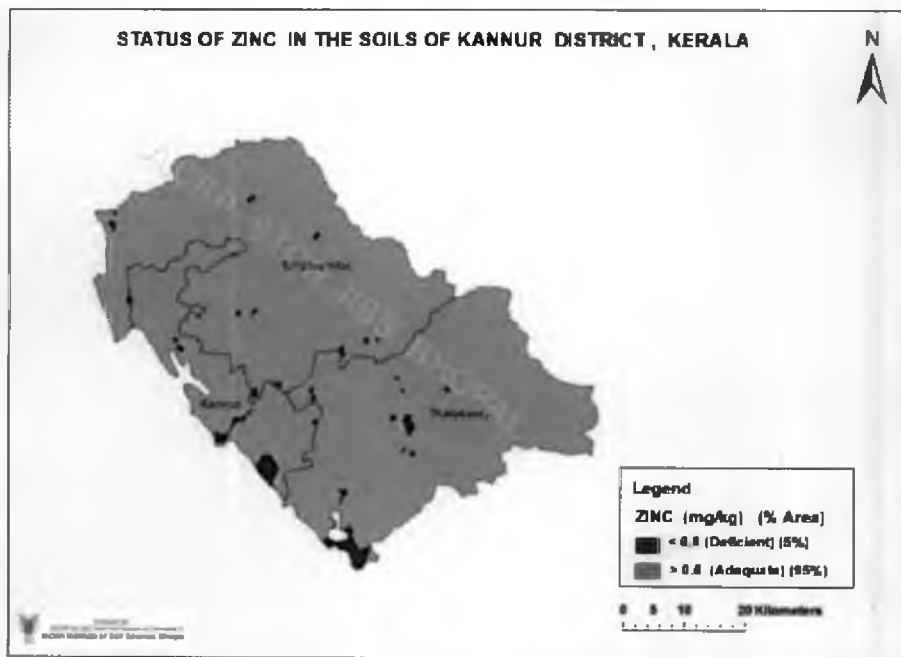


Fig. 14 Status of boron in the soils of Kannur

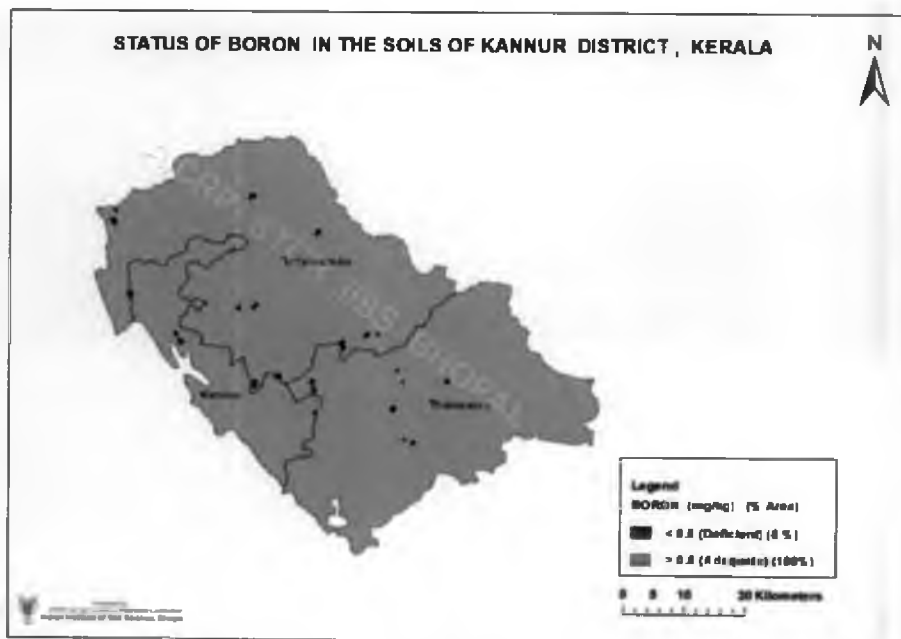


Table 13. Fertilizer recommendations for the farmers of Kannur district based on GPS and GIS based soil fertility maps

Major crops: Pepper, arecanut, rubber, cocoa, cashew

<p>Recommendations/ Strategies for soil amendment (for correction of soil acidity/sodicity/salinity etc.)</p>	<p>Ninety three per cent of samples were acidic. So liming is essential according to the pH. Liming can be done by using dolomite or CaCO₃</p>
<p>Recommendations/ Strategies for organic matter (this should include application of manures, residues, microbial culture for decomposition like Trichoderma etc.</p>	<p>Organic carbon - above eighty per cent of samples showed low to medium status. Apply compost, coir pith compost, vermicompost, FYM/organic manure/green manure etc Growing of green manure crops should be recommended.</p>
<p>Recommendations/ Strategies for NPK management</p>	<p>Nitrogen - low to medium for about 50 per cent samples. So N fertilizer application as per GRD required. Phosphorus - 75 per cent samples were high, so apply maintenance dose only. Needs P application as rock phosphate for perennial crops. Potassium - 32 per cent of the samples were high. Apply maintenance dose only for areas where the K content is high. In all other areas, K should be applied as per GRD.</p>
<p>Recommendations/ Strategies for secondary/micronutrient management</p>	<p>Sulphur - only ten per cent samples were deficient. Apply gypsum only if required No deficiency is noted for Fe and Mn. Zinc - 17 to 43 per cent of samples were deficient in different taluks (application, as ZnSO₄ is required). Boron - 33 per cent samples were deficient (Apply B fertilizers as borax, solubor etc.)</p>
<p>Training requirements</p>	<p>1) Training required for STL personnel about micronutrient deficiencies and requirement of liming. 2) Farmers can be given training on necessity of soil testing, compost making, vermicomposting etc.</p>
<p>Any other recommendations</p>	<p>Boron deficiency symptoms were noticed in coconut in certain areas. Create awareness among the farmers about the need for micronutrient analysis of soil samples.</p>

Table 14. Nutrient uses based on resource base in Kannur

Sl. No.	Nutrients added	Resource base		
		Small	Medium	Large
1	Major nutrients	N - 20-70 kg/ha P ₂ O ₅ - 25-35 kg/ha K ₂ O - 15-20 kg/ha	N - 25-70 kg/ha P ₂ O ₅ - 25-40 kg/ha K ₂ O - 20-30 kg/ha	N - 25-60 kg/ha P ₂ O ₅ - 30-45 kg/ha K ₂ O - 30-40 kg/ha
2	Secondary nutrients	MgSO ₄ - 25 kg/ha Lime - 100 kg/ha	MgSO ₄ - 25 kg/ha Lime - 150 kg/ha	MgSO ₄ - 25 kg/ha Lime - 150-200kg/ha
3	Micro nutrients	Borax - 5 kg/ha	Borax - 5kg/ha	Borax - 5 kg/ha
4	Organic manures	Neem cake -15 kg/ha Ground nut cake - 25 kg/ha	Neem cake -15 kg Ground nut cake -30 kg/ha	FYM - 20-50 kg/ha Ground nut cake - 20-40 kg/ha

Conclusion

Samples collected from Kannur district showed a mean pH of 5.74 and EC of 0.14 dS m⁻¹. In the case of available nitrogen, 41.73 per cent of the samples came in the category of medium and 40.37 per cent in high. More than 60 per cent of the samples showed high content of available phosphorus in all taluks. In Kannur taluk, 75 per cent of the samples were low in available potassium. Medium range of organic carbon was shown by 60.80 per cent of samples. Adequate levels of certain micronutrients (Fe, Mn and Cu) and sulphur were found in the samples collected from this district. Deficiencies of Zn and B were noted to the extent of 32.34 and 33.46 per cent samples respectively. So addition of fertilizers is essential to increase crop productivity in low/deficient categories. Maintenance dose of fertilizers is required in high category for restoration of soil fertility.

Chapter 3

Soil fertility status of Wayanad

Wayanad district is situated in the north-east of Kerala. The district stands on the southern tip of the Deccan plateau and its chief glory is the majestic rugged terrain of the Western Ghats, with lofty ridges interspersed with dense forest, tangled jungles and deep valleys, with altitudes ranging from 700 to 2100 metres above mean sea level. It lies between north latitude $11^{\circ} 27'$ and 12° and east $75^{\circ} 46'$ and $70^{\circ} 27'$.

This high altitude district is characterized by the cultivation of perennial plantation crops and spices. The major plantation crops include coffee, tea, pepper, cardamom and rubber. Coffee based farming system is a notable feature of Wayanad. Coffee is grown both as pure crop and as mixed crop along with pepper. The rice fields of Wayanad are in the valleys formed by hillocks and in majority of paddy lands, only a single crop is harvested. Ginger cultivation in Wayanad has also substantially increased in recent times and the ginger produced is mainly marketed in the form of green ginger. Homestead farming assumes importance in this district. The agro-ecological zones of the district are depicted in Fig. 15.

Table 15. Major crops, fertilizers, organic nutrient sources and sources of irrigation in Wayanad

Crops	Chemical fertilizers	Organic sources	Sources of irrigation
Banana	Urea	Cow dung	Wells
Nutmeg	Fertilizer	Poultry manure	
Vegetables	complex	Green leaves	
Clove	Suphala	Vermi compost	
Ginger	Factomphos	Bone meal	
Cardamom	Coconut mixture	Neem cake	
Pepper		Rajphos	
Coffee, coconut			
Arecanut, rubber			

The district is divided into three taluks, which are Vythiri, Sulthan Bathery and Mananthavady. A total of 6 villages were selected based on stratified multistage random sampling method covering all the three taluks and a total of 36 surface soil samples (six from each village) were collected using GPS representing small, medium and large farmer category. The samples were processed and were analysed for 12 chemical parameters viz., pH, electrical conductivity, organic carbon, available nitrogen, phosphorus, potassium, sulphur, zinc, copper, iron, manganese and boron.

Table 16. Number of villages selected in different taluks of Wayanad

Sl. No.	Name of taluk	Number of villages selected
1	Vythiri	2
2	Sulthan Bathery	2
3	Mananthavady	2

Table 17. Selected villages in different taluks of Wayanad

Vythiri	Sulthan Bathery	Mananthavady
Muttill North	Cheeral	Panamaram
Chundel	Padichira	Payampilly

Soil fertility status

The results of soil analysis are listed in the following tables. The soil fertility maps generated from the analytical data are presented in figures, 16 to 27. These fertility maps reveal the percentage area under different categories with respect to each parameter in the total geographic area of 2,131 sq. km in Wayanad district.

3.1 pH and electrical conductivity

The pH of the surface soils ranged from 5.27 to 6.98. It was observed that 80.56 per cent of the samples analysed were acidic and 19.44 per cent of the samples were neutral. Alkaline soils were not present. In Vythiri taluk, 91.67 per cent soil samples were acidic. In Mananthavady and Sulthan Bathery taluks, 75 per cent soil samples were acidic.

Table 18. Status of pH in different taluks of Wayanad

Sl. No.	Taluks	No. of samples	Range	Mean	Per cent sample category		
					Acidic	Neutral	Alkaline
1	Vythiri	12	5.66 - 6.91	6.20	91.67	8.33	0.00
2	Mananthavady	12	5.27 - 6.96	6.13	75.00	25.00	0.00
3	Sulthan Bathery	12	5.72 - 6.98	6.34	75.00	25.00	0.00
# Range/Mean		36	5.27 - 6.98	6.22	80.56	19.44	0.00

The whole area of the district was non saline. The electrical conductivity of the soils ranged from 0.02 to 1.10 dS m⁻¹ with a mean of 0.17 dS m⁻¹.

Fig. 15 Agro ecological map of Wayanad

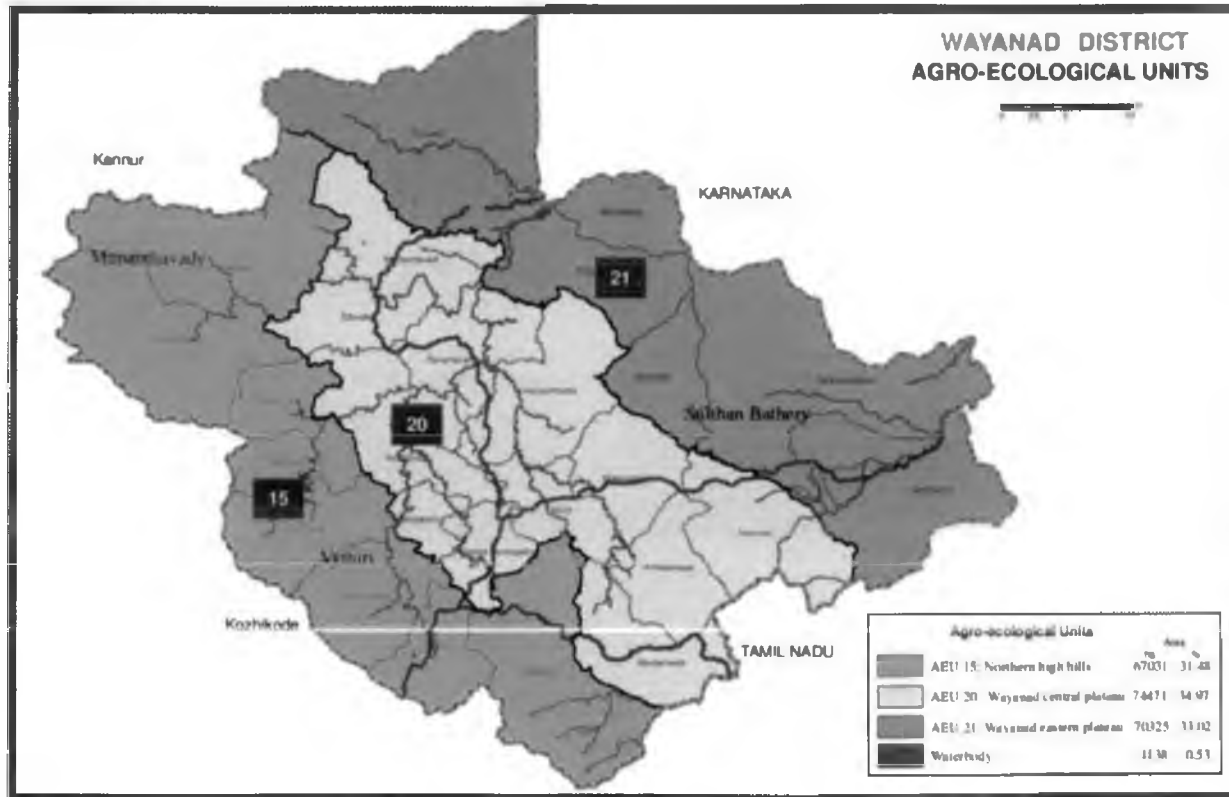


Table 19. Status of EC (dS m⁻¹) in different taluks of Wayanad

Sl. No.	Taluks	Range	Mean
1	Vythiri	0.02 - 0.12	0.06
2	Mananthavady	0.04 - 0.55	0.15
3	Sulthan Bathery	0.03 - 1.10	0.31
Range/Mean		0.02 - 1.10	0.17

3.2 Organic carbon

The organic carbon status of the soil was medium and ranged from 0.11 to 1.7 per cent with a mean value of 0.99 per cent. Sulthan Bathery taluk recorded the highest mean organic carbon content of 1.10 per cent followed by Vythiri taluk (0.99 per cent). The per cent of soils coming under low, medium and high categories were 13.89, 77.78 and 8.33 respectively

Table 20. Status of organic carbon (per cent) in different taluks of Wayanad

Sl. No.	Taluks	No. of samples	Range	Mean	Per cent sample category			NIV	Fertility rating
					Low	Medium	High		
1	Vythiri	12	0.27-1.70	0.99	16.66	66.67	16.67	2.00	Medium
2	Mananthavady	12	0.11-1.41	0.87	16.66	83.34	0.00	4.33	High
3	Sulthan Bathery	12	0.48-1.54	1.10	8.34	83.33	8.33	2.00	Medium
# Range/Mean		36	0.11-1.70	0.99	13.89	77.78	8.33	2.78	High

3.3 Available nitrogen

The available nitrogen status in the surface soils ranged from 219.77 to 760.27 kg ha⁻¹ with mean value of 449.80 kg ha⁻¹. The per cent samples under low, medium and high categories were 8.33, 72.22 and 19.44 respectively. Among the three taluks, Vythiri and Sulthan Bathery recorded the highest per cent of samples (75) under medium available N; highest per cent of samples under low available N was observed in Vythiri (16.67 per cent). The mean value of nutrient index for available nitrogen was 2.11. The fertility rating for available nitrogen was medium.

Table 21. Status of available nitrogen (kg ha^{-1}) in different taluks of Wayanad

Sl. No.	Taluks	No. of samples	Range	Mean	Per cent sample category			NIV	Fertility rating
					Low	Medium	High		
1	Vythiri	12	219.77-760.27	398.03	16.67	75.00	8.33	1.92	Medium
2	Mananthavady	12	240.89-716.27	474.10	8.33	66.67	25.00	2.17	Medium
3	Sulthan Bathery	12	319.12-757.11	477.27	0.00	75.00	25.00	2.25	Medium
# Range/Mean		36	219.77-760.27	449.80	8.33	72.22	19.44	2.11	Medium

3.4 Available phosphorus

The available Bray-P content ranged from 3.60 to 89.84 kg ha^{-1} with a mean value of 27.02 kg ha^{-1} . The per cent sample of soils under low, medium and high categories were 38.89, 25.00 and 36.11 respectively. Among the three taluks, Sulthan Bathery recorded the highest per cent of samples under high available P (41.67 per cent); the highest per cent of samples under low available P was observed in Mananthavady taluk (66.67 per cent). The mean value of nutrient index for available phosphorus was 1.97. The fertility rating for available phosphorus was medium

Table 22. Status of available phosphorus (kg ha^{-1}) in different taluks of Wayanad

Sl. No.	Taluks	No. of samples	Range	Mean	Per cent sample category			NIV	Fertility rating
					Low	Medium	High		
1	Vythiri	12	7.80 - 89.84	31.93	25.00	41.67	33.33	2.08	Medium
2	Mananthavady	12	3.60 - 42.62	17.41	66.67	0.00	33.33	1.67	Medium
3	Sulthan Bathery	12	7.20 - 79.23	31.71	25.00	33.33	41.67	2.17	Medium
# Range/Mean		36	3.60 - 89.84	27.02	38.89	25.00	36.11	1.97	Medium

3.5 Available potassium

The available K status in surface soils of different taluks ranged from 140 to 980 kg ha^{-1} . Considering the mean values, the highest value of 560 kg ha^{-1} was recorded in Sulthan Bathery taluk and the lowest mean value of 357.00 kg ha^{-1} in Vythiri taluk. The per cent sample categories under low, medium and high categories were 0, 30.56 and 69.44 respectively. The mean value of nutrient index for available K was 2.69 and fertility rating was high.

Table 23. Status of available potassium (kg ha^{-1}) in different taluks of Wayanad

Sl. No.	Taluks	No. of samples	Range	Mean	Per cent sample category			NIV	Fertility Rating
					Low	Medium	High		
1	Vythiri	12	140-784	357.00	0.00	41.67	58.33	2.58	High
2	Mananthavady	12	140-980	359.33	0.00	41.67	58.33	2.58	High
3	Sulthan Bathery	12	252-888	560.00	0.00	8.33	91.67	2.92	High
# Range/Mean		36	140-980	425.44	0.00	30.56	69.44	2.69	High

3.6 Available sulphur

The Available S content ranged from 1.91 to 64.64 mg kg^{-1} with a mean value of 20.28 mg kg^{-1} . The mean available S status was found to be low in Sulthan Bathery taluk (14.04 mg kg^{-1}) and high in Mananthavady taluk (24.50 mg kg^{-1}). With respect to available S content, 13.89 per cent of samples were deficient and 86.11 were adequate.

Table 24. Status of available sulphur (mg kg^{-1}) in different taluks of Wayanad

Sl. No.	Taluks	No. of samples	Range	Mean	Per cent sample category	
					Deficient	Adequate
1	Vythiri	12	6.89 - 32.78	22.29	8.33	91.67
2	Mananthavady	12	4.60 - 64.64	24.50	8.33	91.67
3	Sulthan Bathery	12	1.91 - 23.28	14.04	25.00	75.00
# Range/Mean		36	1.91 - 64.64	20.28	13.89	86.11

3.7 Available micronutrients

The DTPA-Zn content ranged from 0.20 to 13.50 mg kg^{-1} with a mean value of 3.94 mg kg^{-1} . The DTPA-Fe content varied from 22.50 to 170.30 mg kg^{-1} with a mean value of 72.15 mg kg^{-1} . The available Cu content ranged from 0.20 to 14.85 mg kg^{-1} with a mean value of 3.54 mg kg^{-1} . The available Mn content in the soils ranged from 3.35 to 189.30 mg kg^{-1} with a mean of 64.10 mg kg^{-1} . Copper, zinc and boron were also found to be sufficient in all the taluks. The B content ranged from 0.27 to 7.12 mg kg^{-1} with a mean value of 1.99 mg kg^{-1} . The nutrient index value for Fe, Cu and Mn was 2.00. The value for Zn ranged from 1.83 to 2.00 and 1.67 to 1.92 for B. Fertility rating was medium for all the micronutrients in Wayanad district. All the micronutrients were found to be sufficient in Wayanad district (Appendix III).

Table 25. Status of available micronutrients (mg kg⁻¹) in different taluks of Wayanad

Sl. No	Taluks	No. of samples	Micronutrient status (Range)				
			Zn	Fe	Cu	Mn	B
1	Vythiri	12	0.20 -13.50 *(3.96)	22.50 -128.05 (70.27)	0.75 -14.80 (4.52)	3.35 -172.15 (47.66)	0.33 - 7.12 (2.13)
2	Mananthavady	12	0.63 - 9.65 (3.81)	41.80 -170.30 (81.77)	0.72 -14.85 (3.80)	3.70 -189.30 (79.87)	0.27 - 1.45 (2.29)
3	Sulthan Bathery	12	0.59 - 9.18 (4.04)	43.85 -110.10 (64.42)	0.20 - 6.30 (2.29)	24.15 -135.20 (64.76)	0.48 - 3.58 (1.55)
# Range/Mean		36	0.20 -13.50 (3.94)	22.50 -170.10 (72.15)	0.20 -14.85 (3.54)	3.35 -189.30 (64.10)	0.27 - 7.12 (1.99)

*Values in parenthesis indicate mean

Table 26. Per cent sample category of available micronutrients in different taluks of Wayanad

Taluk	No of samples	Zn		Fe		Cu		Mn		B	
		D (%)	A (%)	D (%)	A (%)	D (%)	A (%)	D (%)	A (%)	D (%)	A (%)
Vythiri	12	16.67	83.33	0	100	0	100	0	100	16.67	83.33
Mananthavady	12	0.00	100.00	0	100	0	100	0	100	33.33	66.67
Sulthan Bathery	12	8.33	91.67	0	100	0	100	0	100	8.33	91.67
Mean	36	8.33	91.67	0	100	0	100	0	100	19.44	80.56

D = Deficient, A = Adequate

Fig. 16 Status of pH in the soils of Wayanad

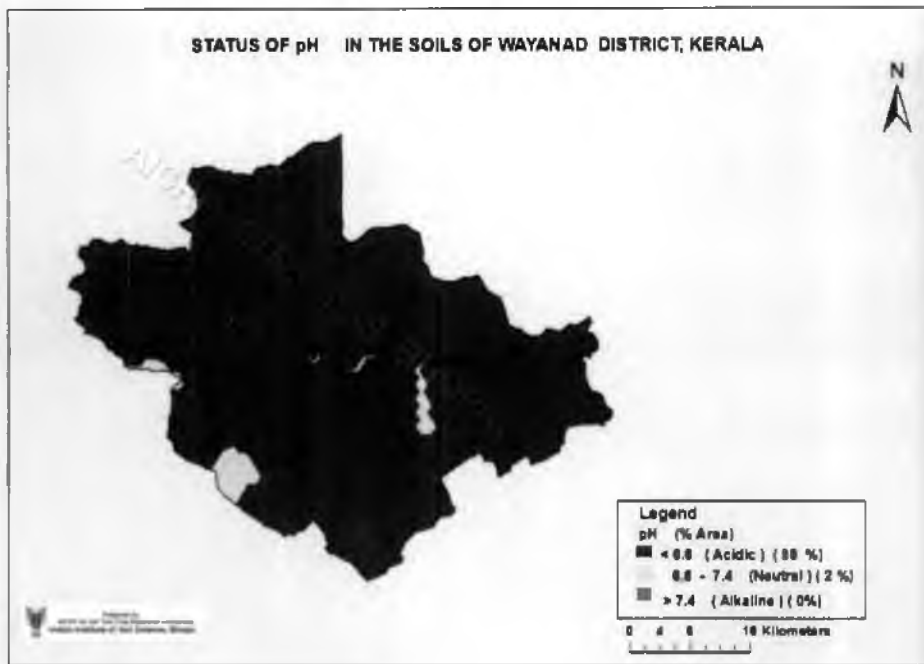


Fig. 17 Status of electrical conductivity in the soils of Wayanad



Fig. 18 Status of organic carbon in the soils of Wayanad

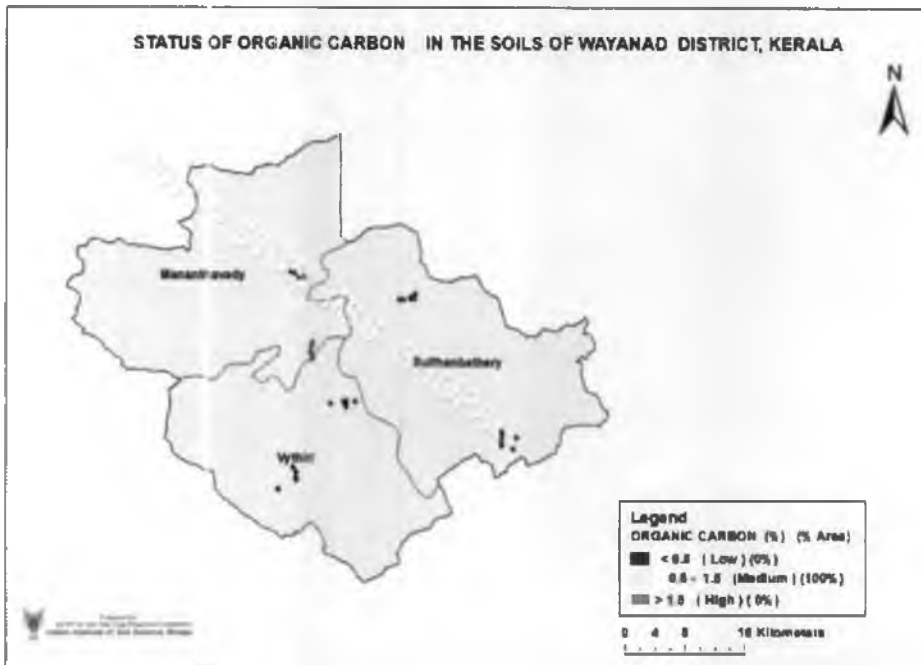


Fig. 19 Status of nitrogen in the soils of Wayanad

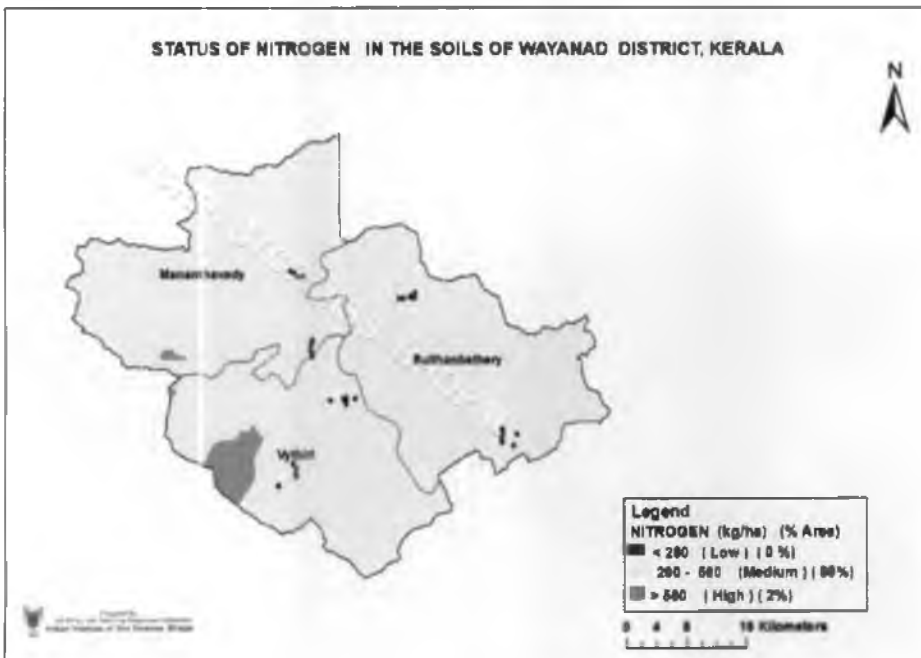


Fig. 20 Status of phosphorus in the soils of Wayanad

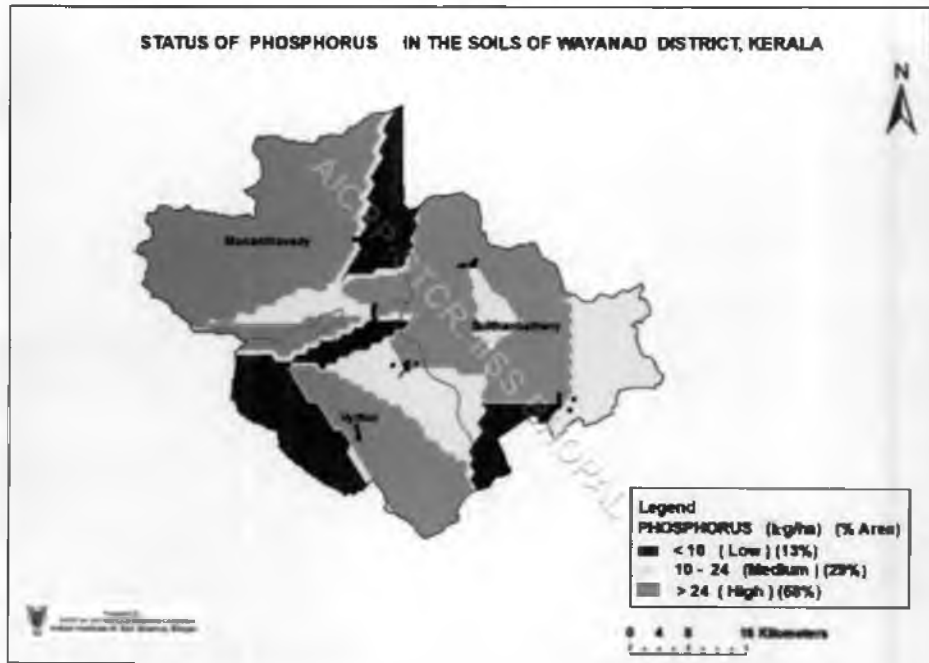


Fig. 21 Status of potassium in the soils of Wayanad

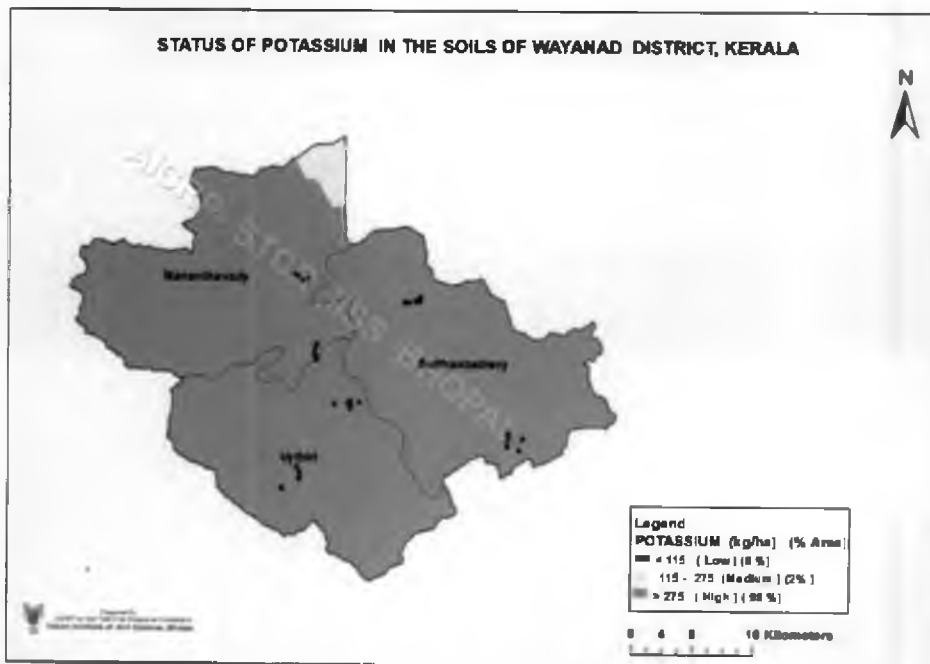


Fig. 22 Status of sulphur in the soils of Wayanad

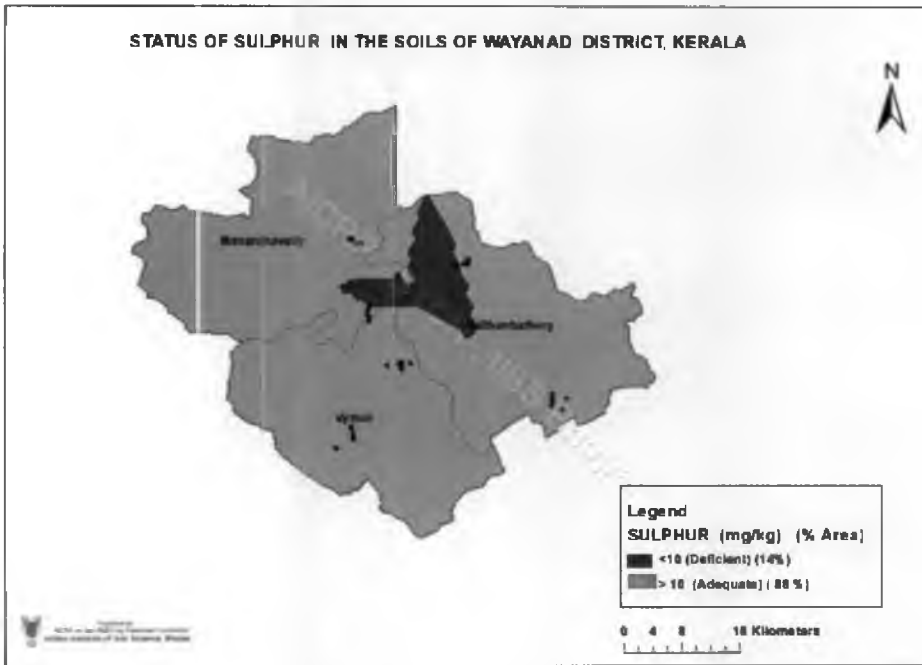


Fig. 23 Status of iron in the soils of Wayanad

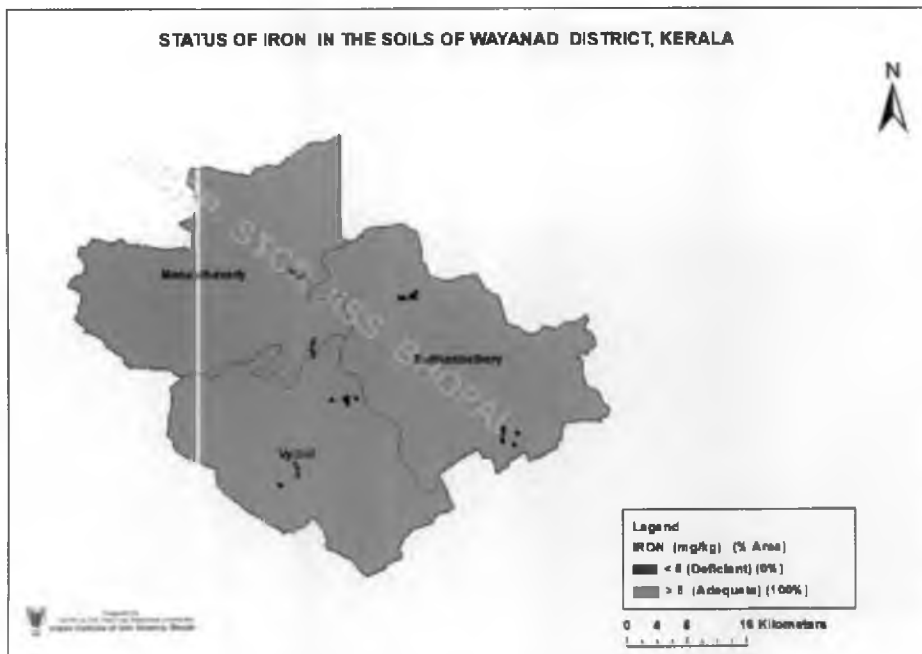


Fig. 24 Status of manganese in the soils of Wayanad

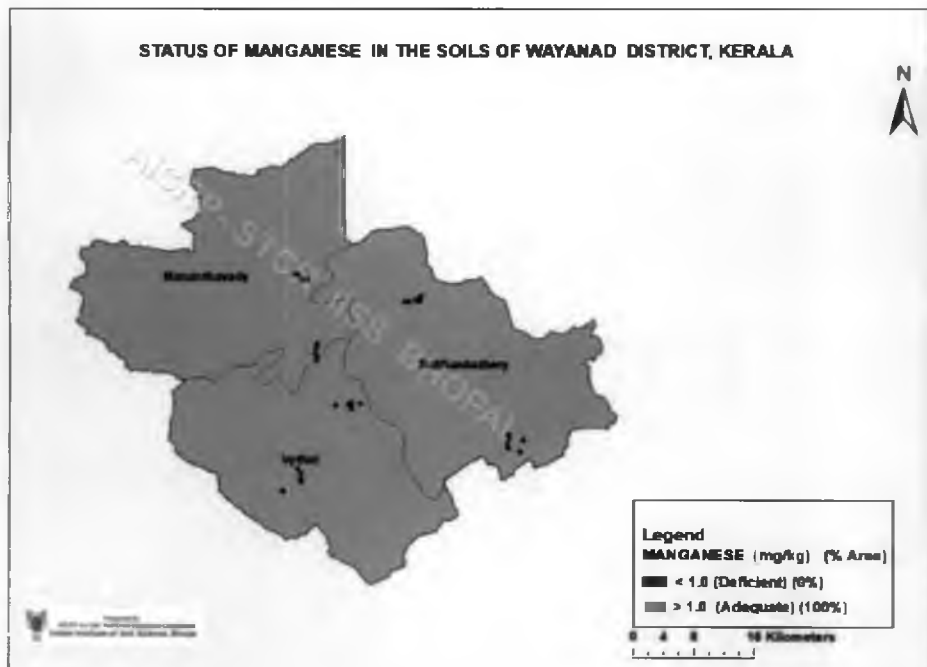


Fig. 25 Status of copper in the soils of Wayanad



Fig. 26 Status of zinc in the soils of Wayanad



Fig. 27 Status of boron in the soils of Wayanad

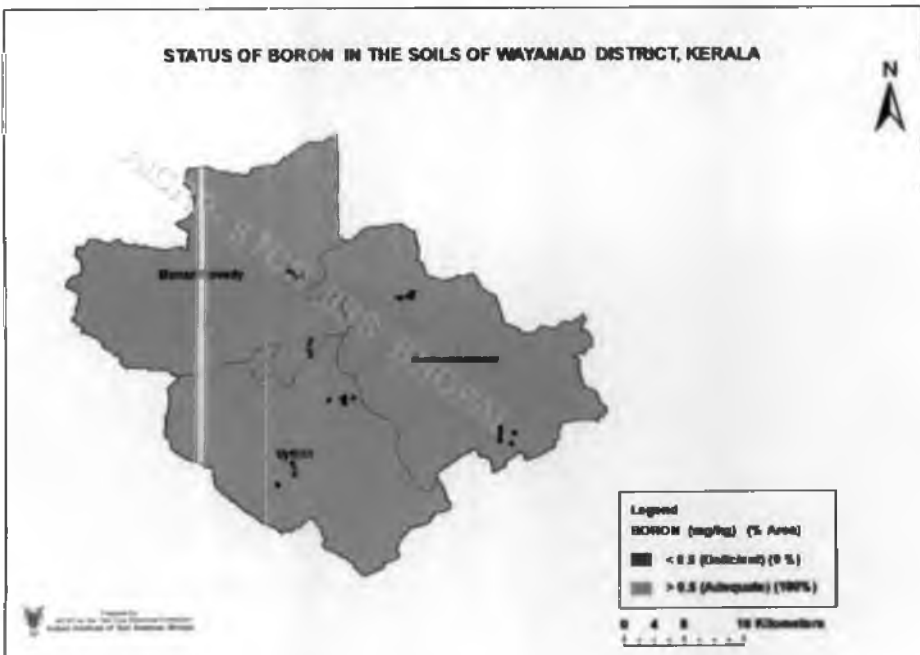


Table. 27. Fertilizer recommendations for the farmers of Wayanad district based on GPS and GIS based soil fertility maps

Main crops: Coffee, spices, coconut, banana, arecanut

Recommendations/ strategies for soil amendment (for correction of soil acidity/sodicity/salinity etc.)	Majority of samples (81 per cent) were acidic, so liming should be done as Ca CO ₃ , dolomite etc. The soils were not saline.
Recommendations/ strategies for organic matter (this should include application of manures, residues, microbial culture for decomposition like Trichoderma etc.)	Ninety one percent of samples were low to medium in organic carbon. Maintenance of organic carbon level by application of organic manures as crop residues/weed composting, vermi composting etc. Application of trichoderma and bio fertilizers can also be done. Organic manures can be applied. viz. neem cake, groundnut cake etc.
Recommendations/ strategies for NPK management	Nitrogen content of samples was in low to medium range (81 per cent). So fertilizer application is required. Apply coated urea fertilizer, organic manures rich in N etc. Phosphorus content of samples was high, so apply rock phosphate as P sources in deficient areas. Potassium content of samples was high (69 per cent). Only maintenance dose is required. In all other areas apply as per GRD.
Recommendations/ strategies for secondary/micronutrient management	Sulphur -14 per cent of the samples were deficient. Elemental S, single super phosphate, factomphos etc can be applied. No need to apply micronutrients like Fe, Mn, Zn and Cu. Because they were present in sufficient quantities. Boron – 19 per cent samples were deficient. In these areas apply organic manures and sources of B fertilizers like borax, solubor etc
Training requirements	Training required for STL personnel regarding soil analysis and composting of crop residue
Any other recommendations	Agriculture extension workers and fertilizer based firms should create awareness among farmers on the importance of soil fertility maps.

Table 28. Nutrient uses based on resource base in Wayanad

Sl. No.	Nutrients added	Resource base		
		Small	Medium	Large
1	Major nutrients	N-80 - 100 kg/ha P ₂ O ₅ - 45-60 kg/ha K ₂ O - 70 kg/ha	N- 80 - 100 kg/ha P ₂ O ₅ - 50 -70 kg/ha K ₂ O - 70 kg/ha	N- 90-125 kg/ha P ₂ O ₅ -50-70 kg/ha K ₂ O - 80 kg/ha
2	Secondary nutrients	Lime - 100 kg/ha	MgSO ₄ - 20 kg/ha Lime - 150 kg/ha	MgSO ₄ - 20 kg/ha Lime - 200 kg/ha
3	Micro nutrients		Micro food - 10 kg/ha	Micro food - 10 kg/ha
4	Organic manures	Neem cake - 10 kg/ha		POABS mixture FYM- 2.5-10 kg/ha

Conclusion

The samples collected from Wayanad district showed an average pH of 6.22 and EC of 0.17 dS m⁻¹. Available nitrogen status in the soils collected from Wayanad district came under medium range (72.22 per cent). In the case of available phosphorus, 38.89 per cent of samples came under low category and 36.11 per cent in high. Majority of samples showed high potassium content. In the case of organic carbon, 77.78 per cent of samples were in the medium range. All the samples were categorized under the adequate level for micronutrients except in Mananthavady taluk where deficiency of boron was found to be 33.33 per cent. The per cent of samples coming under adequate class for sulphur was 86.11 per cent.

Chapter 4

Soil fertility status of Kozhikode

Kozhikode district has a rich heritage in agriculture as it was a port city famous for pepper and spices trade. Agriculture plays a major role in the district economy. Topographically the district has three distinct regions; the sandy coastal belt, the rocky highlands formed by the hilly portion of the Western Ghats and lateritic midland. All the three taluks are spread over the three regions. The district has a coastal length of about 80 km. Kozhikode district is situated on the south-west coast of India. The district is bounded on the north by Kannur district, on the east by Wayanad district, on the south by Malappuram district and on the west by the Arabian Sea. It is situated between North latitudes 11^o09' and 11^o49' and East longitudes 75^o32' and 76^o09'. Main crops cultivated in Kozhikode district are paddy, banana and plantation crops like coconut and arecanut. The agro-ecological zones of the district are depicted in Fig.28.

Table 29. Major crops, fertilizers, organic nutrient sources and sources of irrigation in Kozhikode

Crops	Chemical fertilizers	Organic sources	Sources of irrigation
Paddy	MOP	Cow dung	Wells
Banana	Urea	Green leaves	
Vegetables	Factomphos	Lime	
Tapioca	Magnesium	Rajphos	
Pepper	sulphate		
Coconut, arecanut			
Rubber, cashew			

The district is divided into three taluks namely Kozhikode, Vadakara and Koyilandi. A total of 17 villages were selected based on stratified multistage random sampling method covering all the three taluks and a total of 102 surface soil samples (six from each village) were collected using GPS representing small, medium and large farmers category. The samples were processed and were analysed for 12 chemical parameters viz., pH, electrical conductivity, organic carbon, available nitrogen, phosphorus, potassium, sulphur, zinc, copper, iron, manganese and boron.

Fig. 28 Agro ecological map of Kozhikode

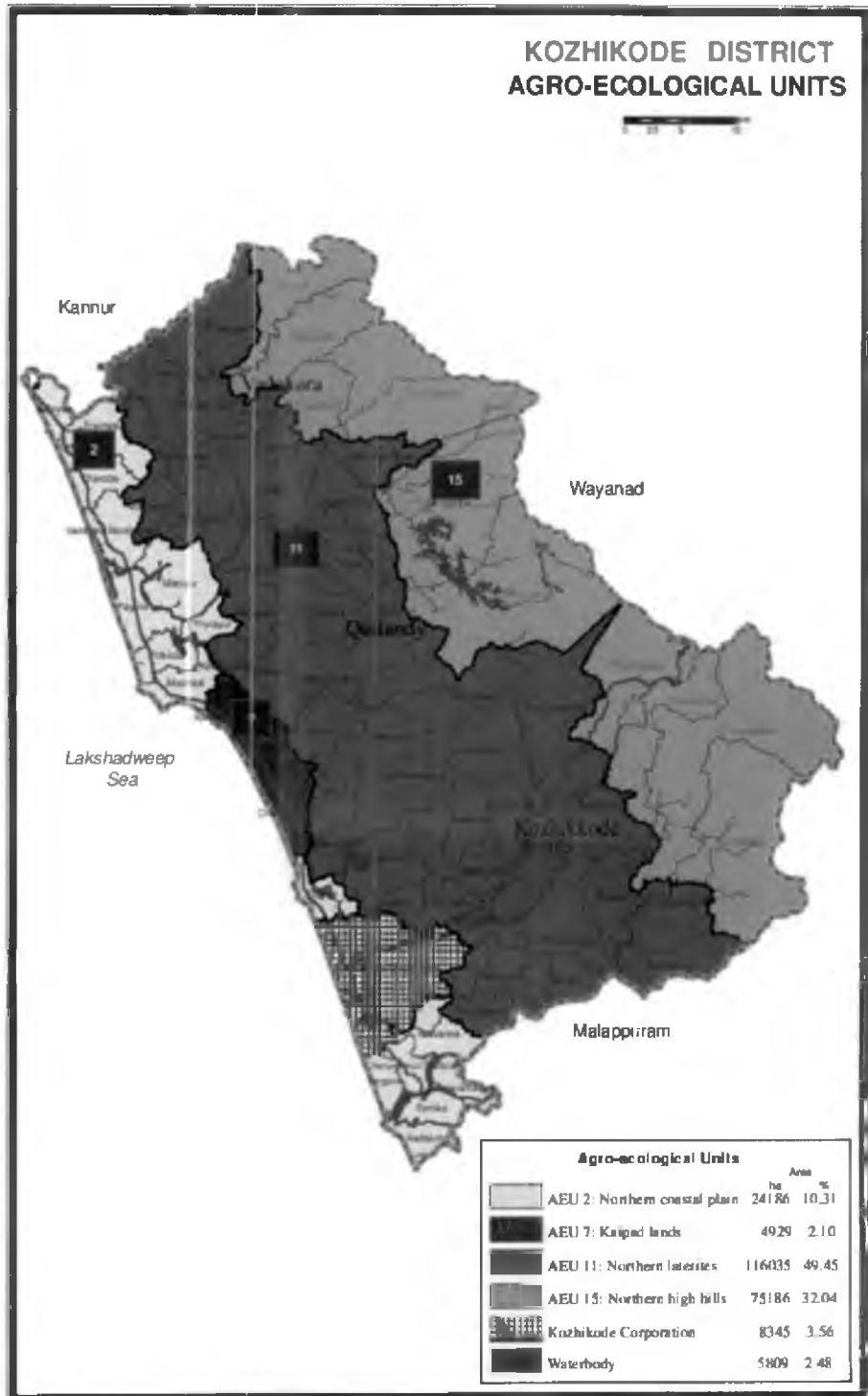


Table 30. Number of villages selected in different taluks of Kozhikode

Sl. No.	Name of taluk	Number of villages selected
1	Kozhikode	5
2	Vadakara	5
3	Koyilandi	7

Table 31. Selected villages in different taluks of Kozhikode

Kozhikode	Vadakara	Koyilandi
Kizhakothe	Onchiyam	Payyoli
Chathamangalam	Azhiyur	Kinalur
Madavur	Valayam	Kanthalad
Pulakode	Kavilumpara	Paleri
Perumanna	Kunnummal	Kizhariyur
		Naduvannur, Kurachundu

Soil fertility status

The results of soil analysis are listed in the following tables. The soil fertility maps generated from the analytical data are presented in figures, 29 to 40. These fertility maps reveal the percentage area under different categories with respect to each parameter in the total geographic area of 2,206 sq. km in the Kozhikode district.

4.1 pH and electrical conductivity

The pH of the surface soil ranged from 5.14 to 6.83. It was observed that 94.29 per cent of the samples analysed were acidic and 5.71 per cent of the samples were neutral. Alkaline soils were not present. In the taluks Kozhikode, Vadakara, and Koyilandi 96.67, 93.33 and 92.86 per cent respectively were acidic.

Table 32. Status of pH in different taluks of Kozhikode

Sl. No.	Taluks	No. of samples	Range	Mean	Per cent sample category		
					Acidic	Neutral	Alkaline
1	Kozhikode	30	5.40 - 6.61	6.23	96.67	3.33	0.00
2	Vadakara	30	5.82 - 6.70	6.30	93.33	6.67	0.00
3	Koyilandi	42	5.14 - 6.83	6.13	92.86	7.14	0.00
# Range/Mean		102	5.14 - 6.83	6.22	94.29	5.71	0.00

With regard to electrical conductivity (dS m^{-1}), the whole area of the district was non saline. The electrical conductivity of the soil ranged from 0.01 to 1.31 dS m^{-1} with a mean of 0.12 dS m^{-1} .

Table 33. Status of EC (dS m^{-1}) in different taluks of Kozhikode

Sl. No.	Taluks	Range	Mean
1	Kozhikode	0.01 - 0.65	0.14
2	Vadakara	0.01 - 1.31	0.15
3	Koyilandi	0.01 - 0.47	0.08
# Range/Mean		0.01 - 1.31	0.12

4.2 Organic carbon

The organic carbon status of the soil ranged from 0.03 to 2.22 per cent with mean value of 0.88 per cent. Kozhikode and Koyilandi taluks recorded the highest mean organic carbon content of 0.97 per cent followed by Vadakara (0.70 per cent). The per cent of soils coming under low, medium and high categories were 16.19, 79.21 and 4.60 respectively.

Table 34. Status of organic carbon (per cent) in different taluks of Kozhikode

Sl. No.	Taluks	No. of samples	Range	Mean	Per cent sample category			NIV	Fertility rating
					Low	Medium	High		
1	Kozhikode	30	0.14 - 2.22	0.97	10.00	83.33	6.67	1.40	Medium
2	Vadakara	30	0.11 - 1.47	0.70	26.67	73.33	0.00	1.24	Low
3	Koyilandi	42	0.03 - 1.75	0.97	11.90	80.96	7.14	1.95	Medium
# Range/Mean		102	0.03 - 2.22	0.88	16.19	79.21	4.60	1.53	Medium

4.3 Available nitrogen

The available nitrogen status in the surface soils ranged from 119.17 to 934.53 kg ha^{-1} with mean value of 336.48 kg ha^{-1} . The per cent of samples under low, medium and high categories were 44.29, 46.67 and 9.05 respectively. Among the three taluks, Koyilandi recorded the highest per cent of samples under medium available N (50 per cent); highest per cent of samples under low available N was observed in Kozhikode (46.67 per cent). The mean value of nutrient index for available nitrogen was 1.32. The fertility rating was low for available nitrogen.

Table 35. Status of available nitrogen (kg ha^{-1}) in different taluks of Kozhikode

Sl. No.	Taluks	No. of samples	Range	Mean	Per cent sample category			NIV	Fertility rating
					Low	Medium	High		
1	Kozhikode	30	144.26 - 777.73	345.17	46.67	46.67	6.66	1.14	Low
2	Vadakara	30	119.17 - 934.53	337.97	43.33	43.33	13.34	1.21	Low
3	Koyilandi	42	156.80 - 799.68	326.31	42.86	50.00	7.14	1.62	Medium
# Range/Mean		102	119.17 - 934.53	336.48	44.29	46.67	9.05	1.32	Low

4.4 Available phosphorus

The available Bray-P content ranged from 6.14 to 585.79 kg ha^{-1} with a mean value of 163.89 kg ha^{-1} . The per cent of samples under low, medium and high categories were 1.11, 1.11 and 97.78 respectively. Among the three taluks, Koyilandi recorded the highest per cent of samples under high available P (100 per cent). The mean value of nutrient index for available phosphorus was 2.40. The fertility rating for available phosphorus was high.

Table 36. Status of available phosphorus (kg ha^{-1}) in different taluks of Kozhikode.

Sl. No.	Taluks	No. of samples	Range	Mean	Per cent sample category			NIV	Fertility rating
					Low	Medium	High		
1	Kozhikode	30	6.14 - 329.01	129.56	3.33	0.00	96.67	2.10	Medium
2	Vadakara	30	18.41 - 358.18	165.00	0.00	3.33	96.67	2.12	Medium
3	Koyilandi	42	25.22 - 585.79	197.10	0.00	0.00	100.00	3.00	High
# Range/Mean		102	6.14 - 585.79	163.89	1.11	1.11	97.78	2.40	High

4.5 Available potassium

The available K status in surface soils of different taluks ranged from 28 to 560 kg ha^{-1} . Considering the mean values, the highest value of 262.60 kg ha^{-1} was recorded in Kozhikode taluk and the lowest mean value of 223.88 kg ha^{-1} in Koyilandi taluk. The per cent of samples under low, medium and high categories were 11.43, 54.60 and 33.97 respectively. The mean nutrient index value of available K was 1.79. The fertility rating for available K was medium.

Table 37. Status of available potassium (kg ha^{-1}) in different taluks of Kozhikode

Sl. No.	Taluks	No. of samples	Range	Mean	Per cent sample category			NIV	Fertility Rating
					Low	Medium	High		
1	Kozhikode	30	28.00 - 420.00	262.60	10.00	46.66	43.33	1.67	Medium
2	Vadakara	30	112.00 - 560.00	243.63	10.00	60.00	30.00	1.57	Medium
3	Koyilandi	42	56.00 - 420.00	223.88	14.29	57.14	28.57	2.14	Medium
# Range/Mean		102	28.00 - 560.00	243.37	11.43	54.60	33.97	1.79	Medium

4.6 Available sulphur

The available S content ranged from 0.19 to 323.60 mg kg^{-1} with an mean value of 18.93 mg kg^{-1} . The mean available S status was found to be low in Vadakara taluk (12.67 mg kg^{-1}) and high in Kozhikode taluk (28.65 mg kg^{-1}). The deficient and adequate sample categories were to the tune of 68.57 and 31.42 respectively.

Table 38. Status of available sulphur (mg kg^{-1}) in different taluks of Kozhikode

Sl. No.	Taluks	No. of samples	Range	Mean	Per cent sample category	
					Deficient	Adequate
1	Kozhikode	30	0.57 - 323.60	28.65	73.34	26.66
2	Vadakara	30	0.19 - 81.80	12.67	63.33	36.66
3	Koyilandi	42	0.19 - 125.93	15.47	69.05	30.95
# Range/Mean		102	0.19 - 323.60	18.93	68.57	31.42

4.7 Available micronutrients

The DTPA-Zn content ranged from 0.02 to 10.15 mg kg^{-1} with a mean value of 3.28 mg kg^{-1} . The DTPA-Fe content varied from 6.05 to 268.65 mg kg^{-1} with a mean value of 44.07 mg kg^{-1} . The Fe content was found to be sufficient in all the taluks (100 per cent). The availability of Cu ranged from 0.10 to 11.25 mg kg^{-1} with a mean value of 1.75 mg kg^{-1} . The Mn availability in the soils ranged from 1.30 to 107.75 mg kg^{-1} with a mean of 19.71 mg kg^{-1} . The boron content ranged from 0.51 to 80.00 mg kg^{-1} with a mean value of 2.44 mg kg^{-1} . The nutrient index value ranged from 1.83 to 1.90 for Zn and ranged from 1.98 to 2.00 for Cu. The index value for Fe, Mn and B was 2.00. The fertility rating for micronutrients in the soils of Kozhikode district revealed medium fertility status for Zn, Fe, Cu, Mn and B (Appendix III).

Table 39. Status of available micronutrients (mg kg⁻¹) in different taluks of Kozhikode

Sl. No.	Taluks	No. of samples	Micronutrient status (Range)				
			Zn	Fe	Cu	Mn	B
1	Kozhikode	30	0.02 - 8.46 (3.99)	6.05 - 268.65 (58.63)	0.15 - 11.25 (2.14)	1.30 - 107.75 (27.71)	0.76 - 80.00 (2.69)
2	Vadakara	30	0.03 - 9.38 (3.25)	6.80 - 51.10 (26.71)	0.22 - 3.20 (1.12)	2.10 - 52.50 (14.75)	0.51 - 5.21 (1.97)
3	Koyilandi	42	0.23 - 10.15 (2.78)	17.30 - 256.75 (46.08)	0.10 - 6.75 (1.91)	1.75 - 103.15 (17.55)	1.24 - 5.71 (2.60)
# Range/Mean		102	0.02 - 10.15 (3.28)	6.05 - 268.65 (44.07)	0.10 - 11.25 (1.75)	1.30 - 107.75 (19.71)	0.51 - 80.00 (2.44)

*Values in parenthesis indicate mean

Table 40. Per cent sample category of available micronutrients in different taluks of Kozhikode

Taluk	No of samples	Zn		Fe		Cu		Mn		B	
		D (%)	A (%)	D (%)	A (%)	D (%)	A (%)	D (%)	A (%)	D (%)	A (%)
Kozhikode	30	16.67	83.33	0.00	100	0.00	100	0.00	100	0.00	100
Vadakara	30	10.00	90.00	0.00	100	0.00	100	0.00	100	0.00	100
Koyilandy	42	11.91	88.09	0.00	100	2.38	97.62	0.00	100	0.00	100
Mean	102	12.86	87.14	0.00	100	0.79	99.21	0.00	100	0.00	100

D = Deficient, A = Adequate

Fig. 29 Status of pH in the soils of Kozhikode



Fig. 30 Status of electrical conductivity in the soils of Kozhikode



Fig. 31 Status of organic in the soils of Kozhikode

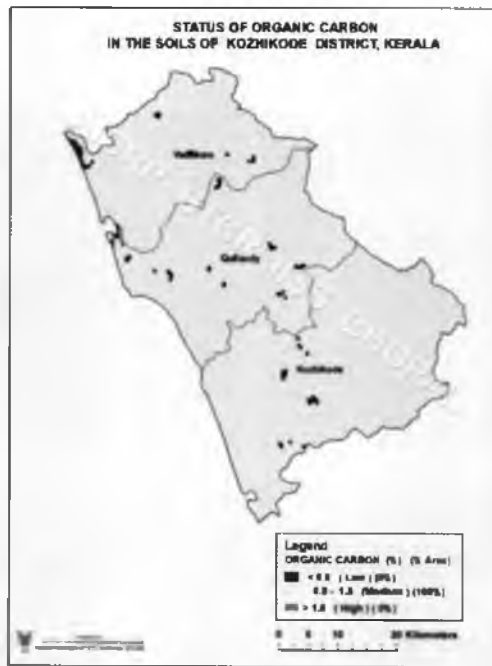


Fig. 32 Status of nitrogen the soils of Kozhikode

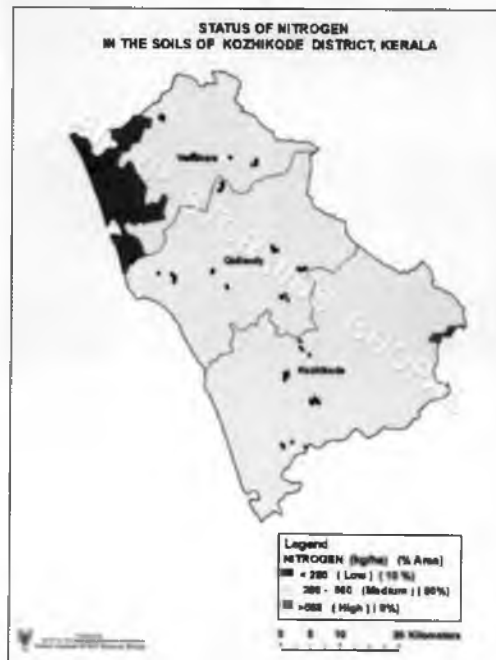


Fig. 33 Status of phosphorus in the soils of Kozhikode



Fig. 34 Status of potassium in the soils of Kozhikode

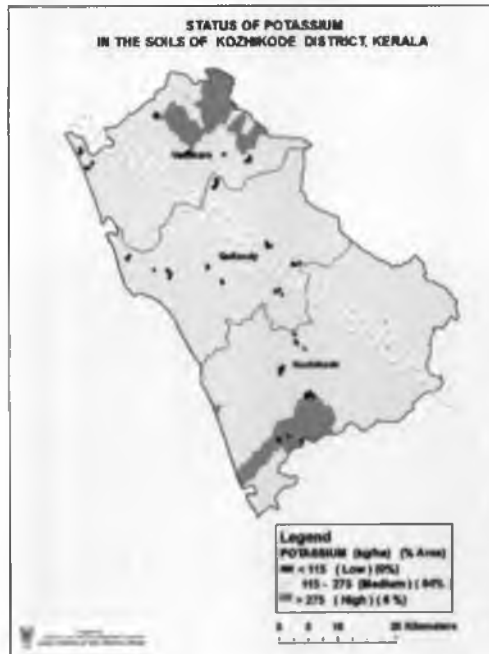


Fig. 35 Status of sulphur in the soils of Kozhikode

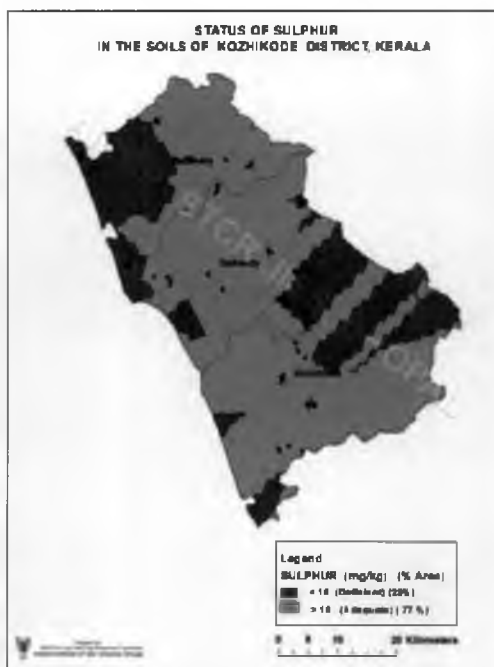


Fig. 36 Status of iron in the soils of Kozhikode

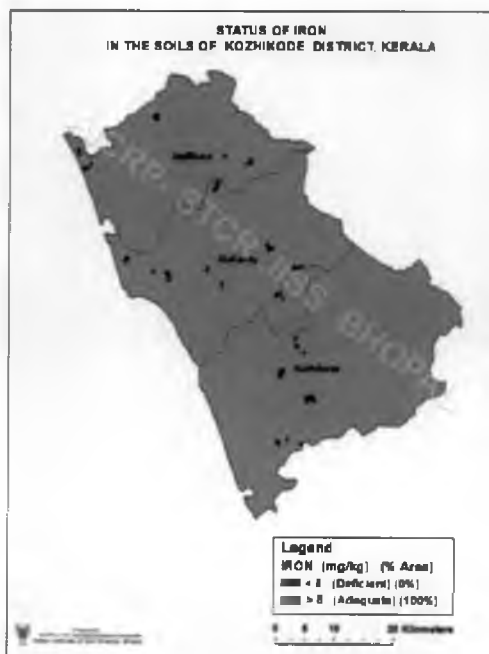


Fig. 37 Status of manganese in the soils of Kozhikode

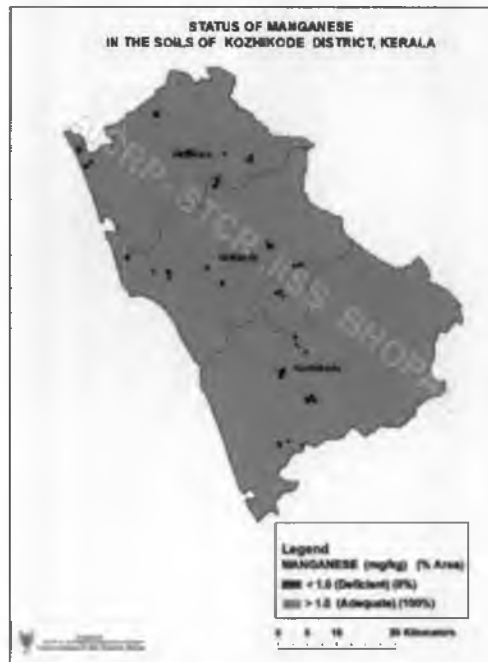


Fig. 38 Status of copper in the soils of Kozhikode



Fig. 39 Status of zinc in the soils of Kozhikode

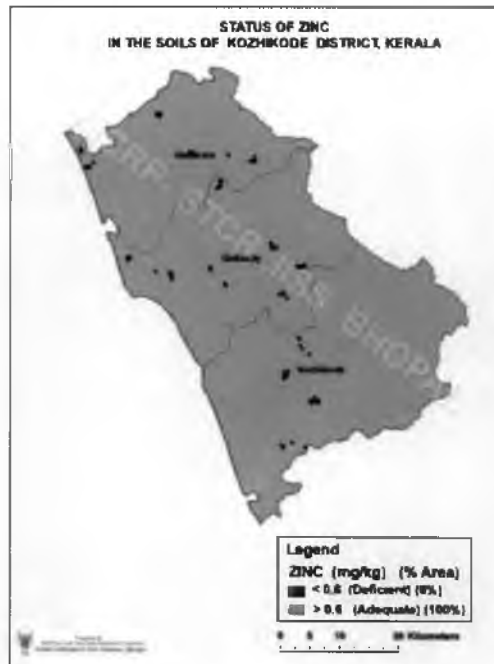


Fig. 40 Status of boron in the soils of Kozhikode

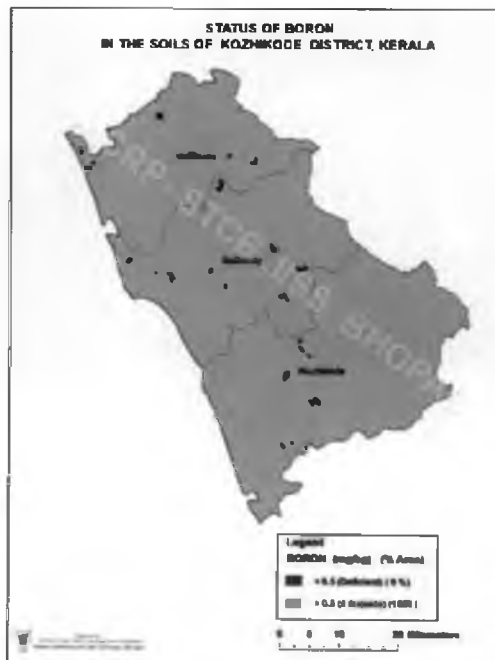


Table 41. Fertilizer recommendations for the farmers of Kozhikode district based on GPS and GIS based soil fertility maps

Main crops: Paddy, coconut, banana, arecanut

<p>Recommendations/ Strategies for soil amendment (for correction of soil acidity/sodicity/salinity etc.)</p>	<p>Acidic soils covered 94 per cent of the total samples. To correct acidity, liming is required by using amendments like lime, dolomite etc. depending upon the soil pH values. The soils are non-saline.</p>
<p>Recommendations/ Strategies for organic matter (this should include application of manures, residues, microbial culture for decomposition like Trichoderma etc.)</p>	<p>Organic carbon – About 95 per cent samples were low to medium in organic carbon status. Organic manures like Vermicomposting, compost crop residues, ash, biofertilizers etc. can be used. Azolla in the paddy field can be incorporated in the soil for increasing the N status of soil.</p>
<p>Recommendations/ Strategies for NPK management</p>	<p>Nitrogen - The content was low in 44 per cent of samples. So apply N Fertilizers as urea, factomphos etc. Phosphorus - 98 per cent samples were high in P. So only maintenance dose is required. Potassium – About 67 per cent samples were low to medium in K status. So K fertilizer application is required.</p>
<p>Recommendations/ Strategies for secondary/micronutrient management</p>	<p>Sulphur – Area wise, 23 per cent was deficient, S application is required as elemental sulphur, gypsum, factomphos etc. Zinc – 13 per cent of samples were deficient. Application of Zinc sulphate was essential Boron and Copper deficiency was not noticed. To correct boron deficiency borax can be used and to correct Cu deficiency $CuSO_4$ can be used.</p>
<p>Training requirements</p>	<p>Training required for STL personnel in coconut leaf vermicomposting and soil analysis.</p>
<p>Any other recommendations</p>	<p>Agricultural extension workers and fertilizer-based firms should create awareness among farmers on the importance of soil fertility maps.</p>

Table 42. Nutrient use based on resource base in Kozhikode

Sl. No.	Nutrients added	Resource base		
		Small	Medium	Large
1	Major nutrients	N-20-70 kg/ha P ₂ O ₅ -25-35 kg/ha K ₂ O- 15-20 kg/ha	N-25-70 kg/ha P ₂ O ₅ -25-40 kg/ha K ₂ O- 20-30 kg/ha	N-25-60 kg/ha P ₂ O ₅ -30-45 kg/ha K ₂ O- 30-40 kg/ha
2	Secondary nutrients	MgSO ₄ -30 kg/ha Lime-80-120 kg/ha	MgSO ₄ -30 kg/ha Lime-150 kg/ha	MgSO ₄ -30 kg/ha Lime-200 kg/ha
3	Micronutrients			
4	Organic manures	FYM-2.5-5 kg/ha	FYM-2.5-5 kg/ha	FYM-2.5-10 kg/ha Groundnut cake- 4-5 kg/ha
5	Biofertilizers			Azospirillum-2.5 kg/ha

Conclusion

The samples collected from the district showed an average pH of 6.22 and electrical conductivity 0.12 dS m⁻¹. Only 9.05 per cent samples showed high nitrogen content and 97.78 per cent samples showed high range of phosphorus content. In the case of available potassium, 54.60 per cent of samples were in medium category and 33.97 per cent in high category. Organic carbon content was found to be medium in all taluks. Among the micronutrients, all the samples were categorized into the adequate level for iron, copper, manganese, zinc and boron. But there was deficiency of sulphur in these soils up to the extent of 68.57 per cent.

Chapter 5

Soil fertility status of Malappuram

The district lies between 10° 41' - 11° 32' N latitude and 75° 49' - 76° 34' E longitude, in the geographical map. Like most of the other districts of the state, Malappuram too consists of three natural divisions, viz; lowland, midland and highland. The low land stretches along the seacoast, the midland in the centre and the highland region towards the east and north-eastern parts. The topography of the district is highly undulating; starting from the hilltops covered with thick forests on the east along the Nilgiris. It gradually slopes down to the valleys and small hills, before finally ending on the sandy tract of luxuriant coconut plantations in the west. The climate is generally hot and humid; the average annual rainfall is 2418.5 mm. Agriculture is the mainstay of the population, involving 75 per cent of the people, directly or indirectly. The agro-ecological zones of the district are depicted in Fig.41.

The main crops raised are paddy, coconut, tapioca, arecanut, cashew, banana, rubber and betel vine. Betel leaf from locally cultivated betel vine in and around Tirur taluk is famous for pungency and quality and is a highly export oriented masticatory.

Table 43. Major crops, fertilizers, organic nutrient sources and sources of irrigation in Malappuram

Crops	Chemical fertilizers	Organic sources	Sources of irrigation
Paddy	Urea	Cow dung	Wells
Banana	Factomphos	Goat manure	
Vegetables	DAP	Wood ash	
Tapioca	Magnesium	Bone meal	
Coconut, Arecanut	sulphate	Neem cake	
Rubber, Betel vine		Rajphos	

The district is divided into six taluks which are Perinthalmanna, Tirur, Nilambur, Ernad, Tirurangadi and Ponnani. A total of 26 villages were selected based on stratified multistage random sampling method covering all the six taluks and 156 surface soil samples (six from each village) were collected using GPS representing small, medium and large farmer category. The samples were processed and were analysed for 12 chemical parameters viz., pH, electrical conductivity, organic carbon, available nitrogen, phosphorus, potassium, sulphur, zinc, copper, iron, manganese and boron.

Fig. 41 Agro ecological map of Malappuram

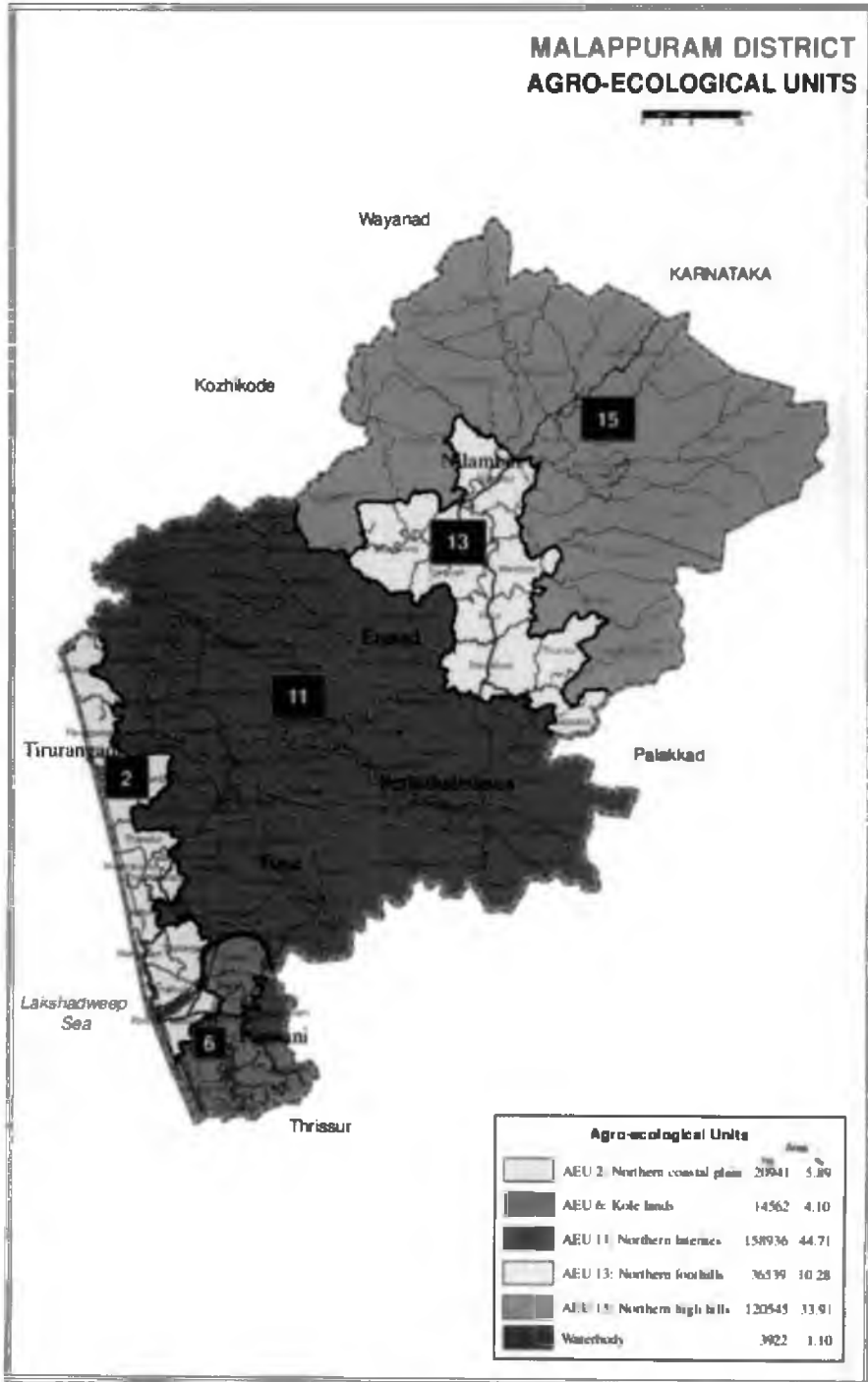


Table 44. Number of villages selected in different taluks of Malappuram

Sl. No.	Name of taluk	Number of villages selected
1	Perinthalmanna	4
2	Tirur	6
3	Nilambur	4
4	Ernad	6
5	Tirurangadi	4
6	Ponnani	2

Table 45. Selected villages in different taluks of Malappuram**Part (A)**

Perinthalmanna	Nilambur	Tirurangadi
Kodur	Pullipadam	Peruvallur
Valambur	Nilambur	A.R.Nagar
Thazhekodde	Chokkad	Parappanangadi
Anamangad	Kerala Estate	Tirurangadi

Part (B)

Tirur	Ernad	Ponnani
Tanalur	Cherukavu	Vattamkulam
Marakkara	Areekkode	Nannamukku
Kottakkal	Kavannoor	
Vettom	Elankur	
Mangalam	Vettikkattiri	
Irimbilyam	Chembrasserri	

Soil fertility status

The results of soil analysis are listed in the following tables. The soil fertility maps generated from the analytical data are presented in figures, 42 to 53. These fertility maps reveal the per cent area under different categories with respect to each parameter in the total geographic area of 3, 550 sq. km in the Malappuram district.

5.1 pH and electrical conductivity

The pH of the surface soils ranged from 4.40 to 7.20 with a mean of 5.82. It was observed that 90.97 per cent of the samples analysed were acidic and 9.03 per cent of the samples were neutral. Alkaline soils were not present. In the taluks of

Nilambur, Tirur, Ponnani, Perinthalmanna, Tirurangadi and Ernad 91.67, 83.33, 91.67, 95.83, 91.67, and 91.67 per cent of samples respectively were acidic.

Table 46. Status of pH in different taluks of Malappuram

Sl. No.	Taluks	Range	Mean	Per cent sample category		
				Acidic	Neutral	Alkaline
1	Tirur	4.80 - 7.20	5.90	83.33	16.67	0.00
2	Tirurangadi	4.80 - 6.70	5.72	91.67	8.33	0.00
3	Ernad	4.80 - 6.70	5.86	91.67	8.33	0.00
4	Nilambur	4.40 - 7.10	5.83	91.67	8.33	0.00
5	Perinthalmanna	4.50 - 6.90	5.80	95.83	4.17	0.00
6	Ponnani	5.00 - 7.10	5.81	91.67	8.33	0.00
# Range /Mean		4.40 - 7.20	5.82	90.97	9.03	0.00

With regard to electrical conductivity (dS m^{-1}), the whole area of the district is non saline. The electrical conductivity of the soils ranged from 0.01 to 0.28 dS m^{-1} with a mean of 0.07 dS m^{-1} .

Table 47. Status of EC (dS m^{-1}) in different taluks of Malappuram

Sl. No.	Taluk	Range	Mean
1	Tirur	0.01 - 0.15	0.06
2	Tirurangadi	0.01 - 0.25	0.07
3	Ernad	0.01 - 0.28	0.08
4	Nilambur	0.02 - 0.17	0.08
5	Perinthalmanna	0.02 - 0.22	0.06
6	Ponnani	0.02 - 0.25	0.08
# Range/Mean		0.01 - 0.28	0.07

5.2 Organic carbon

The organic carbon status of the soil was medium and ranged from 0.12 to 2.19 per cent with a mean value of 0.99 per cent. Nilambur taluk recorded the highest mean organic carbon content of 1.20 per cent followed by Ernad taluk (1.07 per cent). The per cent of soils coming under low, medium and high categories were 11.81, 76.85 and 11.3 respectively.

Table 48. Status of organic carbon (per cent) in different taluks of Malappuram

Sl. No	Taluks	Range	Mean	Per cent sample category			NIV	Fertility rating
				Low	Medium	High		
1	Tirur	0.12-1.36	0.79	30.56	69.44	0.00	1.69	Medium
2	Tirurangadi	0.48-1.76	0.99	16.67	70.83	12.50	2.54	High
3	Ernad	0.15-1.96	1.07	2.78	83.33	13.89	2.11	Medium
4	Nilambur	0.12-2.19	1.20	12.50	62.50	25.00	2.13	Medium
5	Perinthalmanna	0.23-1.85	0.95	8.33	83.33	8.34	2.00	Medium
6	Ponnani	0.78-1.56	1.04	0.00	91.67	8.33	1.83	Medium
# Range/Mean		0.12-2.19	0.99	11.81	76.85	11.34	2.05	Medium

5.3 Available nitrogen

The available nitrogen status in the surface soils ranged from 75.26 to 1501.37 kg ha⁻¹ with a mean value of 604.07 kg ha⁻¹. The per cent of samples under low, medium and high categories were 6.02, 34.72 and 59.26 respectively. Among the six taluks, Nilambur recorded the highest per cent of samples under high available N (79.16); the highest per cent of samples under low available N was observed in Tirur (16.67 per cent). The mean value of nutrient index for available nitrogen was 2.02. The fertility rating was medium for available nitrogen.

Table 49. Status of available nitrogen (kg ha⁻¹) in different taluks of Malappuram

Sl. No	Taluk	Range	Mean	Per cent sample category			NIV	Fertility rating
				Low	Medium	High		
1	Tirur	216.38-953.34	534.49	16.67	33.33	50.00	1.69	Medium
2	Tirurangadi	536.19-1501.37	657.87	8.33	20.83	70.84	2.58	High
3	Ernad	75.26-930.32	637.35	2.78	33.33	63.89	1.33	Medium
4	Nilambur	200.70-849.86	646.78	4.17	16.67	79.16	2.71	High
5	Perinthalmanna	264.87-882.09	587.12	4.17	45.83	50.00	2.46	High
6	Ponnani	304.25-990.47	560.79	0	58.33	41.67	1.33	Medium
# Range/Mean		75.26-1501.37	604.07	6.02	34.72	59.26	2.02	Medium

5.4 Available phosphorus

The available Bray-P content ranged from 0.70 to 393.53 kg ha⁻¹ with a mean value of 45.19 kg ha⁻¹. The per cent of soils under low, medium and high categories

were 26.39, 25.00 and 48.61 respectively. Among the six taluks, Ponnani recorded the highest per cent of samples under high available P (66.67 per cent); the highest per cent of samples under low available P was observed in Ernad taluk (50 per cent). The mean value of nutrient index for available phosphorus was 2.22. The fertility rating for available phosphorus was medium.

Table 50. Status of available phosphorus (kg ha⁻¹) in different taluks of Malappuram

Sl. No	Taluks	Range	Mean	Per cent sample category			NIV	Fertility rating
				Low	Medium	High		
1	Tirur	3.48-242.78	48.90	33.33	25.00	41.67	2.08	Medium
2	Tirurangadi	4.64-393.53	76.67	8.33	29.17	62.50	2.54	High
3	Ernad	0.70-279.41	31.74	50.00	16.67	33.33	1.83	Medium
4	Nilambur	2.32-127.06	26.85	20.83	41.67	37.50	2.17	Medium
5	Perinthalmanna	2.32-217.08	41.27	29.17	20.83	50.00	2.21	Medium
6	Ponnani	1.74-118.41	45.68	16.66	16.67	66.67	2.50	High
# Range/Mean		0.70-393.53	45.19	26.39	25.00	48.61	2.22	Medium

5.5 Available potassium

The available K status in surface soils of different taluks ranged from 33.60 to 873.60 kg ha⁻¹. Considering the mean values, the highest value of 332.73 kg ha⁻¹ was recorded in Perinthalmanna taluk and the lowest mean value of 239.20 kg ha⁻¹ in Tirur taluk. The per cent samples under low, medium and high categories were 12.73, 44.68 and 42.59 respectively. The mean nutrient index value of available K was 2.30. The fertility rating for available K was medium.

Table 51. Status of available potassium (kg ha⁻¹) in different taluks of Malappuram

Sl. No	Taluks	Range	Mean	Per cent sample category			NIV	Fertility rating
				Low	Medium	High		
1	Tirur	84.00-806.40	239.20	11.11	58.33	30.56	2.19	Medium
2	Tirurangadi	134.40-672.00	278.37	4.17	50.00	45.83	2.42	High
3	Ernad	89.60-674.40	248.91	27.78	38.89	33.33	2.06	Medium
4	Nilambur	33.60-873.60	247.80	20.83	54.17	25.00	2.04	Medium
5	Perinthalmanna	44.80-716.80	332.73	4.18	41.69	54.13	2.50	High
6	Ponnani	112.00-571.20	314.53	8.33	25.00	66.67	2.58	High
# Range/Mean		33.60-873.60	276.92	12.73	44.68	42.59	2.30	Medium

5.6 Available sulphur

The available S content ranged from 4.62 to 195.59 mg kg⁻¹ with a mean value of 31.33 mg kg⁻¹. The mean available S status was found to be low in Ponnani taluk (20.57 mg kg⁻¹) and high in Ernad taluk (38.14 mg kg⁻¹). Out of the total samples, 9.95 per cent were deficient and 90.05 per cent were adequate with respect to available S content.

Table 52. Status of available sulphur (mg kg⁻¹) in different taluks of Malappuram

Sl. No	Taluku	Range	Mean	Per cent sample category	
				Deficient	Adequate
1	Tirur	5.20 - 171.13	33.89	11.11	88.89
2	Tirurangadi	4.62 - 195.59	29.45	16.67	83.33
3	Ernad	5.20 - 173.61	38.14	11.11	88.89
4	Nilambur	5.68 - 145.43	31.50	12.50	87.50
5	Perinthalmanna	5.87 - 117.67	34.43	0.00	100.00
6	Ponnani	8.19 - 38.00	20.57	8.33	91.67
# Range/Mean		4.62 - 195.59	31.33	9.95	90.05

5.7 Available micronutrients

The DTPA-Zn content ranged from 0.01 to 25.84 mg kg⁻¹ with a mean value of 2.27 mg kg⁻¹. The DTPA-Fe content varied from 0.20 to 239.40 mg kg⁻¹ with a mean value of 39.52 mg kg⁻¹, Fe was found to be sufficient in all the taluks. The availability of Cu ranged from 0.20 to 41.00 mg kg⁻¹ with a mean value of 3.16 mg kg⁻¹. The Mn availability in the soils ranged from 0.95 to 104.60 mg kg⁻¹ with a mean of 14.93 mg kg⁻¹. The boron content ranged from 0.03 to 22.22 mg kg⁻¹ with a mean value of 2.39 mg kg⁻¹ and 85.88 per cent of the samples were found to be in adequate class. The nutrient index value ranged from 1.47 to 1.92 for Zn, 1.89 to 2.00 for Fe, 1.97 to 2.00 for Mn and 1.67 to 2.00 for B. The index value for Cu was 2.00. The fertility rating for micronutrients in the soils of Malappuram district revealed medium fertility status for Zn, Fe, Cu, Mn and B (Appendix III).

Table 53. Status of available micronutrients in different taluks of Malappuram

Sl. No	Taluks	No. of samples	Micronutrient status (Range)				
			Zn	Fe	Cu	Mn	B
1	Tirur	36	0.03-10.57 (2.44)	0.20-119.70 (39.36)	0.20-14.15 (2.66)	0.95-48.75 (12.51)	0.09-9.34 (1.71)
2	Tirurangadi	24	0.10-25.84 (2.26)	3.15- 93.28 (38.99)	0.45-18.25 (2.78)	1.30-53.55 (15.75)	0.23-11.23 (2.10)
3	Ernad	36	0.01-10.04 (1.18)	1.40-120.35 (31.33)	0.30-6.50 (1.89)	1.52-30.65 (14.28)	0.05-22.22 (2.85)
4	Nilambur	24	0.10-18.24 (3.29)	10.10-239.40 (52.11)	0.63-14.35 (4.27)	1.15-51.35 (12.94)	0.03-20.95 (3.51)
5	Perinthalmanna	24	0.17-9.93 (2.54)	4.15-109.60 (33.74)	0.45-9.85 (2.53)	1.00-104.60 (22.58)	0.92-8.33 (2.21)
6	Ponnani	12	0.48-5.60 (2.51)	1.95-103.85 (41.60)	0.95-41.00 (8.33)	1.31-27.25 (11.23)	0.65-5.13 (1.74)
# Range/Mean		120	0.01-25.84 (2.27)	0.20-239.40 (39.52)	0.20-41.00 (3.16)	0.95-104.60 (14.93)	0.03-22.22 (2.39)

*Values in parenthesis indicate mean

Table 54. Per cent sample category of available micronutrients in different taluks of Malappuram

Taluk	No of samples	Zn		Fe		Cu		Mn		B	
		D (%)	A (%)	D (%)	A (%)	D (%)	A (%)	D (%)	A (%)	D (%)	A (%)
Nilambur	24	33.33	66.67	0.00	100	0	100	0.00	100	12.50	87.50
Tirur	36	36.11	63.89	11.11	88.89	0	100	2.78	97.22	33.33	66.67
Ponnani	12	8.33	91.67	8.33	91.67	0	100	0.00	100	0.00	100
Ernad	36	52.78	47.22	2.78	97.22	0	100	0.00	100	5.56	94.44
Tirurangadi	24	25.00	75.00	4.17	95.83	0	100	0.00	100	20.83	79.17
Perinthalmanna	24	37.50	62.50	4.17	95.83	0	100	0.00	100	12.50	87.50
Mean	120	32.18	67.83	5.09	94.91	0	100	0.46	99.54	14.12	85.88

D = Deficient, A = Adequate

Fig. 42 Status of pH in the soils of Malappuram



Fig. 43 Status of electrical conductivity in the soils of Malappuram



Fig. 44 Status of organic carbon in the soils of Malappuram



Fig. 45 Status of nitrogen in the soils of Malappuram

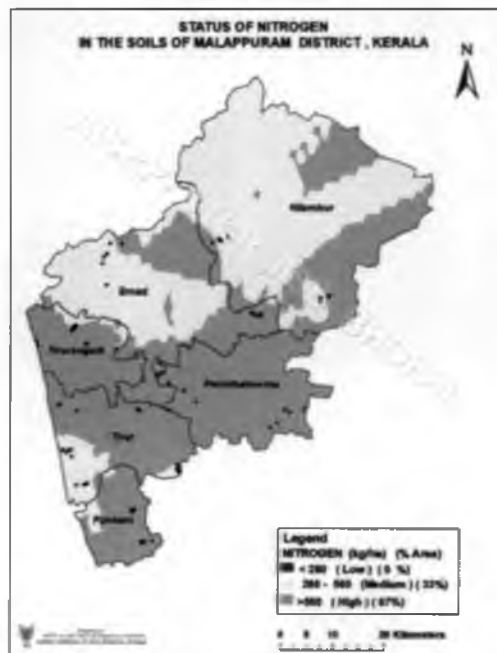


Fig. 46 Status of phosphorus in the soils of Malappuram



Fig. 47 Status of potassium in the soils of Malappuram

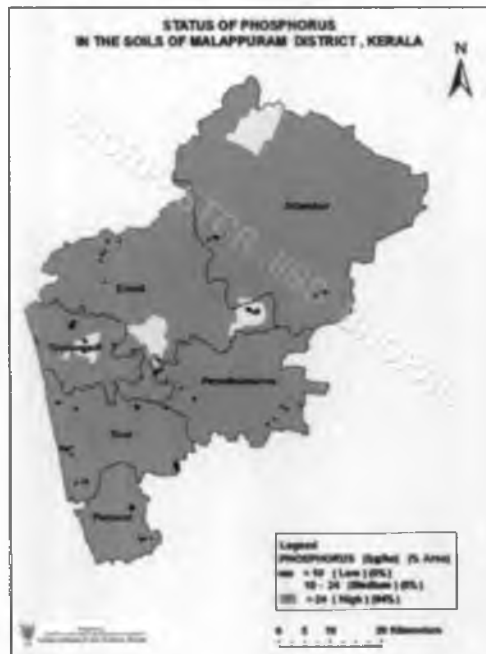


Fig. 48 Status of sulphur in the soils of Malappuram



Fig. 49 Status of iron in the soils of Malappuram



Fig. 50 Status of manganese in the soils of Malappuram



Fig. 51 Status of copper in the soils of Malappuram

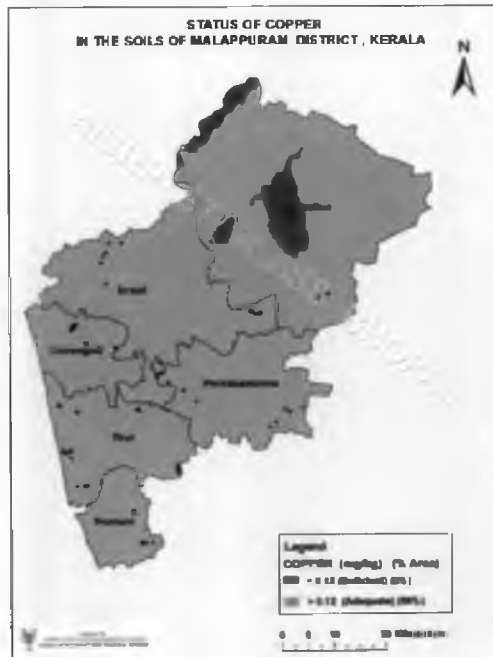


Fig. 52 Status of zinc in the soils of Malappuram

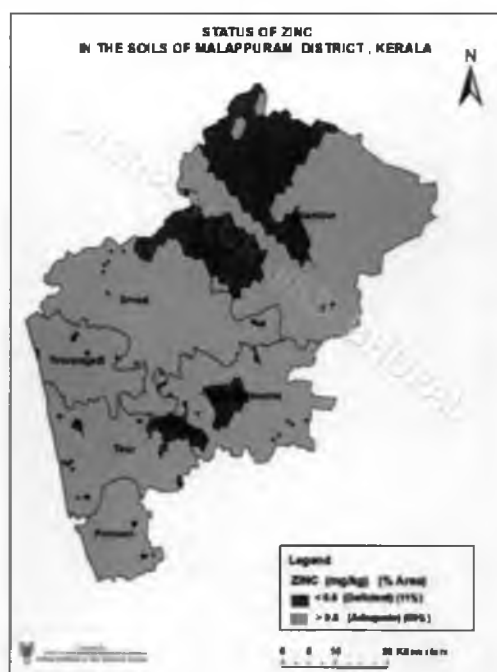


Fig. 53 Status of boron in the soils of Malappuram



Table 55. Fertilizer recommendations for the farmers of Malappuram district based on GPS and GIS based soil fertility maps

Main crops: Paddy, banana, coconut, vegetables, betel vine

<p>Recommendations/ Strategies for soil amendment (for correction of soil acidity/sodicity/salinity etc.)</p>	<p>The soils of Malappuram district were acidic (100 per cent) and should be ameliorated with agricultural lime. Subsidy for liming materials will help the farmers to bring the area to normal pH.</p>
<p>Recommendations/ Strategies for organic matter (this should include application of manures, residues, microbial culture for decomposition like Trichoderma etc.)</p>	<p>Farmers should be encouraged to apply more FYM, organic manure, crop residues, green manure, vermi compost as these areas were medium in organic carbon. Composting, vermi composting, cultivation of green manure crops etc. can raise the organic matter content.</p>
<p>Recommendations/ Strategies for NPK management</p>	<p>Nitrogen - Most areas of the district were medium to high in available N (94 per cent). Hence N fertilizers should be applied judiciously. Phosphorus - High doses of P should be avoided in areas with high available P content (94 per cent). Liming the soils to correct the pH is essential for P availability. Application of phosphorus solubilizing microbes or bio fertilizers should be encouraged. Potassium – Soil samples were medium to high in available K (about 90 per cent). Hence, K fertilizers should be recommended judiciously. About 12.73 per cent of the samples were low in available K. So application of K fertilizer like M.O.P according to soil test value is essential. In addition, locally available organic residue application should be encouraged.</p>
<p>Recommendations/ Strategies for secondary/micronutrient management</p>	<p>In areas low in Zn (11 per cent), application of ZnSO₄ @ 25 kg/ha is essential, irrespective of crops grown. In Ernad taluk, 52.78% of samples were deficient. All the other secondary and micronutrients were adequate; hence, only need-based application is required.</p>
<p>Training requirements</p>	<p>1) Maintaining soil health by the addition of organic matter. 2) Imparting hands on training in composting/vermicomposting, green manuring, application of bio fertilizers etc. 3) Training on use of bio fertilizers and their importance. 4) Awareness on importance of liming in acidic soils and timely application of lime.</p>
<p>Any other recommendations</p>	<p>Creation of awareness among the farmers about soil testing, soil test based fertilizer recommendations by extension workers and fertilizer companies.</p>

Table 56. Nutrient uses based on resource base in Malappuram

Sl. No.	Nutrients added	Resource base		
		Small	Medium	Large
1	Major nutrients	N-50-120 kg/ha P ₂ O ₅ -35-40 kg/ha K ₂ O- 60-100 kg/ha	N-60-120 kg/ha P ₂ O ₅ -35-40 kg/ha K ₂ O- 20-30 kg/ha	N-60-120 kg/ha P ₂ O ₅ -30-40 kg/ha K ₂ O- 20-30 kg/ha
2	Secondary nutrients	Lime-100 kg/ha	MgSO ₄ -20 kg/ha Lime-150 kg/ha	MgSO ₄ -25 kg/ha Lime-200 kg/ha
3	Micro nutrients		Micro food and micronutrient mixture	
4	Organic manures	Neem cake - 20 kg/ha Ground nut cake-50-80 kg/ha	Neem cake - 20kg/ha Ground nut cake-50-80 kg/ha	POABS mixture FYM-2.5-25 kg/ha
5	Bio fertilizers	Pseudomonas-1-2 kg/ha		

Conclusion

Samples collected from different villages of Malappuram district showed a mean pH of 5.82 and EC of 0.07 dS m⁻¹. Only a small percentage of samples were coming under the low category of available nitrogen. High phosphorus content was observed in 48.61 per cent of samples. Potassium content in the soil samples were found to be in medium category (44.68 per cent). More than 60 per cent samples from different taluks belonged to the medium range of organic carbon. Adequate level of sulphur was observed in the samples. Regarding the status of micronutrients, more than 90 per cent of samples were categorized in the adequate levels for iron, copper and manganese. Boron was also found to be in adequate level. But deficiency for zinc was noticed in these samples (32.18 per cent).

Chapter 6

Soil fertility status of Thrissur

Thrissur is situated in south western part of India at 10°10' - 10° 47' N latitude and 75°57' - 76°55' E longitude and is in the central part of Kerala. The total geographical area is 3032 sq.km with an annual average rainfall of 2189.5 mm and annual temperature of 27.68°C. It is bounded on the north by Palakkad and Malappuram districts, on the east by Palakkad district and Coimbatore district of Tamil Nadu, south by Ernakulam district and on the west by the Arabian Sea. The main type of soil is laterite and to a limited extent sandy loam. The agro-ecological zones of the district are depicted in Fig.54.

Main crops cultivated in Thrissur district are paddy, vegetables and plantation crops like coconut and arecanut. Special type of paddy fields known as 'kole' lands also exist here.

Table 57. Major crops, fertilizers, organic nutrient sources and sources of irrigation in Thrissur

Crops	Chemical fertilizers	Organic sources	Sources of irrigation
Paddy	Urea	Cow dung	Wells
Banana	Factomphos	Poultry manure	
Vegetables	MOP	Goat manure	
Pepper	Rubber mixture	Bone meal	
Nutmeg	Coconut mixture	Green leaves	
Coconut		Castor cake	
Arecanut		Wood ash	
Rubber		Vermi compost	
		Ground nut cake	
		Lime	

The district is divided into five taluks viz., Thrissur, Thalappilly, Mukundapuram, Kodungallur and Chavakkad. A total of 41 villages were selected based on stratified multistage random sampling method covering all the five taluks and a total of 246 surface soil samples (six from each village) were collected using GPS representing small, medium and large farmer category. The samples were processed and were analysed for 12 chemical parameters viz., pH, electrical conductivity, organic carbon, available nitrogen, phosphorus, potassium, sulphur, zinc, copper, iron, manganese and boron.

Fig. 54 Agro ecological map of Thrissur

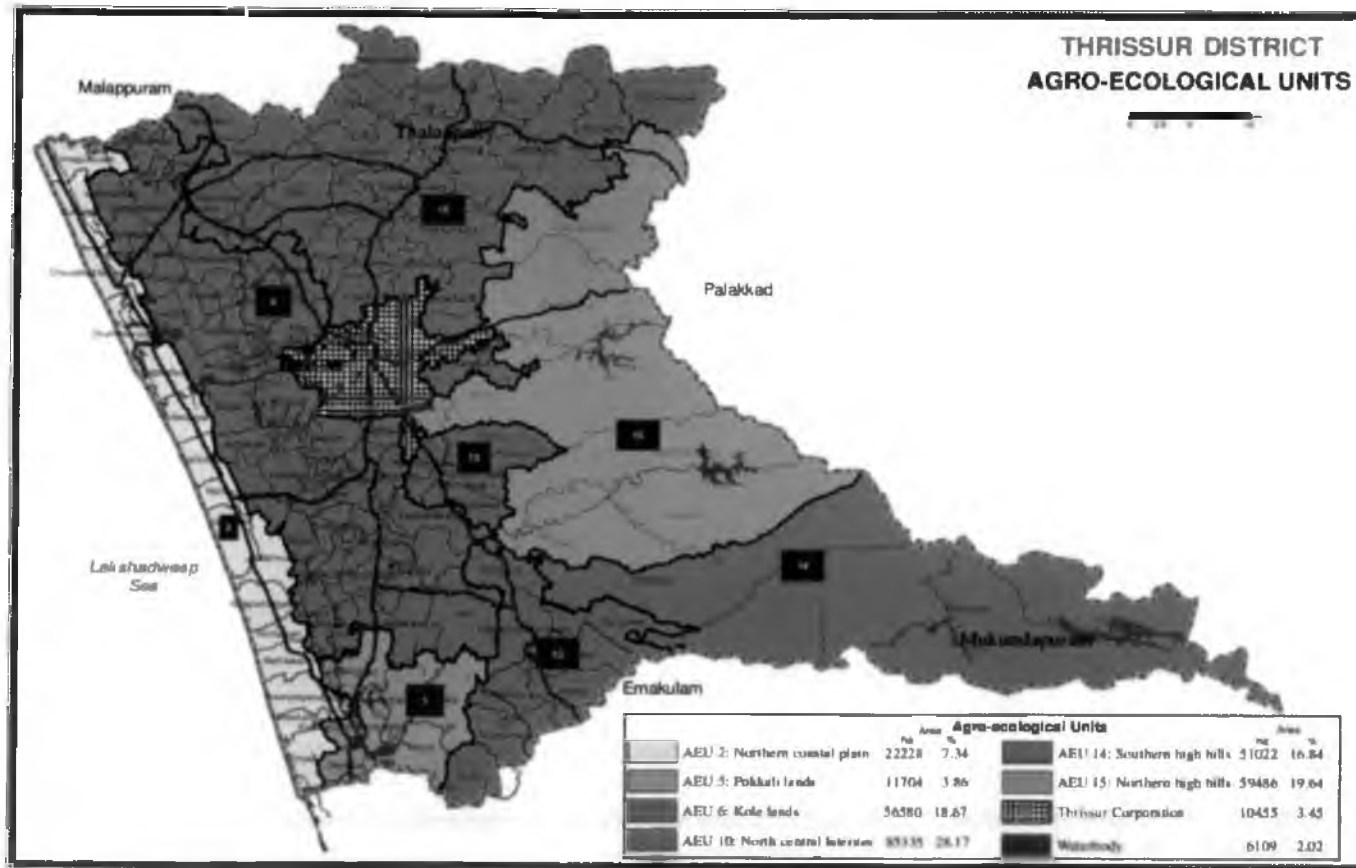


Table 58. Number of villages selected in different taluks of Thrissur

Sl. No.	Name of taluk	Number of villages selected
1	Thrissur	10
2	Thalappilly	14
3	Mukundapuram	10
4	Kodungallur	3
5	Chavakkad	4

Table 59. Selected villages in different taluks of Thrissur**Part (a)**

Thrissur	Thalappilly	Mukundapuram
Kaiparamba	Kadangode	Karalam
Avanur	Arangottukara	Porathisseri
Killannur	Desamangalam	Parappukkara
Peramangalam	Varavoor	Varandarappilly
Tholur	Painkulam	Velukkara
Chalakkal	Kaniyarkode	Kallettumkara
Puthur	Pampadi	Vellikulangara
Eravu	Chittanda	Thazhekkad
Padiyam	Eranellur	Puthenchira
Paralam	Velur	Vadakkumbhagom
	Thekkumkara	
	Kurumala	
	Chelakkara	
	Pangarappilli	

Part (b)

Kodungallur	Chavakkad
Chendrappini	Kadikkad
Edavilangu	Elavally
Pallipuram	Vadanappilly
	Nattika

Soil fertility status

The results of soil analysis are listed in the following tables. The soil fertility maps generated from the analytical data are presented in figures, 55 to 66. These fertility maps reveal the per cent area under different categories with respect to each parameter in the total geographic area of 3,032 sq. km in the Thrissur district.

6.1 pH and electrical conductivity

The pH of the surface soils ranged from 3.50 to 7.40. It was observed that 92.19 per cent of the samples analysed were acidic and 7.81 per cent of the samples were neutral. Alkaline soils were not present. In Thrissur, Thalappilly, Mukundapuram Chavakkad and Kodungallur taluks, above 89 per cent of samples were acidic.

Table 60. Status of pH in different taluks of Thrissur

Sl. No.	Taluks	No. of samples	Range	Mean	Per cent sample category		
					Acidic	Neutral	Alkaline
1	Thrissur	60	3.50-7.20	5.60	90.00	10.00	0
2	Thalappilly	84	4.30-7.40	5.70	89.28	10.72	0
3	Mukundapuram	60	4.10-7.40	5.60	90.00	10.00	0
4	Chavakkad	24	4.70-6.80	5.70	91.67	8.33	0
5	Kodungallur	18	4.60-6.20	5.60	100.00	0.00	0
# Range /Mean		246	3.50-7.40	5.64	92.19	7.81	0

With regard to electrical conductivity (dS m^{-1}), the whole area of the district was non-saline. The electrical conductivity of the soils ranged from 0.01 to 0.46 dS m^{-1} with a mean of 0.06 dS m^{-1} .

Table 61. Status of EC (dS m^{-1}) in different taluks of Thrissur

Sl. No.	Taluks	Range	Mean
1	Thrissur	0.02 - 0.46	0.09
2	Thalappilly	0.02 - 0.19	0.07
3	Mukundapuram	0.01 - 0.25	0.07
4	Chavakkad	0.02 - 0.23	0.06
5	Kodungallur	0.01 - 0.10	0.03
# Range/Mean		0.01 - 0.46	0.06

6.2 Organic carbon

The organic carbon status of the soil was medium and ranged from 0.13 to 1.76 per cent with a mean value of 0.62 per cent. Mukundapuram taluk recorded the highest mean organic carbon content of 0.79 per cent followed by Thalappilly taluk (0.76 per cent). The per cent of soils coming under low, medium and high categories were 36.25, 59.06 and 4.68 respectively.

Table 62. Status of organic carbon (per cent) in different taluks of Thrissur

Sl. No.	Taluks	No. of samples	Range	Mean	Per cent sample category			NIV	Fertility Rating
					Low	Medium	High		
1	Thrissur	60	0.21-1.76	0.69	26.66	61.67	11.67	1.75	Medium
2	Thalappilly	84	0.22-1.42	0.76	10.71	88.10	1.19	1.90	Medium
3	Mukundapuram	60	0.20-1.64	0.79	21.67	73.33	5.00	1.82	Medium
4	Chavakkad	24	0.13-1.04	0.34	83.33	16.67	0.00	1.17	Low
5	Kodungallur	18	0.19-1.09	0.54	38.90	55.54	5.56	1.56	Medium
# Range /Mean		246	0.13-1.76	0.69	36.25	59.06	4.68	1.64	Medium

6.3 Available nitrogen

The available nitrogen status in the surface soils ranged from 32.17 to 2229.70 kg ha⁻¹ with a mean value of 518.62 kg ha⁻¹. The per cent samples under low, medium and high categories were 16.90, 52.65 and 30.45 respectively. Among the five taluks, Kodungallur recorded the highest per cent of samples under medium available N (61.11); highest per cent of samples under low available N was observed in Chavakkad and Kodungallur taluks (33.33 per cent). The mean value of nutrient index for available nitrogen was 2.27. The fertility rating was medium for available nitrogen.

Table 63. Status of available nitrogen (kg ha⁻¹) in different taluks of Thrissur

Sl. No	Taluks	No. of samples	Range	Mean	Per cent sample category			NIV	Fertility Rating
					Low	Medium	High		
1	Thrissur	60	32.17-1395.50	551.47	15.00	43.33	41.67	2.15	Medium
2	Thalappilly	84	213.24-2229.70	669.38	1.19	48.81	50.00	2.49	High
3	Mukundapuram	60	263.42-2132.40	684.00	1.67	51.67	46.66	2.45	High
4	Chavakkad	24	46.47-862.40	332.52	33.33	58.33	8.34	1.75	Medium
5	Kodungallur	18	91.29-928.25	355.75	33.33	61.11	5.56	1.72	Medium
# Range /Mean		246	32.17-2229.70	518.62	16.90	52.65	30.45	2.27	Medium

6.4 Available phosphorus

The available Bray-P content ranged from 1.36 to 657.42 kg ha⁻¹ with a mean value of 148.58 kg ha⁻¹. The per cent of soils under low, medium and high categories were 4.52, 5.19 and 90.29 respectively. Among the five taluks, Mukundapuram recorded the highest per cent of samples under high available P (96.66); the highest per cent of samples under low available P was observed in Thalappilly taluk (9.52). The mean value of nutrient index for available phosphorus was 2.86. The fertility rating for available phosphorus was high.

Table 64. Status of available phosphorus (kg ha⁻¹) in different taluks of Thrissur

Sl. No.	Taluks	No. of samples	Range	Mean	Per cent sample category			NIV	Fertility Rating
					Low	Medium	High		
1	Thrissur	60	2.63 - 657.42	126.33	1.67	10.00	88.33	2.87	High
2	Thalappilly	84	1.36 - 448.58	81.50	9.52	14.29	76.19	2.67	High
3	Mukundapuram	60	9.97 - 492.00	143.25	1.67	1.67	96.66	2.95	High
4	Chavakkad	24	7.17 - 569.60	174.47	4.17	0.00	95.83	2.92	High
5	Kodungallur	18	3.94 - 648.69	217.37	5.56	0.00	94.44	2.89	High
# Range /Mean		246	1.36 - 657.42	148.58	4.52	5.19	90.29	2.86	High

6.5 Available potassium

The available K status in surface soils of different taluks ranged from 26.88 to 1400.00 kg ha⁻¹. Considering the mean values, the highest value of 375.84 kg ha⁻¹ was recorded in Thalappilly taluk and the lowest mean value of 197.86 kg ha⁻¹ in Kodungallur taluk. The per cent samples under low, medium and high categories were 15.09, 41.68 and 43.23 respectively. The mean nutrient index value of available K was 2.42. The fertility rating for available K was high.

Table 65. Status of available potassium (kg ha⁻¹) in different taluks of Thrissur.

Sl. No.	Taluks	No. of samples	Range	Mean	Per cent sample category			NIV	Fertility Rating
					Low	Medium	High		
1	Thrissur	60	80.64 - 840.00	306.50	5.00	46.67	48.33	2.47	High
2	Thalappilly	84	26.88 - 1400.00	375.84	7.14	29.76	63.10	2.54	High
3	Mukundapuram	60	67.20 - 1064.00	353.03	5.00	33.33	61.67	2.57	High
4	Chavakkad	24	56.00 - 896.00	230.99	25.00	54.17	20.83	1.96	Medium
5	Kodungallur	18	56.00 - 806.40	197.86	33.33	44.45	22.22	1.89	Medium
# Range/Mean		246	26.88 - 1400.00	292.84	15.09	41.68	43.23	2.42	High

6.6 Available sulphur

The available S content ranged from 3.26 to 356.97 mg kg⁻¹ with a mean value of 40.21 mg kg⁻¹. The mean available S status was found to be low in Thalappilly taluk (25.92 mg kg⁻¹) and high in Thrissur taluk (49.71 mg kg⁻¹). With respect to available S content 4.04 per cent of samples were deficient and 95.96 per cent were adequate.

Table 66. Status of available sulphur (mg kg⁻¹) in different taluks of Thrissur

Sl. No.	Taluks	No. of samples	Range	Mean	Per cent sample category	
					Deficient	Adequate
1	Thrissur	60	8.81 - 356.97	49.71	1.66	98.33
2	Thalappilly	84	3.52 - 77.72	25.92	7.14	92.86
3	Mukundapuram	60	3.26 - 224.56	35.57	1.67	98.33
4	Chavakkad	24	3.52 - 321.39	42.06	4.17	95.83
5	Kodungallur	18	7.93 - 292.99	47.77	5.56	94.44
# Range/Mean		246	3.26 - 356.97	40.21	4.04	95.96

6.7 Available micronutrients

The DTPA-Zn content ranged from 0.03 to 66.53 mg kg⁻¹ with a mean value of 2.78 mg kg⁻¹. The DTPA-Fe content varied from 4.00 to 238.32 mg kg⁻¹ with a mean value of 66.93 mg kg⁻¹. Fe was found to be sufficient in all the taluks. The availability of Cu ranged from 0.23 to 41.28 mg kg⁻¹ with a mean value of 3.86 mg kg⁻¹. The Mn availability in the soils ranged from 0.10 to 300.25 mg kg⁻¹ with a mean of 31.82 mg kg⁻¹. The boron content ranged from 0.03 to 21.15 mg kg⁻¹ with a mean value of 2.14 mg kg⁻¹. The nutrient index value ranged from 1.77 to 1.90 for

Zn, 1.98 to 2.00 for Fe, 1.96 to 2.00 for Cu, 1.72 to 1.99 for Mn and 1.63 to 1.85 for B. The fertility rating for micronutrients in the soils of Thrissur district revealed medium fertility status for Zn, Fe, Cu, Mn and B (Appendix III).

Table 67. Status of available micronutrients (mg kg⁻¹) in different taluks of Thrissur

Sl. No.	Taluks	No. of samples	Micronutrient status (Range)				
			Zn	Fe	Cu	Mn	B
1	Thrissur	60	0.03-8.19 (2.13)	4.95-156.52 (54.75)	0.30-29.98 (4.75)	0.72-156.87 (33.06)	0.03-11.11 (1.89)
2	Thalappilly	84	0.11-13.21 (2.70)	4.00-186.20 (68.11)	0.23-41.28 (4.10)	1.27-300.25 (48.69)	0.07-10.33 (2.27)
3	Mukundapuram	60	0.03-66.53 (4.07)	7.68-238.32 (78.59)	0.37-39.70 (4.05)	0.12-183.27 (23.87)	0.07-21.15 (2.78)
4	Chavakkad	24	0.39-4.23 (2.02)	23.17-216.35 (68.79)	0.58-3.50 (1.75)	0.37-7.60 (5.17)	0.07-1.04 (0.73)
5	Kodungallur	18	0.23-4.09 (2.05)	6.83-118.72 (60.63)	0.25-7.15 (1.95)	0.10-103.37 (10.95)	0.30-8.73 (1.97)
# Range/Mean		246	0.03-66.53 (2.78)	4.00-238.32 (66.93)	0.23-41.28 (3.86)	0.10-300.25 (31.82)	0.03-21.15 (2.14)

* Values in parenthesis indicate mean

Table 68. Per cent sample category of available micronutrients in different taluks of Thrissur

Taluks	No of samples	Zn		Fe		Cu		Mn		B	
		D (%)	A (%)	D (%)	A (%)	D (%)	A (%)	D (%)	A (%)	D (%)	A (%)
Thrissur	60	23.33	76.67	1.67	98.33	0.00	100	1.67	98.33	31.67	68.33
Thalappilly	84	17.86	82.14	1.19	98.81	0.00	100	1.19	98.81	15.47	84.53
Mukundapuram	60	10.00	90.00	0.00	100	0.00	100	3.33	96.67	20.00	80.00
Chavakkad	24	20.83	79.17	0.00	100	4.17	95.83	8.33	91.67	37.50	62.50
Kodungallur	18	16.66	83.33	0.00	100	0.00	100	27.77	72.23	16.67	83.33
Mean	246	17.74	82.26	0.57	99.43	0.83	99.17	8.46	91.54	24.26	75.74

D = Deficient, A = Adequate

Fig. 55 Status of pH in the soils of Thrissur

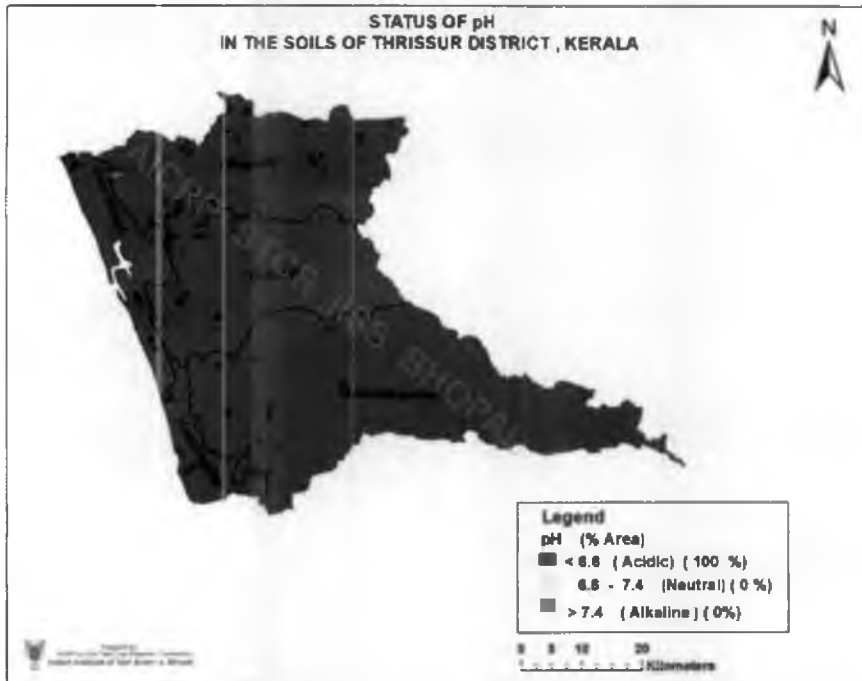


Fig. 56 Status of electrical conductivity in the soils of Thrissur

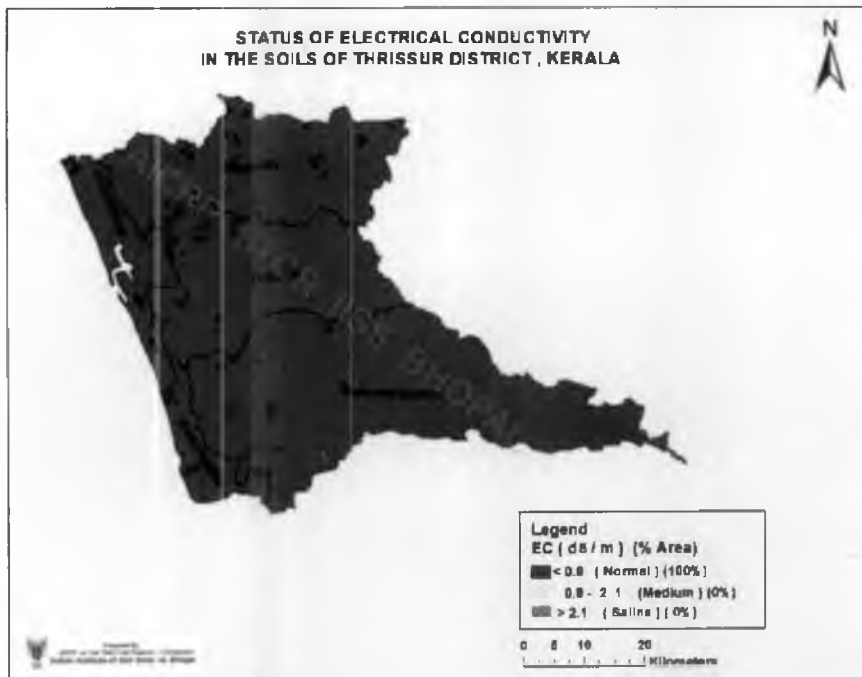


Fig. 57 Status of organic carbon in the soils of Thrissur

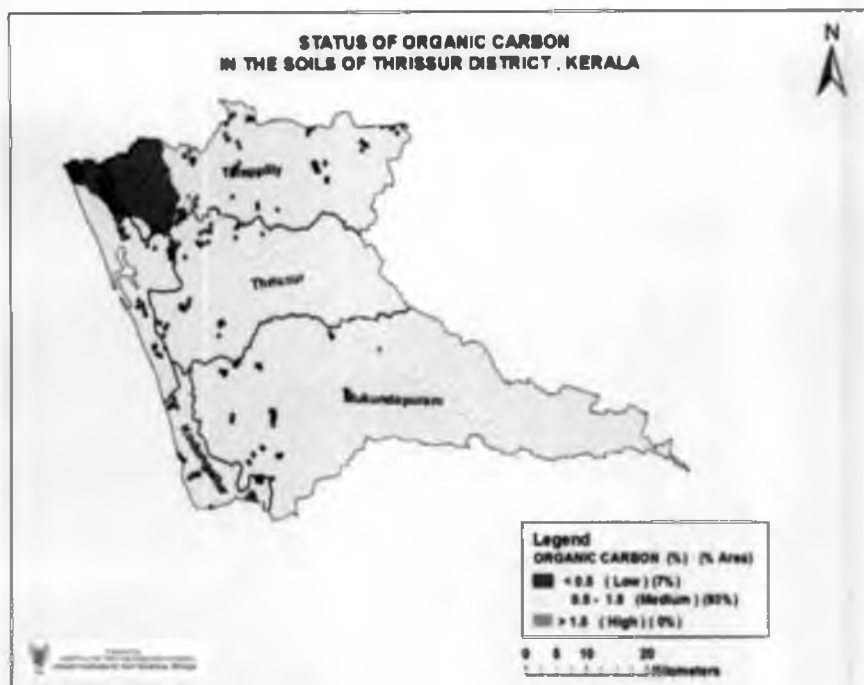


Fig. 58 Status of nitrogen in the soils of Thrissur

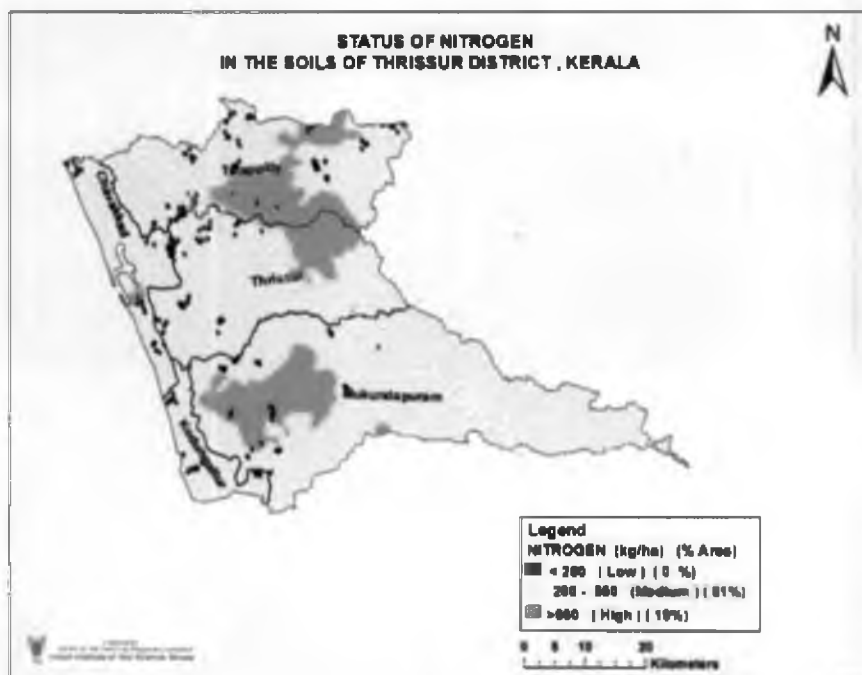


Fig. 59 Status of phosphorus in the soils of Thrissur

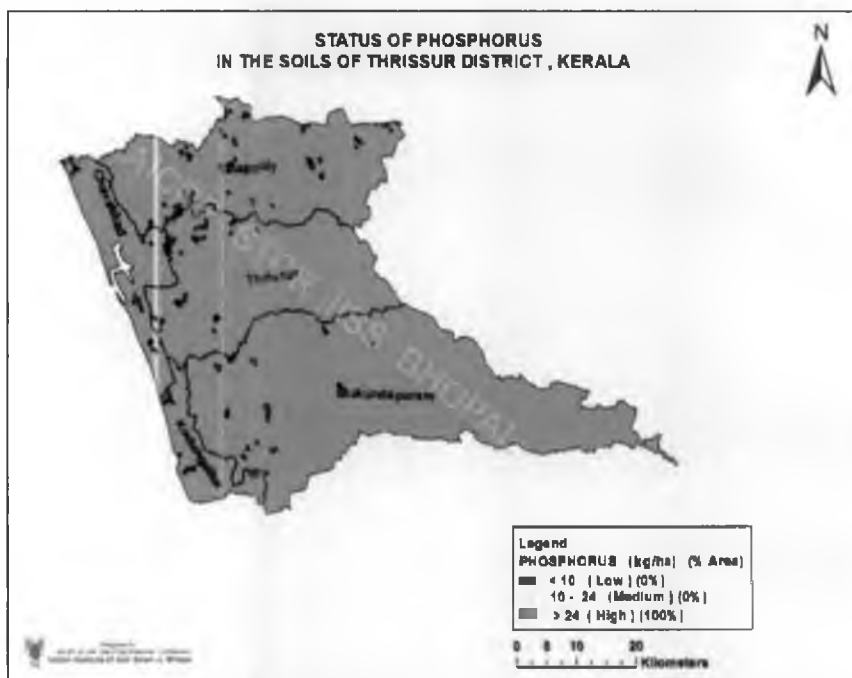


Fig. 60 Status of potassium in the soils of Thrissur

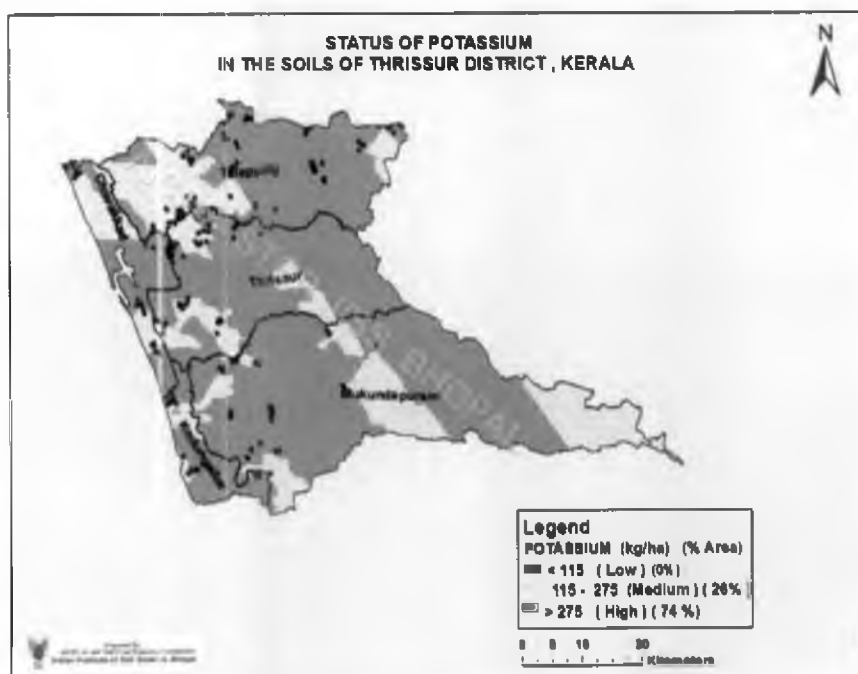


Fig. 61 Status of sulphur in the soils of Thrissur

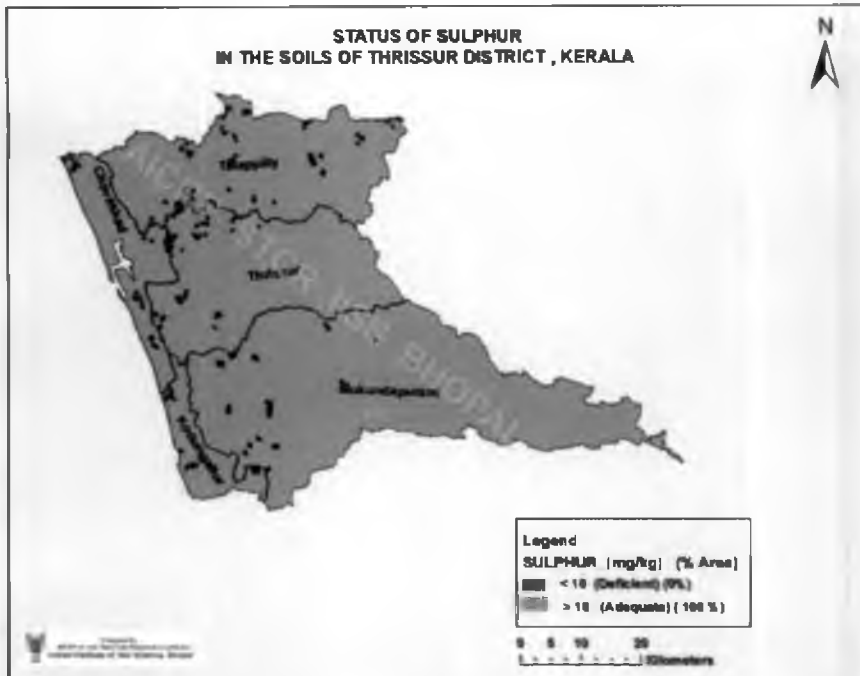


Fig. 62 Status of iron in the soils of Thrissur

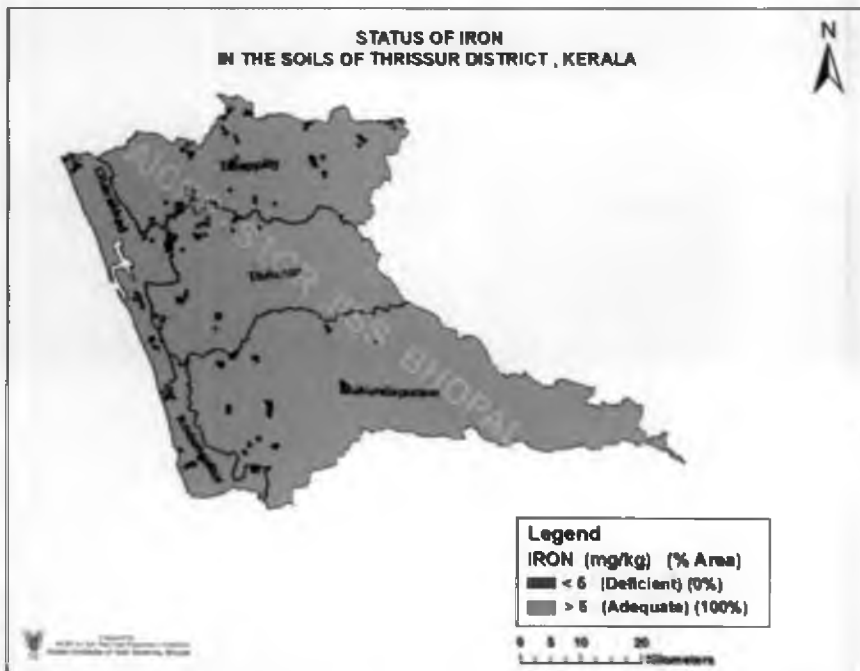


Fig. 63 Status of manganese in the soils of Thrissur

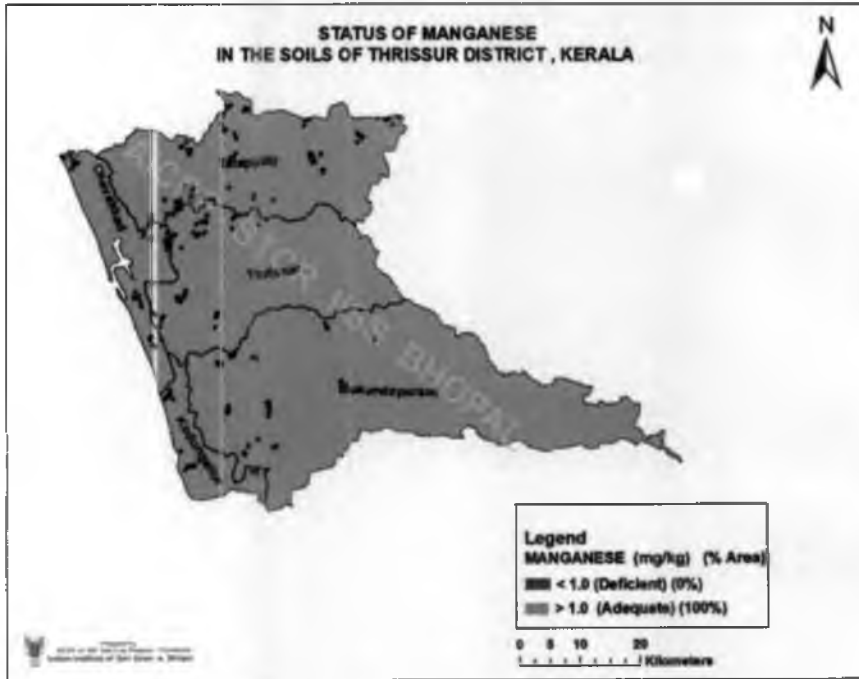


Fig. 64 Status of copper in the soils of Thrissur

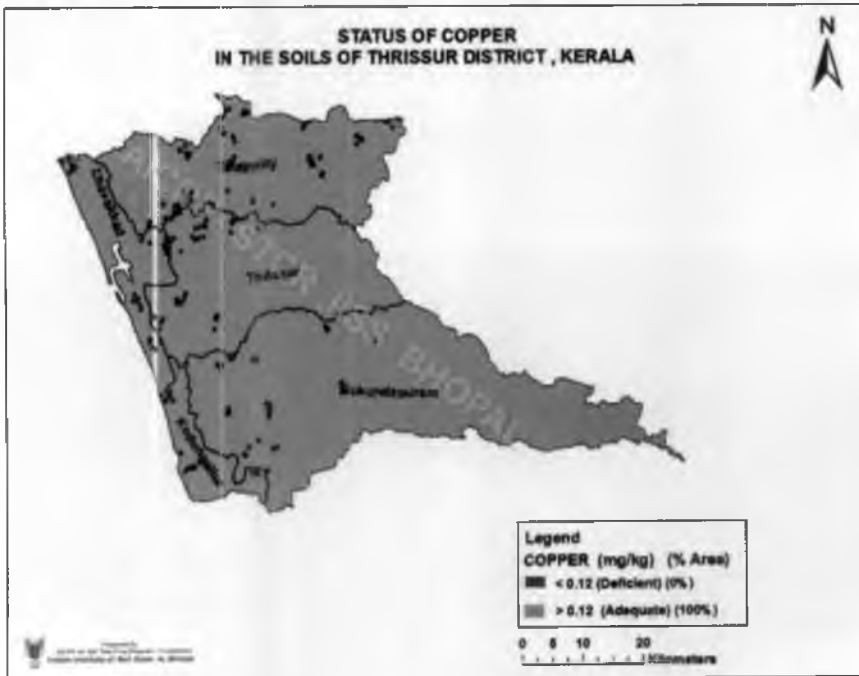


Fig. 65 Status of zinc in the soils of Thrissur

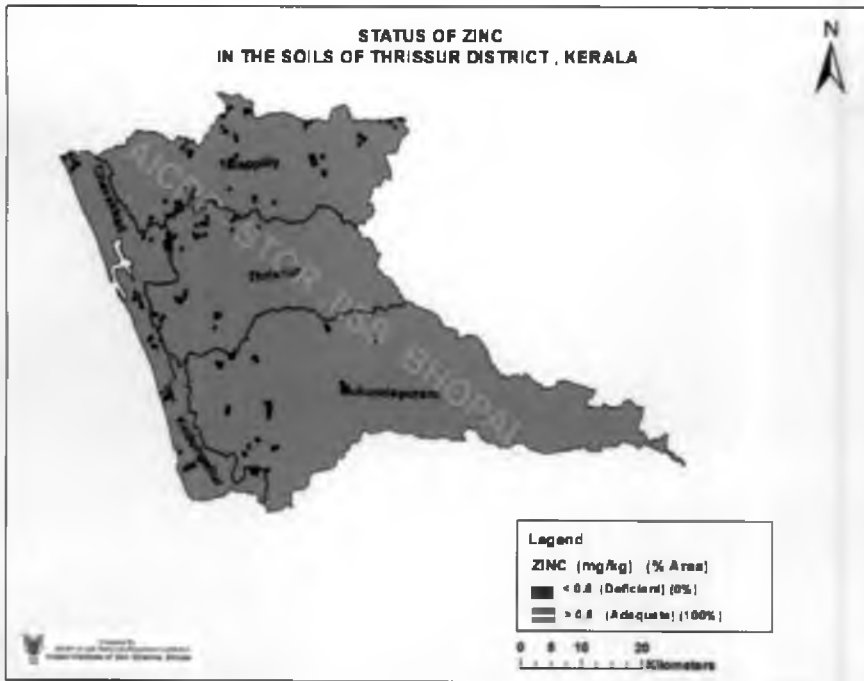


Fig. 66 Status of boron in the soils of Thrissur

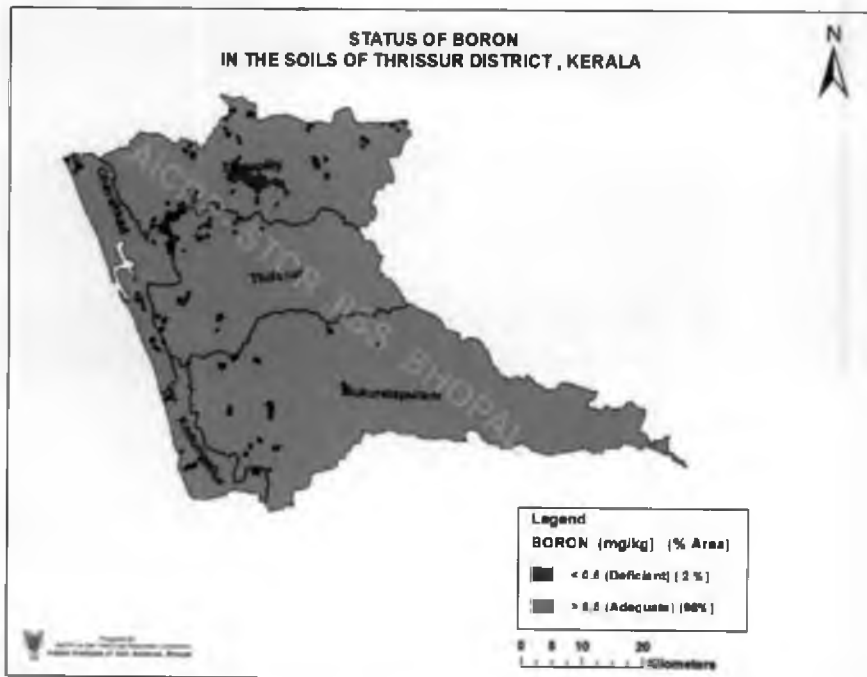


Table 69. Fertilizer recommendations for the farmers of Thrissur district based on GPS and GIS based soil fertility maps

Main crops: Paddy, coconut, banana, vegetables

<p>Recommendations/ Strategies for soil amendment (for correction of soil acidity/sodicity/salinity etc.)</p>	<p>The soils of Thrissur district were acidic (92 per cent) and nonsaline. It should be ameliorated with agricultural lime. For paddy 600 kg/ ha lime is needed. Subsidy for liming materials will help the farmers to bring the area to normal pH.</p>
<p>Recommendations/ Strategies for organic matter (this should include application of manures, residues, microbial culture for decomposition like Trichoderma etc.)</p>	<p>Application of organic manure should be monitored. Other organic sources like vermicompost etc can be advocated. Ninety five per cent of samples came under low to medium in organic carbon. Trichoderma can also be applied.</p>
<p>Recommendations/ Strategies for NPK management</p>	<p>Nitrogen - Thrissur and sandy tracts of Chavakkad and Kodungalloor taluks require N fertilizers. Use coated N fertilizers to avoid the leaching loss. Phosphorus - High doses of P should be avoided in the area with high available 'P' content. (90 per cent). Liming the soils to correct the pH is essential for maintenance of P availability. Application of phosphorus solubilizing microbes or biofertilizers should be encouraged. Potassium - Potassium was at medium level in Chavakkad and Kodungallur taluks. So K application at GRD is recommended. Organic sources of K fertilizer viz., ash also can be applied.</p>
<p>Recommendations/ Strategies for secondary/micronutrient management</p>	<p>Sulphur was adequate and there is no need to apply. Boron application is required for Thrissur and Chavakkad taluks based on per cent sample deficiency and borax can be used.</p>
<p>Training requirements</p>	<ol style="list-style-type: none"> 1) Maintaining soil health by the addition of organic matter. 2) Hands on training in composting/vermicomposting, green manuring, application of biofertilizers etc. 3) Training on use of biofertilizers and their importance. 4) Awareness on importance of liming in acidic soils and timely application of lime. 5) Requirement for soil analysis
<p>Any other recommendations</p>	<p>Agricultural extension workers and fertilizer-based firms should create awareness among farmers on the importance of soil fertility maps.</p>

Table 70. Nutrient uses based on resource base in Thrissur

Sl. No.	Nutrients added	Resource base		
		Small	Medium	Large
1	Major nutrients	N-20-70 kg/ha P ₂ O ₅ -30-40 kg/ha K ₂ O- 15-20 kg/ha	N-20-60 kg/ha P ₂ O ₅ -25-40 kg/ha K ₂ O- 20-30 kg/ha	N-30-60 kg/ha P ₂ O ₅ -30-45 kg/ha K ₂ O- 30-40 kg/ha
2	Secondary nutrients	Lime-100 kg/ha	MgSO ₄ -20 kg/ha Lime-150 kg/ha	MgSO ₄ -25 kg/ha Lime-200 kg/ha
3	Micro nutrients			
4	Organic manures	Goat manure, poultry manure	Ground nut cake - 20 kg/ha Neem cake -100 kg/ha	FYM-2.5-10 kg/ha Ground nut cake- 20 kg/ha
5	Bio fertilizers			Azospirillum-1-5 kg/ha POABS

Conclusion

Soil samples collected from different villages of Thrissur district showed a mean pH of 5.64 and EC of 0.02 dS m⁻¹. Only a small percentage of samples were coming under the low category of available nitrogen. High phosphorus content was observed in 90.29 per cent of the samples. Potassium content in the soil samples were comparatively high and 43.23 per cent of the samples were found to be in the high category. Organic carbon content was found to be medium in all taluks except Chavakkad where it was low. Micronutrients viz., iron, copper, manganese, zinc and boron were found in adequate levels. On an average, more than 90 per cent of the samples from the different taluks belonged to adequate class for sulphur.

Chapter 7

Soil fertility status of Palakkad

Palakkad district is bordered on the north west by Malappuram district, on the south west by Thrissur district and on the east by Coimbatore district of Tamil Nadu and is situated between 10° 19' -11°14' N latitude and 76° 01'-76° 55' E. Agriculture is the main occupation. The agro-ecological zones of the district are depicted in Fig.67.

The most prominent crop is rice. Palakkad is known as the 'rice bowl' of Kerala. But in recent times, rice cultivation has become non profitable due to high wages and low prices. Hence farmers have turned to other crops and the area under rice cultivation has decreased drastically. In the areas bordering Tamil Nadu, crops such as sugar cane, groundnut, tomato, jasmine as well as tree crops like mango are cultivated. Rubber is the main crop in hilly regions. Vegetables like pumpkin, ash gourd, bhindi, snake gourd, bitter gourd, chilli brinjal etc. are now cultivated extensively and palm trees are seen in abundance in Palakkad as in Tamil Nadu. It is a major centre for export of mangoes and tamarind. Jaggery, which is unrefined sugar, is made from sugarcane in Chittur taluk.

Table 71. Major crops, fertilizers, organic nutrient sources and sources of irrigation in Palakkad

Crops	Chemical fertilizers	Organic sources	Sources of irrigation
Paddy	Urea	Cow dung	Canals
Vegetables	Factomphos	Goat manure	Wells
Sugarcane	MOP	Vermi compost	
Tuber crops		Bone meal	
Pepper		Green manure	
Coffee, coconut		Neem cake	
Rubber, arecanut		Lime, rajphos	

The district is divided into five taluks which are Alathur, Chittur, Palakkad, Ottappalam and Mannarkad. A total of 15 villages were selected based on stratified multistage random sampling method covering all the five taluks and a total of 90 surface soil samples (six from each village) were collected using GPS representing small, medium and large farmer category. The samples were processed and analysed for 12 chemical parameters viz., pH, electrical conductivity, organic carbon, available nitrogen, phosphorus, potassium, sulphur, zinc, copper, iron, manganese and boron.

Fig. 67 Agro ecological map of Palakkad

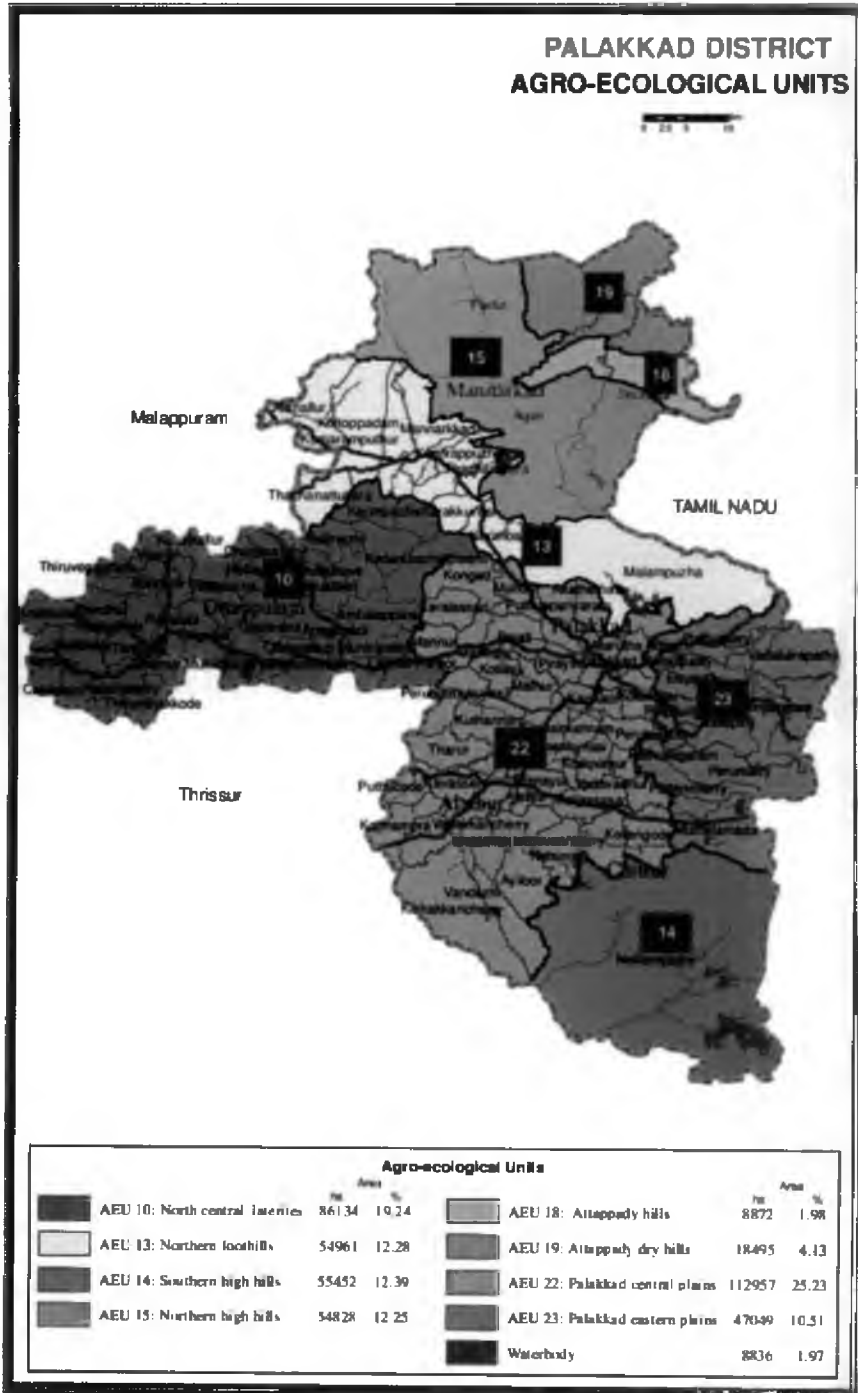


Table 72. Number of villages selected in different taluks of Palakkad

Sl. No.	Name of taluk	Number of villages selected
1	Alathur	3
2	Chittur	3
3	Palakkad	3
4	Ottappalam	3
5	Mannarkad	3

Table 73. Selected villages in different taluks of Palakkad

Alathur	Chittur	Palakkad	Ottappalam	Mannarkad
Thenkurissi	Vadakarapathy	Parali	Parudur	Mannarkad
Tarur	Valiyavallampathy	Kodumbu	Thrithala	Karakurissi
Vadakkancheri	Kollengode	Puthussery	Kadampazhippuram	Sholayur

Soil fertility status

The results of soil analysis are listed in the following tables. The soil fertility maps generated from the analytical data are presented in figures, 68 to 79. These fertility maps reveal the per cent area under different categories with respect to each parameter in the total geographic area of 4,480 sq. km in the Palakkad district.

7.1 pH and electrical conductivity

The pH of the surface soil ranged from 5.58 to 8.58. It was observed that 34.44 per cent of the samples analysed were acidic, 37.78 per cent of the samples were neutral and 27.78 per cent of the samples were alkaline respectively. In Alathur taluk, 72.22 per cent soils were acidic.

Table 74. Status of pH in different taluks of Palakkad

Sl. No.	Taluks	No. of samples	Range	Mean	Per cent sample category		
					Acidic	Neutral	Alkaline
1	Alathur	18	5.81 - 7.60	6.45	72.22	16.67	11.11
2	Chittur	18	6.08 - 8.58	7.46	5.56	50.00	44.44
3	Palakkad	18	6.39 - 8.37	7.39	5.55	55.56	38.89
4	Ottappalam	18	5.58 - 6.44	6.77	55.55	16.67	27.78
5	Mannarkad	18	5.64 - 8.52	6.86	33.33	50.00	16.67
# Range/Mean		90	5.58 - 8.58	6.99	34.44	37.78	27.78

With regard to electrical conductivity, the whole area of the district is non saline. The electrical conductivity of the soils ranged from 0.03 to 0.85 dS m⁻¹ with a mean of 0.15 dS m⁻¹.

Table 75. Status of EC (dS m⁻¹) in different taluks of Palakkad

Sl. No.	Taluk	Range	Mean
1	Alathur	0.03 - 0.85	0.23
2	Chittur	0.05 - 0.70	0.15
3	Palakkad	0.06 - 0.36	0.12
4	Ottappalam	0.04 - 0.13	0.14
5	Mannarkad	0.05 - 0.22	0.13
# Range/Mean		0.03 - 0.85	0.15

7.2 Organic carbon

The organic carbon status of the soil ranged from 0.15 to 1.31 per cent with a mean value of 0.60 per cent. Mannarkad taluk recorded the highest mean organic carbon content of 0.84 per cent followed by Ottappalam (0.65 per cent). The per cent of soils coming under low and medium categories were 48.89 and 51.11 respectively and high category was absent.

Table 76. Status of organic carbon (per cent) in different taluks of Palakkad

Sl. No.	Taluks	No. of samples	Range	Mean	Per cent sample category			NIV	Fertility rating
					Low	Medium	High		
1	Alathur	18	0.27 - 1.07	0.52	50.00	50.00	0.00	1.50	Medium
2	Chittur	18	0.26 - 1.31	0.49	83.33	16.67	0.00	1.17	Low
3	Palakkad	18	0.24 - 0.97	0.52	55.56	44.44	0.00	1.44	Medium
4	Ottappalam	18	0.26 - 0.50	0.65	38.89	61.11	0.00	1.61	Medium
5	Mannarkad	18	0.15 - 1.26	0.84	16.67	83.33	0.00	1.83	Medium
# Range/Mean		90	0.15 - 1.31	0.60	48.89	51.11	0.00	1.51	Medium

7.3 Available nitrogen

The available nitrogen status in the surface soils ranged from 194.43 to 2037.40 kg ha⁻¹ with a mean value of 625.66 kg ha⁻¹. The per cent samples under low, medium and high categories were 7.78, 53.33 and 38.89 respectively. Among the five taluks, Ottappalam recorded the highest per cent of samples (77.78 per cent)

under high available N; highest per cent of samples under low available N was observed in Chittur (16.66 per cent). The mean value of nutrient index for available nitrogen was 2.31. The fertility rating was medium.

Table 77. Status of available nitrogen (kg ha⁻¹) in different taluks of Palakkad

Sl. No	Taluks	No. of samples	Range	Mean	Per cent sample category			NIV	Fertility rating
					Low	Medium	High		
1	Alathur	18	204.72 - 1264.44	461.21	11.11	72.22	16.67	2.06	Medium
2	Chittur	18	225.79 - 1195.48	470.17	16.66	66.67	16.67	2.00	Medium
3	Palakkad	18	261.61 - 1034.25	571.37	5.56	55.56	38.88	2.33	Medium
4	Ottappalam	18	285.79 - 777.47	899.89	0.00	22.22	77.78	2.78	High
5	Mannarkad	18	194.43 - 2037.40	725.68	5.55	50.00	44.45	2.39	High
# Range/Mean		90	194.43 - 2037.40	625.66	7.78	53.33	38.89	2.31	Medium

7.4 Available phosphorus

The available Bray-P content ranged from 4.48 to 152.32 kg ha⁻¹ with a mean value of 44.81 kg ha⁻¹. The per cent of soils under low, medium and high categories were 11.11, 22.22 and 66.67 respectively. Among the five taluks, Ottappalam and Mannarkad taluks recorded the highest per cent of sample under high available P (77.78); the highest per cent of samples under low available P was observed in Alathur taluk (16.67). The mean value of nutrient index for available phosphorus was 2.56. The fertility rating for available phosphorus was high

Table 78. Status of available phosphorus (kg ha⁻¹) in different taluks of Palakkad

Sl. No.	Taluks	No. of samples	Range	Mean	Per cent sample category			NIV	Fertility rating
					Low	Medium	High		
1	Alathur	18	4.48 - 91.84	28.12	16.67	44.44	38.89	2.22	Medium
2	Chittur	18	8.96 - 105.28	37.02	5.55	27.78	66.67	2.61	High
3	Palakkad	18	8.96 - 152.32	48.70	11.11	16.67	72.22	2.61	High
4	Ottappalam	18	5.60 - 35.84	54.54	11.11	11.11	77.78	2.67	High
5	Mannarkad	18	7.84 - 105.28	55.66	11.11	11.11	77.78	2.67	High
# Range/Mean		90	4.48 - 152.32	44.81	11.11	22.22	66.67	2.56	High

7.5 Available potassium

The available potassium status in surface soils of different taluks ranged from 48.16 to 1034.88 kg ha⁻¹. Considering the mean values, the highest value of 272.13 kg ha⁻¹ was recorded in Mannarkad taluk and the lowest mean value of 191.15 kg ha⁻¹ in Chittur taluk. The per cent samples under low, medium and high categories were 22.22, 52.22 and 25.56 respectively. The mean nutrient index value of available K was 2.03. The fertility rating for available K was medium.

Table 79. Status of available potassium (kg ha⁻¹) in different taluks of Palakkad

Sl. No.	Taluks	No. of samples	Range	Mean	Per cent sample category			NIV	Fertility rating
					Low	Medium	High		
1	Alathur	18	90.72 - 1034.88	236.20	5.55	77.78	16.67	2.11	Medium
2	Chittur	18	78.40 - 573.44	191.15	27.77	55.56	16.67	1.89	Medium
3	Palakkad	18	48.16 - 525.28	194.76	44.44	27.78	27.78	1.83	Medium
4	Ottappalam	18	53.76 - 173.60	224.37	16.66	55.56	27.78	2.11	Medium
5	Mannarkad	18	72.80 - 753.20	272.13	16.67	44.44	38.89	2.22	Medium
# Range/Mean		90	48.16 - 1034.88	223.72	22.22	52.22	25.56	2.03	Medium

7.6 Available sulphur

The available S content ranged from 0.36 to 86.36 mg kg⁻¹ with a mean value of 27.27 mg kg⁻¹. The mean available S status was found to be low in Chittur taluk (9.57 mg kg⁻¹) and high in Ottappalam taluk (43.74 mg kg⁻¹). It was found that 17.78 per cent of samples were deficient and 82.22 per cent were adequate with respect to available S content.

Table 80. Status of available sulphur (mg kg⁻¹) in different taluks of Palakkad

Sl. No.	Taluks	No. of samples	Range	Mean	Per cent sample category	
					Deficient	Adequate
1	Alathur	18	1.00 - 58.76	19.96	38.89	61.11
2	Chittur	18	0.36 - 32.40	9.57	11.11	88.89
3	Palakkad	18	0.46 - 54.02	25.42	33.33	66.67
4	Ottappalam	18	15.16 - 43.03	43.74	0.00	100.00
5	Mannarkad	18	2.08 - 86.36	37.64	5.56	94.44
# Range/Mean		90	0.36 - 86.36	27.27	17.78	82.22

7.7 Available micronutrients

The DTPA-Zn content ranged from 0.25 to 20.80 mg kg⁻¹ with a mean value of 3.13 mg kg⁻¹. The DTPA-Fe content varied from 4.83 to 271.20 mg kg⁻¹ with a mean value of 66.48 mg kg⁻¹. In all the taluks Fe was found to be sufficient. The availability of Cu ranged from 1.00 to 47.78 mg kg⁻¹ with a mean value of 5.42 mg kg⁻¹. The Mn availability in the soils ranged from 1.40 to 213.10 mg kg⁻¹ with a mean of 35.31 mg kg⁻¹. The boron content ranged from 0.10 to 25.25 mg kg⁻¹ with a mean value of 2.22 mg kg⁻¹. The nutrient index value ranged from 1.78 to 1.94 for Zn, 1.94 to 2.00 for Fe and 1.61 to 1.82 for B. The index value for Cu and Mn was 2.00. Notably low to medium fertility rating was recorded for B and medium for Zn, Fe, Cu and Mn in most of the taluks (Appendix III).

Table 81. Status of available micronutrients (mg kg⁻¹) in different taluks of Palakkad

Sl. No.	Taluku	No. of samples	Micronutrient status (Range)				
			Zn	Fe	Cu	Mn	B
1	Alathur	18	0.60-20.80 (4.15)	64.20-271.20 (88.61)	1.00-14.00 (5.52)	5.10-213.10 (51.83)	0.10-3.40 (1.19)
2	Chittur	18	0.25-11.80 (2.09)	4.83-93.75 (32.95)	1.10-12.50 (4.27)	4.50-119.40 (33.12)	0.10-17.75 (3.01)
3	Palakkad	18	0.50-7.75 (1.97)	13.10-183.75 (72.26)	2.00-14.90 (4.39)	2.30-83.00 (30.31)	0.10-25.25 (3.38)
4	Ottappalam	18	0.60-8.88 (3.00)	6.75-150.03 (60.63)	1.60-15.10 (6.10)	1.40-74.30 (33.53)	0.20-17.50 (2.19)
5	Mannarkad	18	0.25-20.48 (4.44)	25.43-261.13 (77.96)	1.05-47.78 (6.81)	3.80-66.50 (27.78)	0.10-5.50 (1.33)
# Range/Mean		90	0.25-20.80 (3.13)	4.83-271.20 (66.48)	1.00-47.78 (5.42)	1.40-213.10 (35.31)	0.10-25.25 (2.22)

*Values in parenthesis indicate mean.

Table 82. Per cent sample category of available micronutrients in different taluks of Palakkad

Taluku	No of samples	Zn		Fe		Cu		Mn		B	
		D (%)	A (%)	D (%)	A (%)	D (%)	A (%)	D (%)	A (%)	D (%)	A (%)
Alathur	18	5.56	94.44	0.00	100	0	100	0	100	27.78	77.22
Chittur	18	22.22	77.78	5.56	94.44	0	100	0	100	27.78	77.22
Palakkad	18	5.56	94.44	0.00	100	0	100	0	100	38.89	61.11
Ottappalam	18	5.56	94.44	0.00	100	0	100	0	100	33.33	66.67
Mannarkad	18	11.11	88.89	0.00	100	0	100	0	100	27.78	72.22
Mean	90	10.00	90.00	1.11	98.89	0	100	0	100	31.11	70.89

D = Deficient, A = Adequate.

Fig. 68 Status of pH in the soils of Palakkad

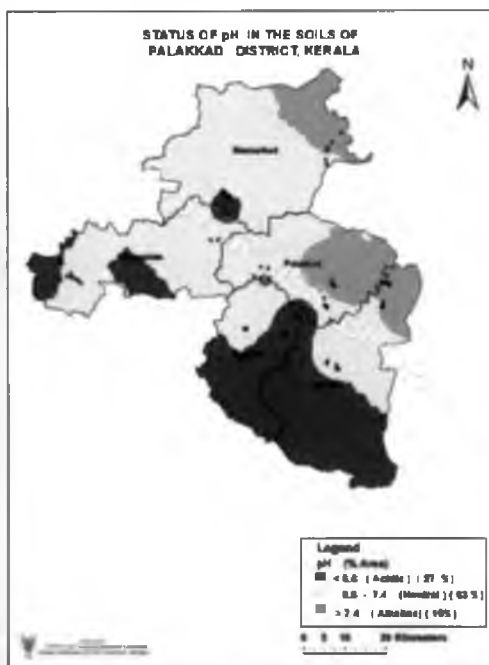


Fig. 69 Status of electrical conductivity in the soils of Palakkad



Fig. 70 Status of organic carbon in the soils of Palakkad

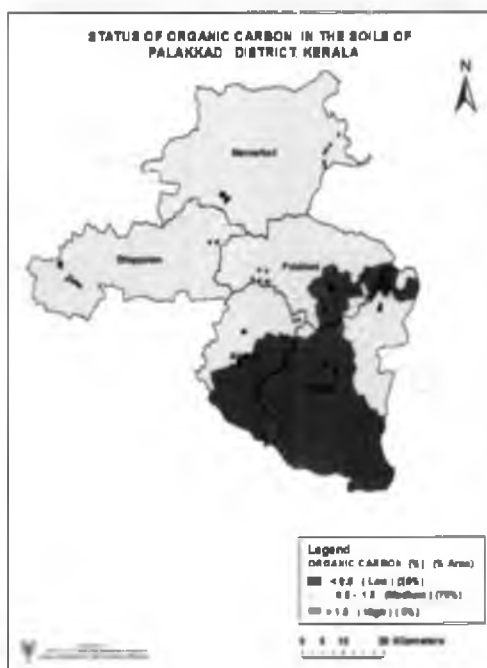


Fig. 71 Status of nitrogen in the soils of Palakkad



Fig. 72 Status of phosphorus in the soils of Palakkad

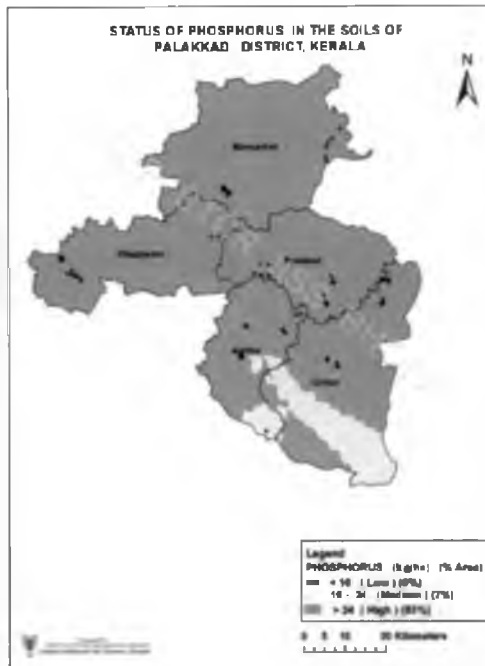


Fig. 73 Status of potassium in the soils of Palakkad

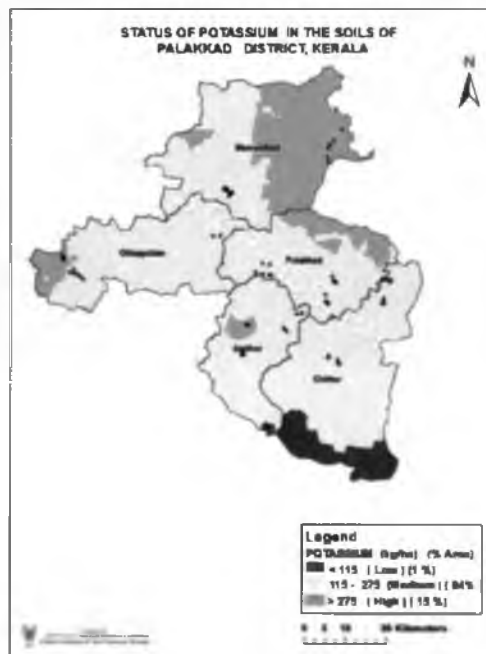


Fig. 74 Status of sulphur in the soils of Palakkad

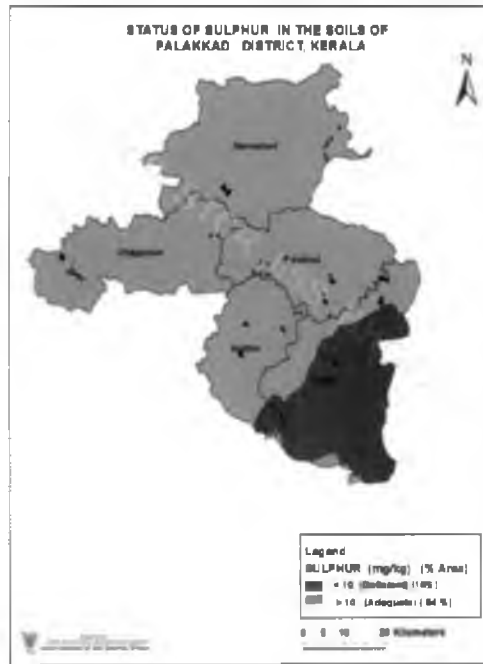


Fig. 75 Status of Iron in the soils of Palakkad

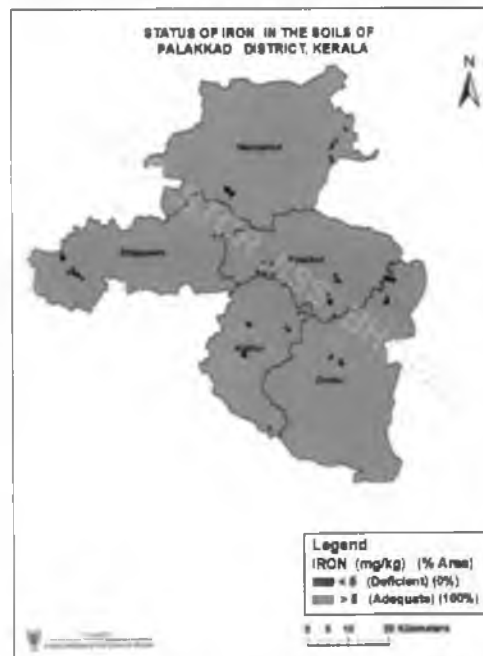


Fig. 76 Status of manganese in the soils of Palakkad

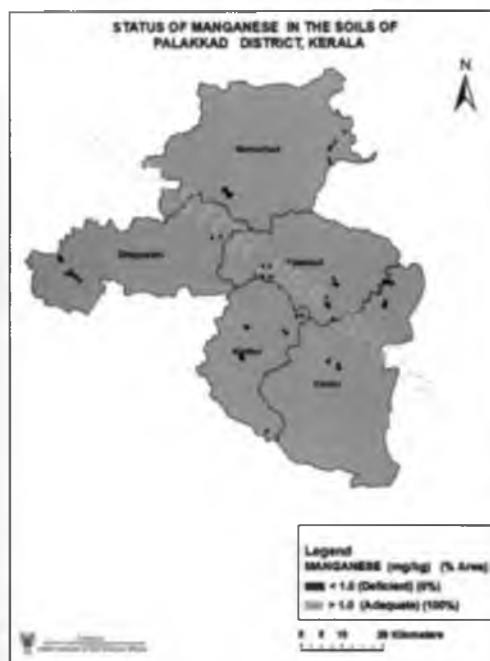


Fig. 77 Status of copper in the soils of Palakkad



Fig. 78 Status of zinc in the soils of Palakkad

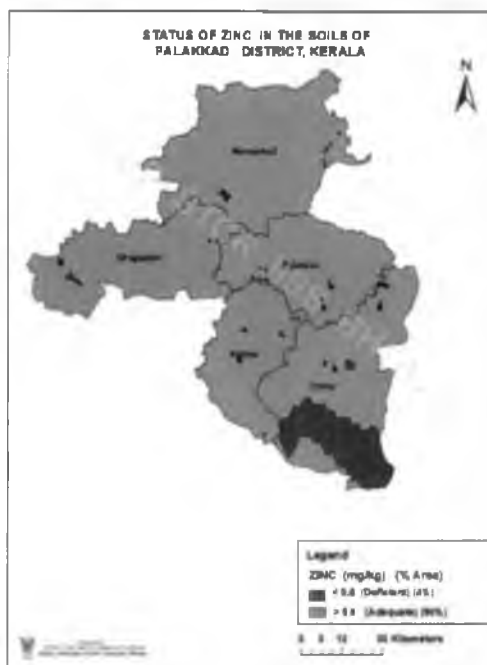


Fig. 79 Status of boron in the soils of Palakkad

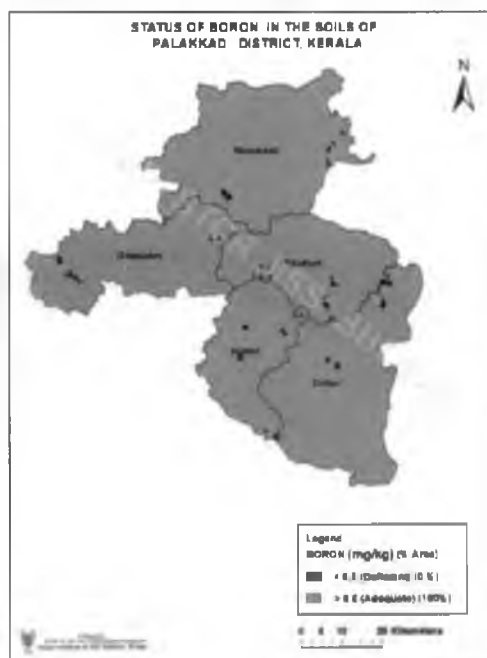


Table 83. Fertilizer recommendations for the farmers of Palakkad district based on GPS and GIS based soil fertility maps

Main crops: Paddy, vegetables, ground nut, mango, spices, coconut, banana, arecanut

<p>Recommendations/Strategies for soil amendment (for correction of soil acidity/sodicity/salinity etc.)</p>	<p>Chittur and Palakkad taluks had 80 to 90 per cent samples in neutral to alkaline range. So there is no need for liming. In the remaining 3 taluks, 33 to 72 per cent samples were acidic and 16 to 50 per cent samples were near neutral; so liming is required. Application of dolomite/lime is essential.</p>
<p>Recommendations /Strategies for organic matter (this should include application of manures, residues, microbial culture for decomposition like trichoderma etc.)</p>	<p>Organic carbon- 100 per cent samples were in low to medium range. So there is a need for organic carbon maintenance. Growing of green manure crops, composting using weeds or crop residues are needed. Application of poultry manure, vermi compost, other organic manures like neem cake, farmyard manure etc.</p>
<p>Recommendations/ Strategies for NPK management</p>	<p>Nitrogen - 61 per cent of samples were in low to medium range. Fertilizer application is required in the form of urea or factomphos. Phosphorus- 67 per cent of samples had high P. Only maintenance dose of P is needed in areas with high P; 33 per cent of samples were low and require general dose of recommendation. Potassium- 74 per cent of samples were low to medium. Apply K fertilizers in the form of MOP.</p>
<p>Recommendations/ Strategies for secondary/micronutrient management</p>	<p>Sulphur -17.78 per cent soil samples were deficient. In deficient areas, apply fertilizers as elemental S, factomphos etc. No need to apply micronutrients like Fe, Mn, and Cu Zinc – 22 per cent samples in Chittur taluk were deficient. So application of Zn SO₄ is essential. Boron- 28 to 39 per cent samples were deficient in different taluks. Application of solubor/borax is required.</p>
<p>Training requirements</p>	<p>Training required for STL personnel regarding soil analysis and composting of crop residue.</p>
<p>Any other recommendations</p>	<p>Agricultural extension workers and fertilizer-based firms should create awareness among farmers on the importance of soil fertility maps.</p>

Table 84. Nutrient uses based on resource base in Palakkad

Sl. No.	Nutrients added	Resource base		
		Small	Medium	Large
1	Major nutrients	N-20-70 kg/ha P ₂ O ₅ -20-35 kg/ha K ₂ O-10-20 kg/ha	N-25-60 kg/ha P ₂ O ₅ -25-40 kg/ha K ₂ O-20-30 kg/ha	N-25-75 kg/ha P ₂ O ₅ -30-45 kg/ha K ₂ O-30-40 kg/ha
2	Secondary nutrients	Lime-80-120 kg/ha	MgSO ₄ -20 kg/ha Lime-150 kg/ha	MgSO ₄ -20 kg/ha Lime-200 kg/ha Zn-Neoplex Gypsum-100kg/ha
3	Micro nutrients		Microfood-10kg/ha	Microfood- 15kg/ha
4	Organic manures	FYM-2.5-3.5 kg/ha	FYM-2.5-3.5 kg/ha	POABS mixture FYM-2.5-10 kg/ha Bonemeal- 50-70kg/ha Neemcake-50kg/ha

Conclusion

Samples collected from Palakkad showed an average pH of 6.99. Some samples showed alkaline pH. Mean electrical conductivity of the samples collected from this district was found to be 0.15 dS m⁻¹. Available nitrogen status in the soils collected from this district was in the medium range. Soil samples belonging to the high class of phosphorus was more in Palakkad district (66.67 per cent). In the case of available potassium, 52.22 per cent of samples were in the medium range. In the case of organic carbon, 51.11 per cent of samples were in the low range and remaining came under medium range. For micronutrients, viz., iron, copper, zinc and manganese, all the samples were under adequate level. Deficiency of boron was shown by 31.11 per cent of the samples analysed. Only 17.78 per cent of the samples showed sulphur deficiency.

Chapter 8

Soil fertility status of Ernakulam

Ernakulam district is located at a latitude of $9^{\circ} 47'$ - $10^{\circ} 18'$ N; longitude $76^{\circ} 9'$ - $77^{\circ} 6'$ E with a geographical area of 3068 sq.km. It is surrounded by Thrissur district in the north, Idukki district in the east, Alappuzha and Kottayam districts in the south and Arabian sea in west. Agriculture constitutes the most important segment of the district's economy and it is the biggest sources of employment. The agro-ecological zones of the district are depicted in Fig.80.

Coconut is the principal crop followed by rubber, paddy and tapioca. A paddy cultivation system called 'pokkali' is peculiar to the district. Under this system only one crop can be taken in a year. After harvest, suitable varieties of fishes and prawn are grown in the fields which are more profitable. Activities allied to agriculture such as dairy, poultry and fishery play an important role in the economy of the district. The agricultural land use consists of cultivating cashew, pepper, pineapple, 'virippu' (first crop), 'mundakan', (double crop/triple crop), orchards and mixed trees. The pattern of agricultural land use shows that agricultural area of the district is mainly concentrated in the central, and some of the upland regions of the district. The highest concentration of agricultural land use within the district is seen in the panchayats of Sreemoolanagaram, Kunnukara, Chengamanad, Paingottur, Valakom and Nedumbassery.

Table 85. Major crops, fertilizers, organic nutrient sources and sources of irrigation in Ernakulam

Crops	Chemical fertilizers	Organic sources	Sources of irrigation
Paddy	Urea	Cow dung, Goat manure	Canals
Vegetables	Factomphos	Vermi compost	Wells
Tuber crops	MOP	Bone meal	
Pepper		Green manure, neem cake	
Coconut , rubber		Lime, rajphos	

The district is divided into eight taluks which are Muvattupuzha, Aluva, Kunnathunadu, Kanayannur, Kothamangalam, Paravur and Perumbavur. A total of 26 villages were selected based on stratified multistage random sampling method covering all the eight taluks and a total of 156 surface soil samples (six from each village) were collected using GPS representing small, medium and large farmer category. The samples were processed and analysed for 12 chemical parameters viz., pH, electrical conductivity, organic carbon, available nitrogen, phosphorus, potassium, sulphur, zinc, copper, iron, manganese and boron.

Fig. 80 Agro ecological map of Ernakulam

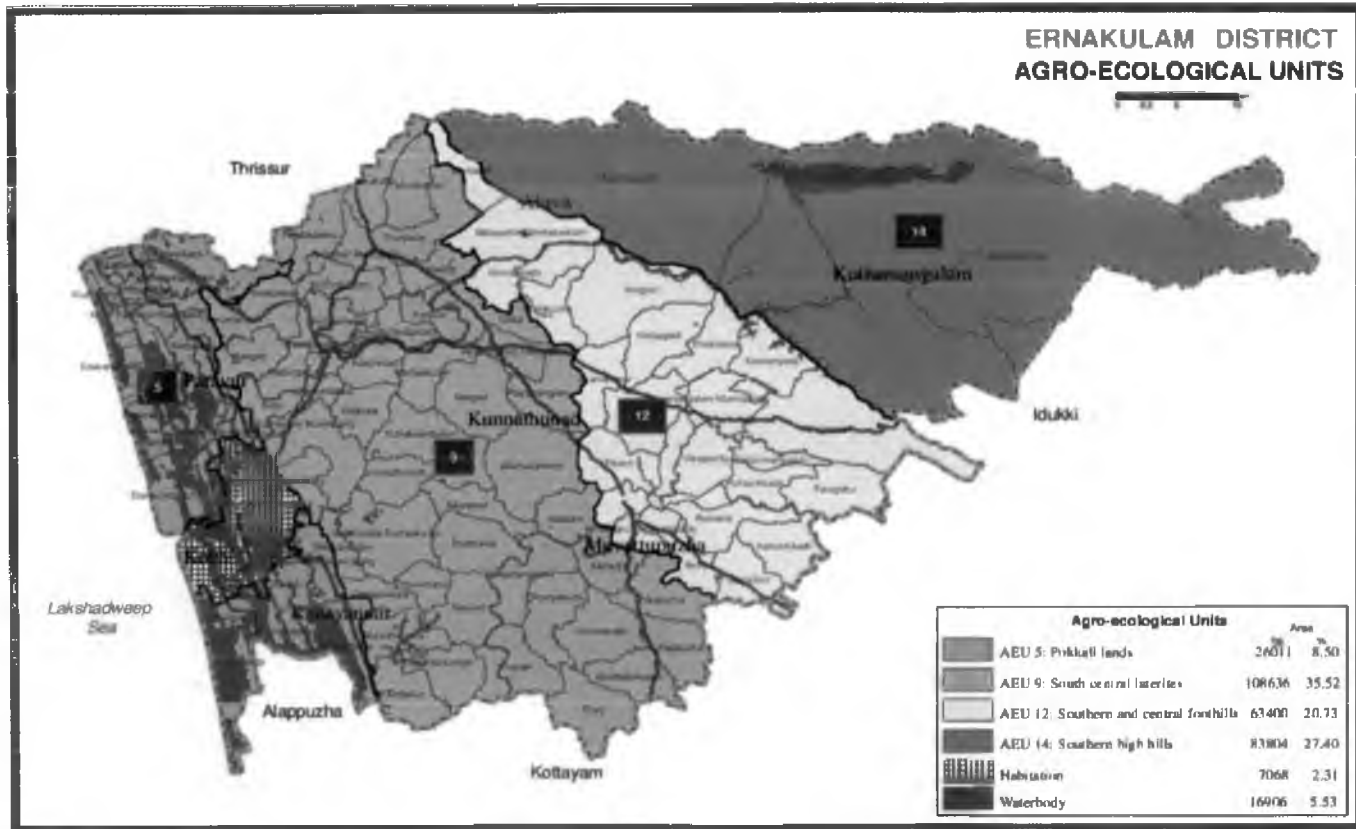


Table 86. Number of villages selected in different taluks of Ernakulam

Sl. No.	Name of Taluk	Number of villages selected
1	Muvattupuzha	5
2	Aluva	4
3	Kunnathunadu	5
4	Kanayannur	3
5	Kothamangalam	4
6	Paravur	1
7	Perumbavur	1
8	Kochi	3

Table 87. Selected villages in different taluks in Ernakulam**Part (a)**

Muvattupuzha	Aluva	Kunnathunadu	Kanayannur
Muvattupuzha	Nedumbassery	Asamannur	Keechery
Maneed	Karukutty	Kizhakkambhalam	Kumbalam
Marady	Malayattoor	Arakkapady	Edakkattuvayal
Velloorkunnam	Thekkumbhagam	Kombanad	
Palakuzha		Aikkaranad North	

Part (b)

Kothamangalam	Kochi	Paravur	Perumbavur
Pothanikkad	Pallippuram	Mootha kunnam	Kunnukara
Thrikariyur	Kumba langhi		
Kuttampuzha	Njarakkal		
Neriamangalam			

Soil fertility status

The results of soil analysis are listed in the following tables. The soil fertility maps generated from the analytical data are presented in figures, 81 to 92. These fertility maps reveal the percentage area under different categories with respect to each parameter in the total geographic area of 3,068 sq. km in the Palakkad district.

8.1 pH and electrical conductivity

The pH of the surface soils ranged from 4.29 to 7.28. It was observed that 89.27 per cent of the samples analysed were acidic and 10.73 per cent neutral. Alkaline

soils were not present. In Muvattupuzha and Kanayannur taluks, 96.67 and 94.44 per cent soils respectively were acidic.

Table 88. Status of pH in different taluks of Ernakulum

Sl. No.	Taluks	No. of samples	Range	Mean	Per cent sample category		
					Acidic	Neutral	Alkaline
1	Muvattupuzha	30	4.29-6.66	5.16	96.67	3.33	0
2	Aluva	24	4.50-6.80	5.55	87.50	12.50	0
3	Kunnathunadu	30	4.79-7.07	5.62	80.00	20.00	0
4	Kanayannur	18	4.52-7.09	5.45	94.44	5.56	0
5	Kothamangalam	24	4.40-6.37	5.20	100.00	0.00	0
6	Paravur	6	5.63-7.19	6.33	66.67	33.33	0
7	Perumbavur	6	4.88-6.30	5.52	100.00	0.00	0
8	Kochi	18	4.65-7.28	5.64	88.89	11.11	0
# Range/Mean		156	4.29 - 7.28	5.56	89.27	10.73	0

The electrical conductivity of the soil ranged from 0.002 to 1.32 dS m⁻¹ with a mean of 0.18 dS m⁻¹.

Table 89. Status of EC (dS m⁻¹) in different taluks of Ernakulum

SI. No.	Taluks	Range	Mean
1	Muvattupuzha	0.003 – 1.26	0.15
2	Aluva	0.003 – 0.87	0.18
3	Kunnathunadu	0.04 – 1.32	0.27
4	Kanayannur	0.04 – 0.36	0.10
5	Kothamangalam	0.003 – 0.43	0.12
6	Paravur	0.09 – 0.33	0.18
7	Perumbavur	0.05 – 0.27	0.15
8	Kochi	0.002 – 0.89	0.21
# Range/Mean		0.002 – 1.32	0.18

8.2 Organic carbon

The organic carbon status of the soil ranged from 0.17 to 1.91 per cent with mean value of 0.90 per cent. Kothamangalam taluk recorded the highest mean organic carbon content of 1.21 per cent followed by Muvattupuzha (1.14 per cent). The per cent sample categories for organic carbon were 16.15, 76.98 and 6.88 respectively in low, medium and high classes.

Table 90. Status of organic carbon (per cent) in different taluks of Ernakulum

Sl. No.	Taluks	No. of samples	Range	Mean	Per cent sample category			NIV	Fertility rating
					Low	Medium	High		
1	Muvattupuzha	30	0.65-1.75	1.14	0.00	93.33	6.67	2.07	Medium
2	Aluva	24	0.41-1.91	1.02	12.50	70.83	16.67	2.04	Medium
3	Kunnathunadu	30	0.52-1.81	1.04	0.00	93.33	6.67	2.07	Medium
4	Kanayannur	18	0.26-1.14	0.67	38.89	61.11	0.00	1.61	Medium
5	Kothamangalam	24	0.56-1.81	1.21	0.00	75.00	25.00	2.25	Medium
6	Paravur	6	0.52-1.37	0.94	0.00	100	0.00	2.00	Medium
7	Perumbavur	6	0.48-1.21	0.75	16.67	83.33	0.00	1.83	Medium
8	Kochi	18	0.17-0.65	0.44	61.11	38.89	0.00	1.39	Medium
# Range/Mean		156	0.17-1.91	0.90	16.15	76.98	6.88	1.91	Medium

8.3 Available nitrogen

The available nitrogen status in the surface soils ranged from 6.40 to 1744.81 kg ha⁻¹ with mean value of 494.97 kg ha⁻¹. The per cent samples under low, medium and high categories were 22.64, 46.91 and 30.46 respectively. Among the eight taluks, Muvattupuzha recorded the highest per cent (80) samples under medium available N; highest per cent samples under low available N was observed in Kochi (55.55 per cent). The mean value of nutrient index for available nitrogen was 2.08. The fertility rating for available N was medium.

Table 91. Status of available nitrogen (kg ha⁻¹) in different taluks of Ernakulum

Sl. No.	Taluks	No. of Samples	Range	Mean	Per cent sample category			NIV	Fertility Rating
					Low	Medium	High		
1	Muvattupuzha	30	285.38-1042.78	518.42	0.00	80.00	20.00	2.20	Medium
2	Aluva	24	180.07-1744.81	614.37	16.66	33.34	50.00	2.33	Medium
3	Kunnathunadu	30	6.40-1356.25	615.00	3.34	46.66	50.00	2.47	High
4	Kanayannur	18	122.30-564.48	345.89	38.89	55.55	5.56	1.67	Medium
5	Kothamangalam	24	376.32-1672.92	683.86	0.00	54.16	45.84	2.46	High
6	Paravur	6	204.91-785.47	467.25	33.33	16.67	50.00	2.17	Medium
7	Perumbavur	6	247.74-617.35	433.77	33.33	50.00	16.67	1.83	Medium
8	Kochi	18	112.90-713.31	281.21	55.55	38.88	5.57	1.50	Medium
# Range/Mean		156	6.40 - 1744.81	494.97	22.64	46.91	30.46	2.08	Medium



8.4 Available phosphorus

The available Bray-P content ranged from 5.60 to 473.20 kg ha⁻¹ with a mean value of 126.25 kg ha⁻¹. The per cent of soils under low, medium and high categories were 0.52, 12.05 and 87.43 respectively. Among the eight taluks, Perumbavur and Paravur taluks recorded the highest per cent of sample under high available P (100 per cent); highest per cent of samples under low available P was nil. The mean value of nutrient index for available phosphorus was 2.87. The fertility rating for available phosphorus was high.

Table 92. Status of available phosphorus (kg ha⁻¹) in different taluks of Ernakulam

Sl. No.	Taluks	No. of Samples	Range	Mean	Per cent sample category			NIV	Fertility Rating
					Low	Medium	High		
1	Muvattupuzha	30	14.00-313.60	82.97	0.00	23.33	76.67	2.77	High
2	Aluva	24	17.92-207.20	94.27	0.00	8.33	91.67	2.92	High
3	Kunnathunadu	30	11.20-218.40	70.28	0.00	30.00	70.00	2.70	High
4	Kanayannur	18	11.20-473.20	155.18	0.00	16.67	83.33	2.83	High
5	Kothamangalam	24	5.60-380.80	120.75	4.17	12.50	83.33	2.79	High
6	Paravur	6	58.80-352.80	168.00	0.00	0.00	100	3.00	High
7	Perumbavur	6	58.80-364.00	180.13	0.00	0.00	100	3.00	High
8	Kochi	18	19.60-327.60	138.44	0.00	5.56	94.44	2.94	High
# Range/Mean		156	5.60-473.20	126.25	0.52	12.05	87.43	2.87	High

8.5 Available potassium

The available potassium status in surface soils of different taluks ranged from 50.40 to 890.40 kg ha⁻¹. Considering the mean values, the highest value of 331.63 kg ha⁻¹ was recorded in Kunnathunadu taluk and the lowest mean value of 153.07 kg ha⁻¹ in Paravur taluk. The per cent samples under low, medium and high categories were 16.25, 55.45 and 28.30 respectively. The mean nutrient index value of available K was 2.14. The fertility rating for available K was medium.

Table 93. Status of available potassium (kg ha⁻¹) in different taluks of Ernakulam

Sl. No	Taluku	No. of samples	Range	Mean	Per cent sample category			NIV	Fertility Rating
					Low	Medium	High		
1	Muvattupuzha	30	79.50-529.80	279.00	6.67	50.00	43.33	2.33	Medium
2	Aluva	24	90.70-552.20	291.75	8.33	50.00	41.67	2.33	Medium
3	Kunnathunadu	30	50.40-789.60	331.63	6.66	36.67	56.67	2.50	High
4	Kanayannur	18	63.80-427.80	181.43	33.33	50.00	16.67	1.94	Medium
5	Kothamangalam	24	101.90-890.40	316.96	8.33	45.83	45.84	2.46	High
6	Paravur	6	87.40-231.80	153.07	33.33	66.67	0.00	1.67	Medium
7	Perumbavur	6	129.90-459.20	240.23	0.00	83.33	16.67	2.17	Medium
8	Kochi	18	67.20-458.10	176.77	33.33	61.11	5.56	1.72	Medium
# Range/Mean		156	50.40- 890.40	246.36	16.25	55.45	28.30	2.14	Medium

8.6 Available sulphur

The available S content ranged from 0.19 to 91.32 mg kg⁻¹ with a mean value of 13.19 mg kg⁻¹. The mean available S status was found to be low in Paravur taluk (1.04 mg kg⁻¹) and high in Muvattupuzha taluk (24.02 mg kg⁻¹). The per cent of deficient and adequate sample categories were 70.73 and 29.27 respectively.

Table 94. Status of available sulphur (mg kg⁻¹) in different taluks of Ernakulam

Sl. No.	Taluku	No. of samples	Range	Mean	Per cent sample category	
					Deficient	Adequate
1	Muvattupuzha	30	0.19 - 83.13	24.02	43.33	56.66
2	Aluva	24	0.27 - 48.55	12.94	66.66	33.33
3	Kunnathunadu	30	0.46 - 67.60	15.57	60.00	40.00
4	Kanayannur	18	1.02 - 79.84	14.19	77.77	22.23
5	Kothamangalam	24	1.38 - 86.42	22.03	45.83	54.16
6	Paravur	6	0.44 - 1.57	1.04	100.00	0.00
7	Perumbavur	6	0.20 - 15.56	3.48	83.33	16.66
8	Kochi	18	0.88 - 91.32	12.22	88.88	11.11
# Range/Mean		156	0.19 - 91.32	13.19	70.73	29.27

8.7 Available micronutrients

The DTPA-Zn content ranged from 0.18 to 203.50 mg kg⁻¹ with a mean value of 7.78 mg kg⁻¹. The DTPA-Fe content varied from 17.25 to 725.00 mg kg⁻¹ with a mean value of 144.62 mg kg⁻¹. In all the taluks Fe was found to be sufficient. The

availability of Cu ranged from 0.35 to 33.43 mg kg⁻¹ with a mean value of 4.17 mg kg⁻¹. The Mn availability in the soils ranged from 0.05 to 116.40 mg kg⁻¹ with a mean of 13.83 mg kg⁻¹. The content of B ranged from 0.01 to 6.15 mg kg⁻¹ with a mean value of 0.72 mg kg⁻¹. The nutrient index value ranged from 1.88 to 2.00 for Zn, 1.83 to 2.00 for Mn and 1.22 to 1.83 for B. The NIV for Fe and Cu was 2.00. Very low to medium fertility rating was recorded for B and medium for Zn, Fe, Cu and Mn in all the taluks (Appendix III).

Table 95. Status of available micronutrients (mg kg⁻¹) in different taluks of Ernakulam

Sl. No.	Taluks	No. of samples	Micronutrient status (Range)				
			Zn	Fe	Cu	Mn	B
1	Muvattupuzha	30	1.05-203.50 (16.18)	29.05-430.40 (109.82)	0.80-15.75 (4.75)	0.50-50.80 (18.01)	0.05-5.13 (0.75)
2	Aluva	24	0.18-14.65 (3.68)	19.40-725.00 (164.18)	0.35-7.65 (3.09)	1.10-53.13 (13.29)	0.03-2.59 (0.59)
3	Kunnathunadu	30	0.45-96.23 (9.10)	17.25-322.15 (97.57)	0.70-12.80 (4.39)	1.03-116.40 (27.37)	0.05-3.77 (0.83)
4	Kanayannur	18	0.75-16.75 (6.44)	25.70-264.00 (105.39)	0.73-16.10 (2.95)	0.05-22.03 (5.82)	0.02-2.00 (0.46)
5	Kothamangalam	24	0.25-23.88 (4.91)	17.80-445.70 (148.50)	1.50-33.43 (5.82)	1.20-30.35 (9.82)	0.05-6.15 (0.96)
6	Paravur	6	1.03-3.88 (2.66)	44.25-404.75 (213.65)	0.68-5.65 (3.67)	1.80-4.35 (3.06)	0.01-1.11 (0.50)
7	Perumbavur	6	2.85-11.83 (6.89)	98.08-330.10 (195.47)	1.73-9.15 (4.37)	0.05-32.78 (13.73)	0.46-2.15 (0.95)
8	Kochi	18	1.05-7.40 (4.20)	22.68-506.65 (249.05)	0.75-9.45 (3.39)	0.73-3.83 (2.03)	0.05-4.93 (0.60)
# Range/Mean		156	0.18 - 203.50 (7.78)	17.25 - 725.00 (144.62)	0.35 - 33.43 (4.17)	0.05 - 116.40 (13.83)	0.01 - 6.15 (0.72)

*Values in parenthesis indicate mean.

Table 96. Per cent sample category of available micronutrients in different taluks of Ernakulam

Taluks	No of samples	Zn		Fe		Cu		Mn		B	
		D (%)	A (%)	D (%)	A (%)	D (%)	A (%)	D (%)	A (%)	D (%)	A (%)
Muvattupuzha	30	0.00	100	0	100	0	100	3.33	96.66	56.66	43.33
Aluva	24	12.50	87.50	0	100	0	100	0.00	100.00	62.50	37.50
Kunnathunadu	30	6.66	93.33	0	100	0	100	0.00	100.00	56.66	43.33
Kanayannur	18	0.00	100	0	100	0	100	5.55	94.44	72.22	27.77
Kothamangalam	24	8.33	91.66	0	100	0	100	0.00	100.00	45.83	54.16
Paravur	6	0.00	100	0	100	0	100	0.00	100.00	50.00	50.00
Perumbavur	6	0.00	100	0	100	0	100	16.66	83.33	16.66	83.33
Kochi	18	0.00	100	0	100	0	100	16.66	83.33	77.77	22.22
Mean	156	3.44	96.56	0	100	0	100	5.28	94.72	54.79	45.21

D = Deficient, A = Adequate

Fig. 81 Status of pH in the soils of Ernakulam

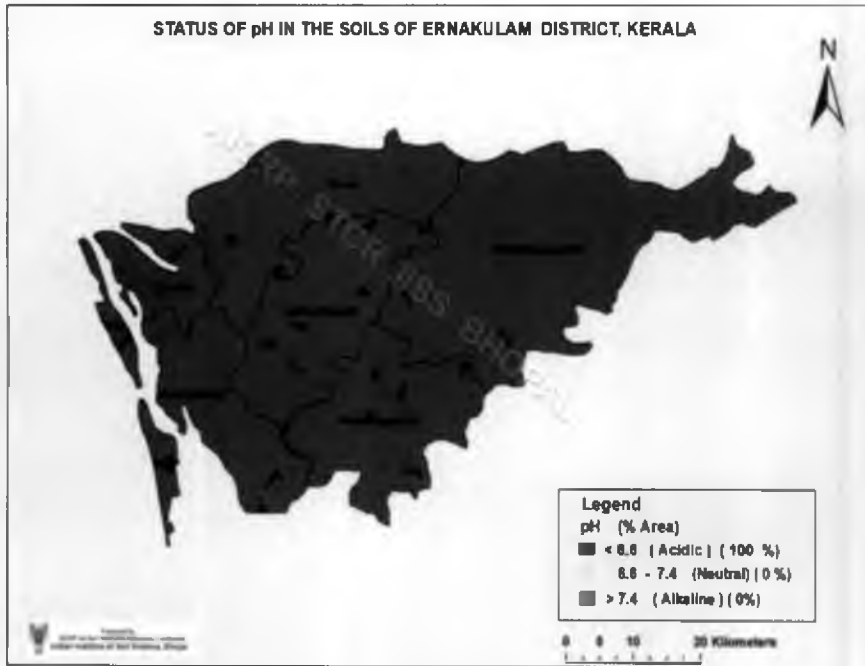


Fig. 82 Status of electrical conductivity in the soils of Ernakulam

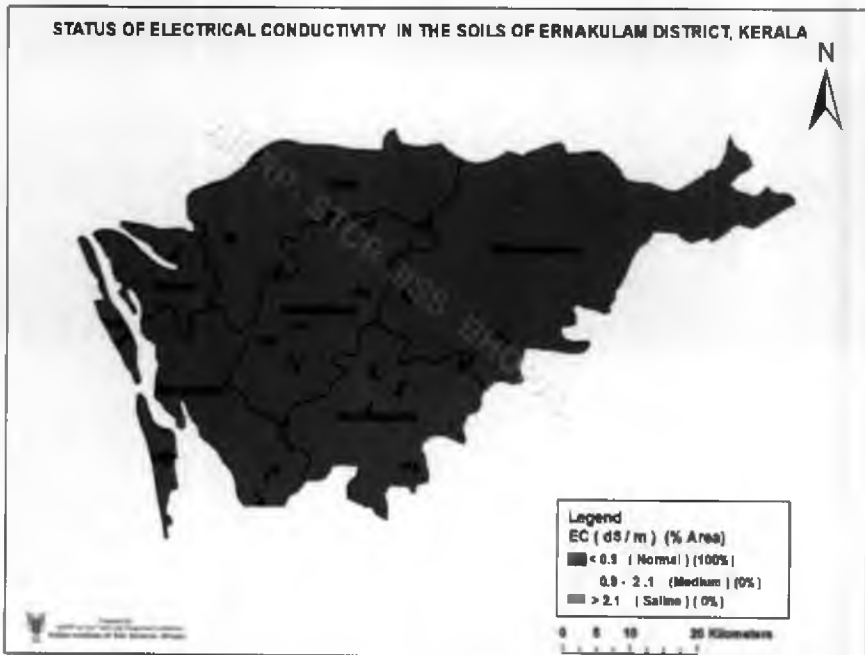


Fig. 83 Status of organic carbon in the soils of Ernakulam

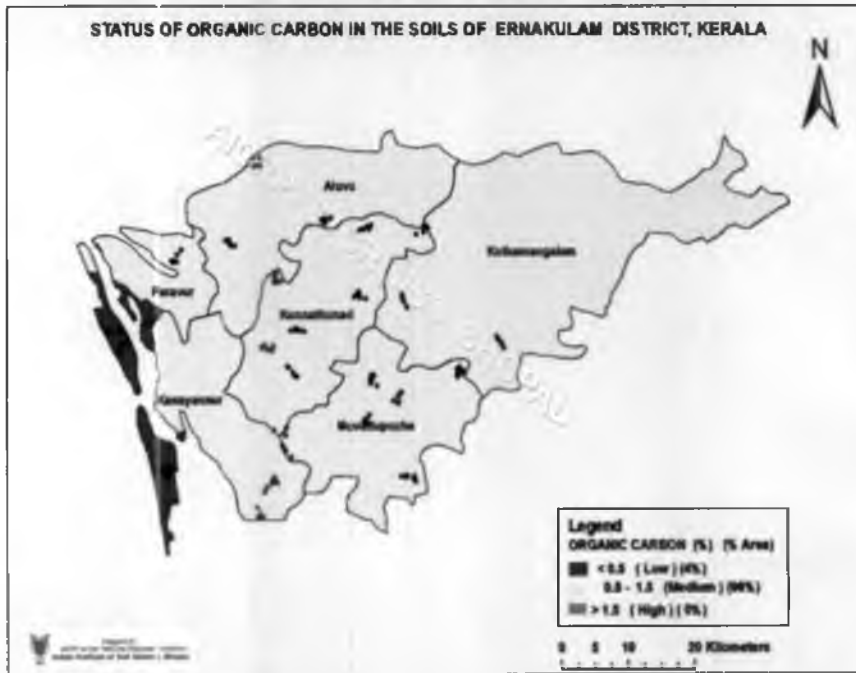


Fig. 84 Status of nitrogen in the soils of Ernakulam

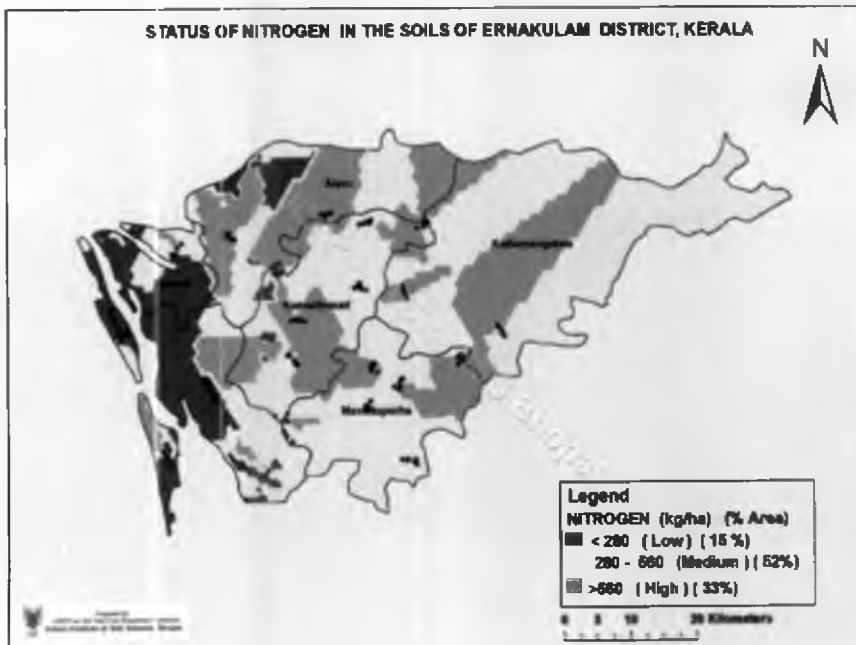


Fig. 85 Status of phosphorus in the soils of Ernakulam



Fig. 86 Status of potassium in the soils of Ernakulam

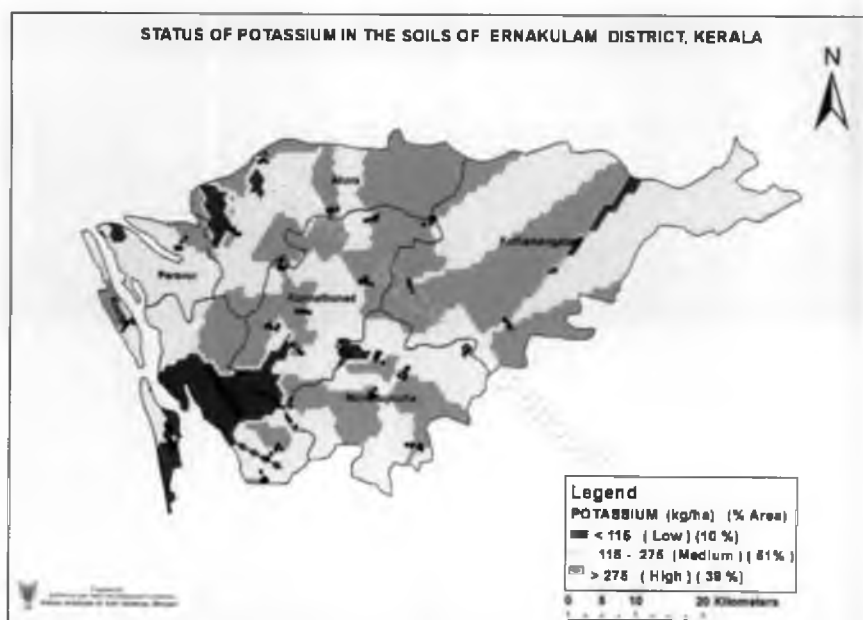


Fig. 87 Status of sulphur in the soils of Ernakulam

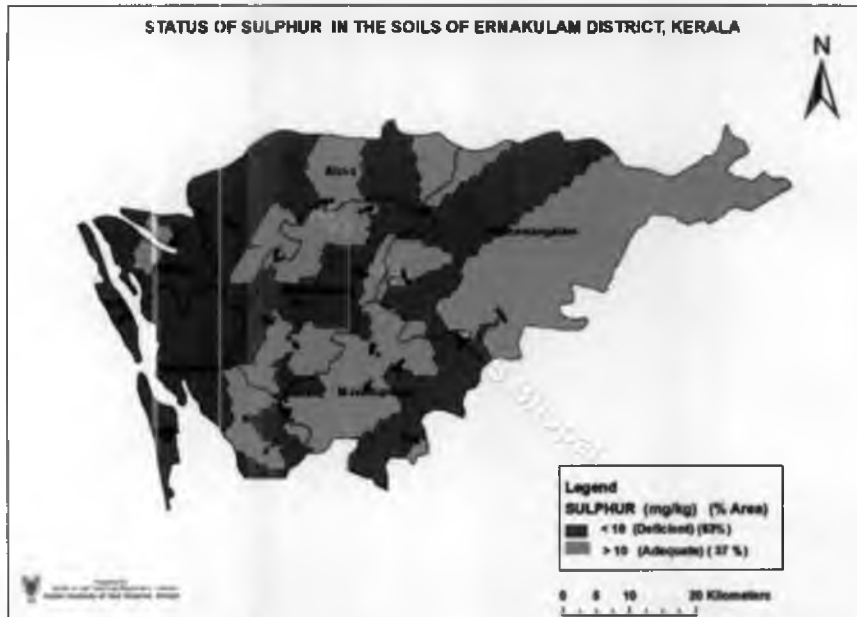


Fig. 88 Status of iron the soils of Ernakulam

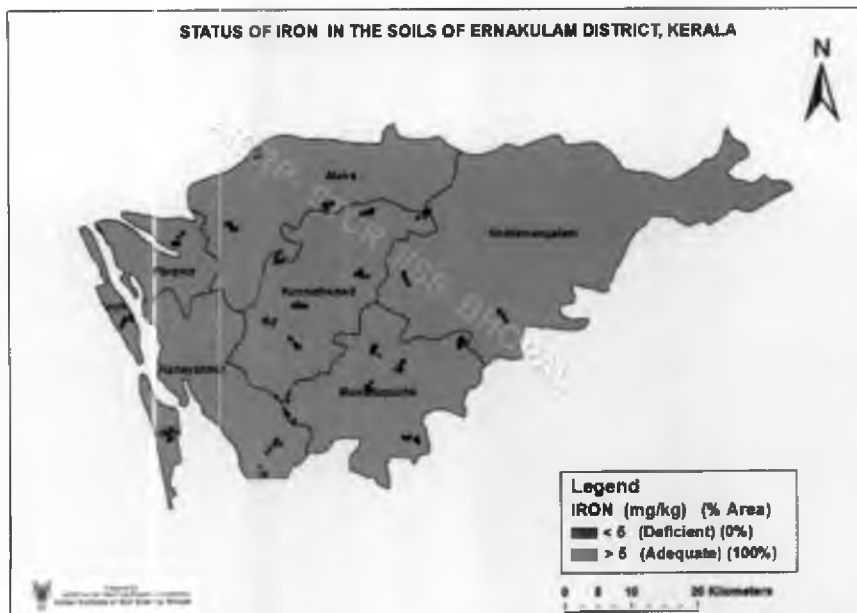


Fig. 89 Status of manganese in the soils of Ernakulam



Fig. 90 Status of copper in the soils of Ernakulam



Fig. 91 Status of zinc in the soils of Ernakulam



Fig. 92 Status of boron in the soils of Ernakulam

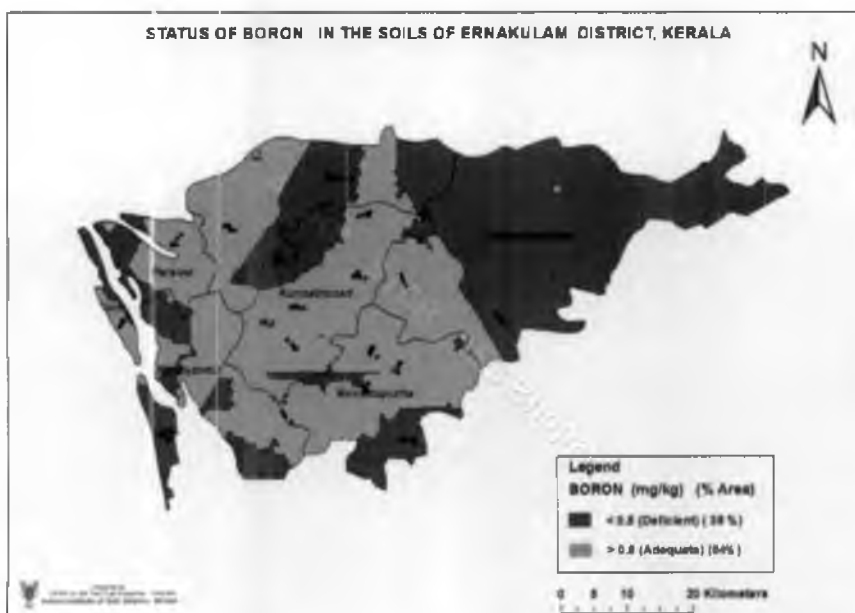


Table. 97. Fertilizer recommendations for the farmers of Ernakulam district based on GPS and GIS based soil fertility maps

Main crops: Paddy, nutmeg, banana

Recommendations/ strategies for soil amendment (for correction of soil acidity/sodicity/salinity etc.)	Acidic soils covered 89 per cent samples in the district. So lime application as dolomite, CaCO ₃ etc considering the soil pH is essential.
Recommendations/ strategies for organic matter (this should include application of manures, residues, microbial culture for decomposition like Trichoderma etc.)	Kochi and Kanayannur Taluks (sandy tract) require maintenance of organic carbon since 61 and 39 per cent of samples were low in organic carbon in these taluks. Application of coirpith compost can improve the soil physical conditions and organic carbon status of the soil. In general, about 77 per cent samples come in medium category. Vermicomposting, comopsting, application of biofertilizers etc can be practiced.
Recommendations/ strategies for NPK management	Nitrogen – 23 to 47 per cent samples were in low to medium category. Application of urea according to GRD is essential Phosphorus – 87 per cent samples were high in available P. So only maintenance dose is required. In the remaining soils, application of rock phosphate according to GRD is required. Potassium – 16 to 55 per cent of samples were low to medium in available K. So application of K fertilizer like muriate of potash is essential to maintain the potassium status of the soil.
Recommendations/ strategies for secondary/micronutrient management	Sulphur – About 43 to 100 per cent samples were deficient in sulphur. So sulphur application as elemental sulphur or factomphos is required Boron – 36 per cent of the area was deficient. So boron application as borax or solubor is required.
Training requirements	Trainings are required for farmers on : 1) Importance of organic manure, composting, vermicomposting etc. 2) Use of biofertilizers and their importance.
Any other recommendations	Agricultural extension workers and fertilizer-based firms should create awareness among farmers on the importance of soil fertility maps.

Table 98. Nutrient uses based on resource base in Ernakulam

Sl. No.	Nutrients added	Resource base		
		Small	Medium	Large
1	Major nutrients	N-10-20 kg/ha P ₂ O ₅ -25-45 kg/ha K ₂ O- 40-50 kg/ha	N-30 - 80 kg/ha P ₂ O ₅ - 40-60 kg/ha K ₂ O - 40-80 kg/ha	N-35-45 kg/ha P ₂ O ₅ -10-25 kg/ha K ₂ O- 40-80 kg/ha
2	Secondary nutrients	MgSO ₄ -25 kg/ha Lime-100 kg/ha	Lime-150 kg/ha	MgSO ₄ -25 kg/ha Lime-200 kg/ha
3	Micro nutrients			
4	Organic manures	FYM-2.5-5 kg/ha	FYM-2.5-5 kg/ha	FYM-50 kg/ha Groundnut cake- 2-4 kg/ha

Conclusion

Samples collected from Ernakulam district showed an average pH of 5.56 and electrical conductivity of 0.18 dS m⁻¹. Available nitrogen in the soils collected from this district was in the medium range (46.91 per cent). High range of phosphorus was found in 87.43 per cent samples. For potassium, 55.45 per cent samples showed medium range. In the case of organic carbon, 76.98 per cent of samples were in the medium range. Among the micronutrients, zinc, iron, copper and manganese were categorized into the adequate level and 54.79 per cent samples showed deficiency of boron. Sulphur deficiency was noticed to the extent of 70.73 per cent.

Chapter 9

Soil fertility status of Alappuzha

The name Alappuzha is derived from the geographical position and physical features of the place. It means the land between the sea and network of rivers flowing into it. The district, Alappuzha, Venice of East is located between $9^{\circ} 05' - 9^{\circ} 54'$ N latitude and $76^{\circ} 16' - 76^{\circ} 42'$ E longitude and is bounded on the north by Ernakulam district, on the east by Kottayam district and Pathanamthitta district, on the south by Kollam district and on the west by Arabian Sea. The average elevation is 1 meter and covers an area of 1,414 sq. km and is flanked by 2,195 sq. km of Vembanad Lake. There are no mountains or hills in the district except some scattered hillocks lying in the eastern portion of the district. The district is unique in that there is no forest area here. One of the major features of this land is the region called Kuttanad, the 'granary of Kerala' and is one of the few places in the world where farming is done below sea level. The paddy fields lie about 0.6 to 2 m below mean sea level. The average rainfall received by the region is 1935.9 mm. The agro-ecological zones of the district are depicted in Fig.93.

Main crops cultivated in Alappuzha district are paddy, vegetables and plantation crops like coconut and arecanut.

Table 99. Major crops, fertilizers, organic nutrient sources and sources of irrigation in Alappuzha

Crops	Chemical Fertilizers	Organic sources	Sources of irrigation
Paddy	Urea	Cow dung	Canals
Banana	Factomphos	Goat manure	Wells
Vegetables	MOP	Green manure	
Tuber crops		Neem cake	
Pepper, coconut		Rajphos	
Arecanut, rubber			

The district is divided into six taluks, which are Ambalapuzha, Karthikappilly, Mavelikkara, Kuttanad, Cherthala and Chengannur. A total of 9 villages were selected based on stratified multistage random sampling method covering all the six taluks and a total of 54 surface soil samples (six from each village) were collected using GPS representing small, medium and large farmer category. The samples were processed and analysed for 12 chemical parameters viz., pH, electrical conductivity, organic carbon, available nitrogen, phosphorus, potassium, sulphur, zinc, copper, iron, manganese and boron.

Fig. 93 Agro ecological map of Alappuzha

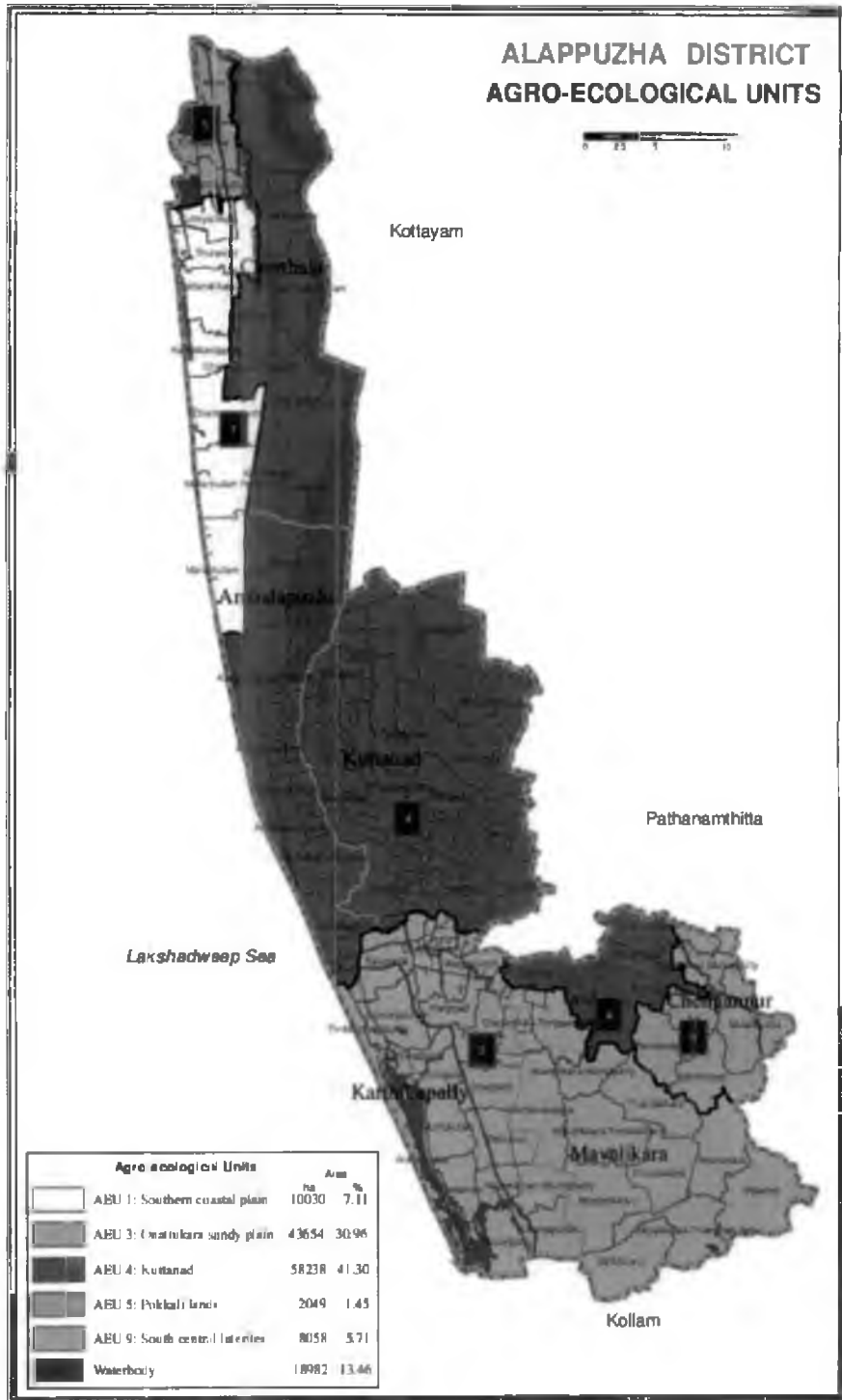


Table 100. Number of villages selected in different taluks of Alappuzha

Sl. No.	Name of Taluk	Number of villages selected
1	Karthikappilly	2
2	Mavelikkara	2
3	Kuttanad	2
4	Cherthala	1
5	Chengannur	1
6	Ambalapuzha	1

Table 101. Selected villages in different taluks of Alappuzha

Part (a)

Karthikappilly	Mavelikkara	Kuttanad
Kumarapuram	Thazhakkara	Muttar
Kandalloor	Palamel	Kavalam

Part (b)

Ambalapuzha	Cherthala	Chengannur
Aryad south	Thiruvandoor	Pallippuram

Soil fertility status

The results of soil analysis are listed in the following tables. The soil fertility maps generated from the analytical data are presented in figures, 94 to 105. These fertility maps reveal the per cent area under different categories with respect to each parameter in the total geographic area of 1,414 sq. km in the Alappuzha district.

9.1 pH and electrical conductivity

The pH of the surface soils ranged from 3.91 to 7.50. It was observed that 97.22 per cent of the samples analysed were acidic and 2.78 per cent of the samples were alkaline.

Table 102. Status of pH in different taluks of Alappuzha

Sl. No.	Taluku	No. of samples	Range	Mean	Per cent sample category		
					Acidic	Neutral	Alkaline
1	Ambalapuzha	6	5.20-7.50	6.19	83.33	0	16.67
2	Karthikappilly	12	5.15-6.28	5.65	100	0	0
3	Mavelikkara	12	4.50-6.13	5.16	100	0	0
4	Cherthala	6	5.42-6.27	5.87	100	0	0
5	Chengannur	6	4.72-6.26	5.41	100	0	0
6	Kuttanad	12	3.91-6.19	4.85	100	0	0
# Range/Mean		54	3.91-7.50	5.52	97.22	0	2.78

With regard to electrical conductivity, the whole area of the district is non-saline. The electrical conductivity of the soils ranged from 0.02 to 1.60 dS m⁻¹.

Table 103. Status of EC (dS m⁻¹) in different taluks of Alappuzha

SI No	Taluks	Range	Mean
1	Ambalapuzha	0.02 – 0.08	0.05
2	Karthikappilly	0.06 – 0.36	0.15
3	Mavelikkara	0.05 – 0.17	0.09
4	Cherthala	0.05 – 0.15	0.10
5	Chengannur	0.04 – 0.09	0.07
6	Kuttanad	0.02 – 1.60	0.39
# Range/Mean		0.02 – 1.60	0.16

9.2 Organic carbon

The organic carbon status of the soil was medium and ranged from 0.12 to 2.73 per cent with a mean value of 0.64 per cent. Kuttanad taluk recorded the highest mean organic carbon content of 1.26 per cent. The per cent of soils coming under low, medium and high categories were 41.67, 52.78 and 5.56 respectively.

Table 104. Status of organic carbon (per cent) in different taluks of Alappuzha

Sl. No.	Taluks	No. of samples	Range	Mean	Per cent sample category			NIV	Fertlity rating
					Low	Medium	High		
1	Ambalapuzha	6	0.18-0.90	0.61	33.33	66.67	0.00	1.67	Medium
2	Karthikappilly	12	0.12-0.86	0.34	83.33	16.67	0.00	1.17	Low
3	Mavelikkara	12	0.21-1.53	0.69	33.33	58.34	8.33	1.75	Medium
4	Cherthala	6	0.12-0.50	0.27	83.33	16.67	0.00	1.17	Low
5	Chengannur	6	0.39-0.90	0.69	16.67	83.33	0.00	1.83	Medium
6	Kuttanad	12	0.51-2.73	1.26	0.00	75.00	25.00	2.25	Medium
# Range/Mean		54	0.12-2.73	0.64	41.67	52.78	5.56	1.64	Medium

9.3 Available nitrogen

The available nitrogen status in the surface soils ranged from 137.98 to 514.30 kg ha⁻¹ with a mean value of 283.59 kg ha⁻¹. The per cent sample categories under both low and medium was 50 per cent each. Among the six taluks, Karthikappilly recorded the highest per cent of samples under low available N (91.67). The mean value of nutrient index for available nitrogen was 1.46. The fertility rating was medium for available nitrogen.

Table 105. Status of available nitrogen (kg ha^{-1}) in different taluks of Alappuzha

Sl. No.	Taluku	No. of samples	Range	Mean	Per cent sample category			NIV	Fertility rating
					Low	Medium	High		
1	Ambalapuzha	6	163.07-501.76	298.97	50.00	50.00	0	1.50	Medium
2	Karthikappilly	12	137.98-301.06	214.29	91.67	8.33	0	1.08	Low
3	Mavelikkara	12	188.16-451.58	281.97	41.67	58.33	0	1.58	Medium
4	Cherthala	6	188.16-363.78	278.06	50.00	50.00	0	1.50	Medium
5	Chengannur	6	263.42-313.60	286.42	33.33	66.67	0	1.67	Medium
6	Kuttanad	12	232.34-514.30	341.82	33.33	66.67	0	2.25	Medium
# Range/Mean		54	137.98-514.30	283.59	50.00	50.00	0	1.46	Medium

9.4 Available phosphorus

The available Bray-P content ranged from 1.87 to 210.80 kg ha^{-1} with a mean value of 73.83 kg ha^{-1} . The per cent sample categories under low, medium and high were 4.17, 23.61 and 72.22 respectively. Among the six taluks, Cherthala and Chengannur taluks recorded the highest per cent of samples under high available P (83.33 per cent); the highest per cent of samples under low available P was observed in Kuttanad taluk (16.67 per cent). The mean value of nutrient index for available phosphorus was 2.65. The fertility rating for available phosphorus was high.

Table 106. Status of available phosphorus (kg ha^{-1}) in different taluks of Alappuzha

Sl. No.	Taluku	No. of samples	Range	Mean	Per cent sample category			NIV	Fertility rating
					Low	Medium	High		
1	Ambalapuzha	6	14.93-108.27	53.82	0.00	33.33	66.67	2.67	High
2	Karthikappilly	12	11.20-197.87	80.27	0.00	25.00	75.00	2.75	High
3	Mavelikkara	12	3.17-210.80	57.12	8.33	41.67	50.00	2.42	High
4	Cherthala	6	14.93-149.33	85.55	0.00	16.67	83.33	2.83	High
5	Chengannur	6	11.20-143.73	95.82	0.00	16.67	83.33	2.83	High
6	Kuttanad	12	1.87-206.00	70.37	16.67	8.33	75.00	2.58	High
# Range/Mean		54	1.87-210.80	73.83	4.17	23.61	72.22	2.65	High

9.5 Available potassium

The available potassium status in surface soils of different taluks ranged from 39.20 to 579.60 kg ha⁻¹. Considering the mean values, the highest value of 309.40 kg ha⁻¹ was recorded in Kuttanad taluk and the lowest mean value of 154.47 kg ha⁻¹ in Cherthala taluk. The per cent sample categories under low, medium and high were 20.83, 50.00 and 29.17 respectively. The mean nutrient index value of available K was 2.13. The fertility rating for available K was medium.

Table 107. Status of available potassium (kg ha⁻¹) in different taluks of Alappuzha

Sl. No.	Taluks	No. of samples	Range	Mean	Per cent sample category			NIV	Fertility rating
					Low	Medium	High		
1	Ambalapuzha	6	89.60-235.20	157.73	16.67	83.33	0.00	1.83	Medium
2	Karthikappilly	12	50.40-462.00	245.47	25.00	41.67	33.33	2.08	Medium
3	Mavelikkara	12	98.00-579.60	234.91	8.33	75.00	16.67	2.08	Medium
4	Cherthala	6	39.20-285.60	154.47	33.33	50.00	16.67	1.83	Medium
5	Chengannur	6	47.60-478.80	299.13	33.33	16.67	50.00	2.17	Medium
6	Kuttanad	12	109.20-574.00	309.40	8.33	33.33	58.34	2.5	High
# Range/Mean		54	39.20-579.60	233.52	20.83	50.00	29.17	2.13	Medium

9.6 Available sulphur

The available S content ranged from 0.44 to 752.20 mg kg⁻¹ with a mean value of 23.18 mg kg⁻¹. The mean available S status was found to be low in Ambalapuzha taluk (2.27 mg kg⁻¹) and high in Kuttanad taluk (119.07 mg kg⁻¹). Among the samples, 87.50 per cent of samples were deficient and 12.50 per cent were adequate in respect to available S content.

Table 108. Status of available sulphur (mg kg⁻¹) in different taluks of Alappuzha

Sl. No.	Taluks	No. of samples	Range	Mean	Per cent sample category	
					Deficient	Adequate
1	Ambalapuzha	6	0.62 - 6.78	2.27	100	0.00
2	Karthikappilly	12	0.53 - 1.82	5.01	83.33	16.67
3	Mavelikkara	12	0.44 - 8.97	3.86	100	0.00
4	Cherthala	6	2.02 - 4.66	3.11	100	0.00
5	Chengannur	6	0.53 - 25.34	5.78	83.33	16.67
6	Kuttanad	12	0.50 - 752.20	119.07	58.33	41.67
# Range/Mean		54	0.44 - 752.20	23.18	87.50	12.50

9.7 Available micronutrients

The DTPA-Zn content ranged from 0.45 to 55.95 mg kg⁻¹ with a mean value of 14.29 mg kg⁻¹. The DTPA -Fe content varied from 5.08 to 400 mg kg⁻¹ with a mean value of 106.98 mg kg⁻¹, Fe was found to be sufficient in all the taluks. The availability of Cu ranged from 0.15 to 14.75 mg kg⁻¹ with a mean value of 1.73 mg kg⁻¹. The Mn availability in the soils ranged from 0.30 to 29.83 mg kg⁻¹ with a mean of 6.24 mg kg⁻¹. The B content ranged from 0.05 to 1.45 mg kg⁻¹ with a mean value of 0.52 mg kg⁻¹. The nutrient index value ranged from 1.92 to 2.00 for Zn, 1.50 to 2.00 for Mn, 1.33 to 1.58 for B and 2.00 for Cu. The NIV for Fe was 2.00. Very low to low fertility rating was recorded for B, low to medium for Mn, and medium for Zn, Fe and Cu in most of the taluks (Appendix III).

Table 109. Status of available micronutrients (mg kg⁻¹) in different taluks of Alappuzha

Sl. No.	Taluks	No. of samples	Micronutrient status (Range)				
			Zn	Fe	Cu	Mn	B
1	Ambalapuzha	6	5.05-36.98 (15.75)	10.03-193.33 (74.75)	0.73-2.90 (1.69)	0.75-8.65 (4.11)	0.15-0.70 (0.43)
2	Karthikappilly	12	1.98-28.18 (6.32)	5.45-187.60 (55.53)	0.15-1.83 (0.62)	0.60-6.48 (2.41)	0.05-1.15 (0.53)
3	Mavelikkara	12	0.45-55.95 (15.47)	5.08-231.18 (70.46)	0.15-2.53 (0.95)	1.00-14.13 (6.27)	0.25-0.85 (0.50)
4	Cherthala	6	1.90-22.95 (10.01)	35.40-152.13 (75.32)	0.40-1.88 (1.01)	0.30-2.80 (1.21)	0.10-1.40 (0.48)
5	Chengannur	6	2.75-48.68 (27.36)	56.28-106.15 (84.07)	2.13-14.75 (4.73)	5.68-29.83 (13.99)	0.35-1.45 (0.66)
6	Kuttanad	12	1.15-29.63 (15.97)	72.08-400.00 (238.36)	0.33-4.10 (2.50)	3.33-22.10 (9.76)	0.10-1.35 (0.52)
# Range/Mean		54	0.45-55.95 (14.29)	5.08- 400 (106.98)	0.15-14.75 (1.73)	0.30-29.83 (6.24)	0.05- 1.45 (0.52)

*Values in parenthesis indicate mean

Table 110. Per cent sample category of available micronutrients in different taluks of Alappuzha

Taluks	No of samples	Zn		Fe		Cu		Mn		B	
		D (%)	A (%)	D (%)	A (%)	D (%)	A (%)	D (%)	A (%)	D (%)	A (%)
Ambalapuzha	6	0.00	100	0.00	100	0	100	16.67	83.33	66.67	33.33
Karthikappilly	12	0.00	100	0.00	100	0	100	33.33	66.67	50.00	50.00
Mavelikkara	12	8.33	91.67	0.00	100	0	100	0.00	100	50.00	50.00
Cherthala	6	0.00	100	0.00	100	0	100	50.00	50.00	66.67	33.33
Chengannur	6	0.00	100	0.00	100	0	100	0.00	100	50.00	50.00
Kuttanad	12	0.00	100	0.00	100	0	100	0.00	100	41.67	58.33
Mean	54	1.39	98.61	0.00	100	0	100	16.67	83.33	54.17	45.83

D = Deficient, A = Adequate

Fig. 94 Status of pH in the soils of Alappuzha



Fig. 95 Status of electrical conductivity in the soils of Alappuzha



Fig. 96 Status of organic carbon in the soils of Alappuzha



Fig. 97 Status of nitrogen in the soils of Alappuzha



Fig. 98 Status of phosphorus in the soils of Alappuzha



Fig. 99 Status of potassium in the soils of Alappuzha



Fig. 100 Status of sulphur in the soils of Alappuzha



Fig. 101 Status of iron in the soils of Alappuzha



Fig. 102 Status of manganese in the soils of Alappuzha



Fig. 103 Status of copper in the soils of Alappuzha



Fig. 104 Status of zinc in the soils of Alappuzha



Fig. 105 Status of boron in the soils of Alappuzha



Table. 111. Fertilizer recommendations for the farmers of Alappuzha district based on GPS and GIS based soil fertility maps

Main crops: Paddy, banana, vegetables

<p>Recommendations/ strategies for soil amendment (for correction of soil acidity/sodicity/salinity etc.)</p>	<p>Soils were acidic and sandy. Amendments such as coirpith and 'kayal' silt which are locally available can be applied to improve the physical properties of these coarse textured soils. Lime can be applied in several splits. Extremely acidic soils like acid sulphate soils are seen in this district. Here liming followed by washing out is required.</p>
<p>Recommendations/ strategies for organic matter (this should include application of manures, residues, microbial culture for decomposition like Trichoderma etc.)</p>	<p>Organic carbon status showed low value in the northern (Cherthala taluk) and southern (Karthikappilly) areas. Application of organic manures is required for organic carbon maintenance. Application of coconut leaf vermicomposting is a good option here. Coir pith, product of coir industry of Alappuzha can use for coirpith composting. VAM can also be used.</p>
<p>Recommendations/ strategies for NPK management</p>	<p>Being a sandy tract, Karthikappilly and Cherthala taluks showed low available N and K. So, N and K fertilizers have to be applied. Apply N in split dose. Vermicomposting of coconut leaves will be a good alternative for K sources here. Except Kuttanad, all taluks require split application of K fertilizers apart from normal practice. It helps to avoid leaching loss of nutrients. Phosphorus – 68 per cent samples were high, so apply maintenance dose only.</p>
<p>Recommendations/ strategies for secondary/micronutrient management</p>	<p>Acute sulphur deficiency was noted (88 per cent). So application of elemental sulphur, sulphur coated urea and factomphos is necessary. Levels of Fe, Mn, Zn and Cu are found to be adequate. In coconut, B deficiency is widely noticed. So application of B containing fertilizers viz., borax, solubor etc. is required.</p>
<p>Training requirements</p>	<p>Training for the STL personnel for a period of 3 to 4 days is essential for a complete awareness about soil testing including micronutrient estimation.</p>
<p>Any other recommendations</p>	<p>Farmers should be given awareness about liming. Training should be imparted on need for split application of N and K fertilizers and organic manure application.</p>

Table 112. Nutrient uses based on resource base in Alappuzha

Sl. No.	Nutrients added	Resource base		
		Small	Medium	Large
1	Major nutrients	N-15-100 kg/ha P ₂ O ₅ -0-50 kg/ha K ₂ O- 10-90 kg/ha	N-50-100 kg/ha P ₂ O ₅ -20-50 kg/ha K ₂ O- 10-90 kg/ha	N-50-100 kg/ha P ₂ O ₅ -40-60 kg/ha K ₂ O- 70-90 kg/ha
2	Secondary nutrients	MgSO ₄ -25 kg/ha Lime-75 kg/ha	MgSO ₄ -25 kg/ha Lime-100 kg/ha	MgSO ₄ -25 kg/ha Lime-150 kg/ha
3	Micro nutrients		Micronutrient mixture 2-5 kg/ha ZnSO ₄ -1-2 kg/ha Borax -5 kg/ha	Micronutrient mixture 2-5 kg/ha ZnSO ₄ 1-2 kg/ha Borax 5-8 kg/ha
4	Organic manures	FYM-2.5-5 kg/ha	FYM-2.5-5 kg/ha	FYM-2.5-10 kg/ha Neem cake-40-50 kg ha Bonemeal-10-50 kg ha
5	Bio fertilizers			Pseudomonas Rhizobium-1-2.5kg/ha

Conclusion

Samples collected from Alappuzha district showed an average pH of 5.52 and mean electrical conductivity 0.16 dS m⁻¹. Available nitrogen status in the soils collected from this district was 50 per cent in the low range and 50 per cent in the medium. Soil samples belonging to the high class of phosphorus was more in Alappuzha district (72.22 per cent). In the case of available potassium, 50 per cent of samples are in the medium range. In the case of organic carbon, 52.78 per cent of samples were in the medium range. Among micronutrients, zinc, iron, copper and manganese were categorized into the adequate level and boron was categorized into deficient level by 54.17 per cent of samples. Sulphur deficiency was noticed in soils to the extent of 87.50 per cent.

Chapter 10

Soil fertility status of Thiruvananthapuram

Thiruvananthapuram district is situated between north latitudes at 8°17' – 8°54' and east longitudes 76° 40' – 77° 17'. The southern-most extremity, Parassala is just 54 km away from the southern peninsular tip of India, KanyaKumari. The state capital is located at Thiruvananthapuram. The district stretches 78 km along the shores with Arabian Sea on the west, Kollam on the north, Tamil Nadu on the east and south respectively. The district can be divided into three geographical regions: highlands, midlands, and lowlands. The Chirayinkeezhu and Thiruvananthapuram taluks are located in the midland and lowland regions, while the Nedumangad taluk lies in the midland and highland regions, and the Neyyattinkara taluk stretches over all the three regions. The highland regions on the east and the north-east comprise the Western Ghats, and this area is ideal for major cash crops like rubber, tea, cardamom and other spices. Timber trees like teak and rosewood are grown in this region. The Ghats maintain an average elevation of 814 m. The forests in the tail end of Western Ghats form the most diverse and unknown ecosystem in Peninsular India. The midland region lying between the Western Ghats and lowlands is made up of small and tiny hills and valleys. This is an area having intense agricultural activities. The agro-ecological zones of the district are depicted in Fig.106.

This southern most district of the state is famous for crops like paddy, tapioca, rubber, eucalyptus, spices and cashew. The lowlands are comparatively narrow, consisting of rivers, deltas and seashore. This area is densely covered with coconut trees.

Table 113. Major crops, fertilizers, organic nutrient sources and sources of irrigation in Thiruvananthapuram

Crops	Chemical fertilizers	Organic sources	Sources of Irrigation
Banana	Urea	Cow dung, neem cake	Canals
Vegetables	Factomphos	Goat manure	Wells
Tuber crops	MOP	Green manure	
Pepper	Magnesium	Bone meal, lime	
Coconut, rubber	sulphate	Rajphos, ash	

The district is divided into four taluks which are Chirayinkeezhu, Neyyattinkara, Nedumangad and Thiruvananthapuram. A total of 10 villages were selected based on stratified multistage random sampling method covering all the four taluks and a total of 60 surface soil samples (six from each village) were collected using GPS representing small, medium and large farmer category. The samples were processed and were analysed for 12 chemical parameters viz., pH, electrical conductivity, organic carbon, available nitrogen, phosphorus, potassium, sulphur, zinc, copper, iron, manganese and boron.

Fig. 106 Agro ecological map of Thiruvananthapuram

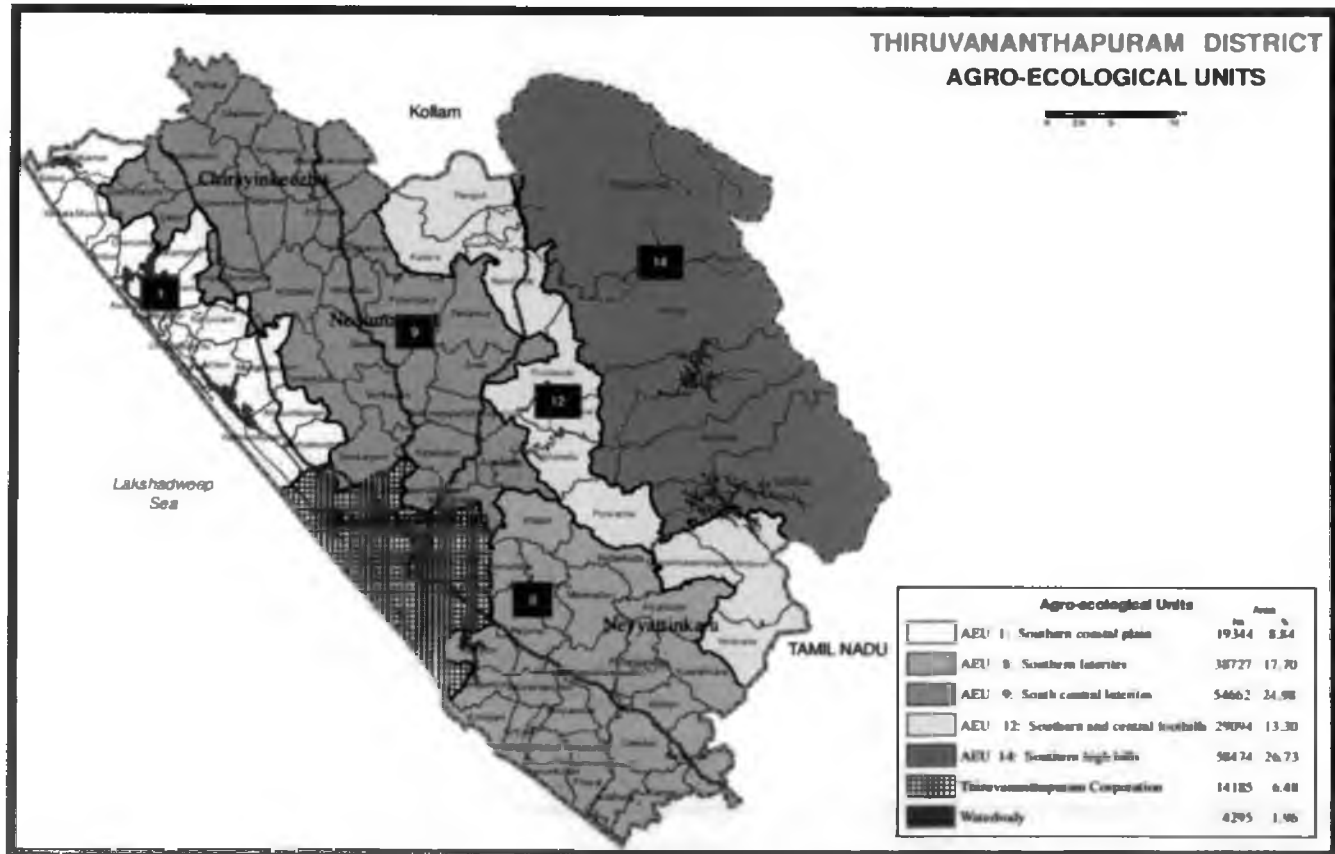


Table 114. Number of villages selected in different taluks of Thiruvananthapuram

Sl. No.	Name of Taluk	Number of villages selected
1	Chirayinkeezhu	3
2	Neyyattinkara	3
3	Nedumangad	3
4	Thiruvananthapuram	1

Table 115. Selected villages in Thiruvananthapuram

Chirayinkeezhu	Neyyattinkara	Nedumangad	Thiruvananthapuram
Kadakkavur	Kallickad	Anad	Pallippuram
Koduvazhannur	Maranellur	Vembayam	
Chemmaruthy	Karode	Vellanad	

Soil fertility status

The results of soil analysis are listed in the following tables. The soil fertility maps generated from the analytical data are presented in figures, 107 to 118. These fertility maps reveal the percentage area under different categories with respect to each parameter in the total geographic area of 2,192 sq. km ha in Thiruvananthapuram district.

10.1 pH and electrical conductivity

The pH of the surface soils ranged from 4.69 to 6.82. It was observed that 97.22 per cent of the samples analysed were acidic and 2.78 per cent of the samples were neutral. Alkaline soils were not present.

Table 116. Status of pH in different taluks of Thiruvananthapuram

Sl. No.	Taluks	No. of samples	Range	Mean	Per cent sample category		
					Acidic	Neutral	Alkaline
1	Chirayinkeezhu	18	4.88-6.82	5.69	88.89	11.11	0.00
2	Nedumangad	18	4.69-6.31	5.53	100	0.00	0.00
3	Neyyattinkara	18	4.79-6.53	5.84	100	0.00	0.00
4	Thiruvananthapuram	6	4.87-5.80	4.87	100	0.00	0.00
# Range/Mean		60	4.69-6.82	5.48	97.22	2.78	0.00

The whole area of the district is non saline. The electrical conductivity of the soils ranged from 0.02 to 0.28 dS m⁻¹ with a mean of 0.10 dS m⁻¹.

Table 117. Status of EC (dS m⁻¹) in different taluks of Thiruvananthapuram

Sl. No.	Taluks	Range	Mean
1	Chirayinkeezhu	0.03-0.18	0.09
2	Nedumangad	0.02-0.28	0.12
3	Neyyattinkara	0.06-0.16	0.09
4	Thiruvananthapuram	0.03-0.11	0.03
# Range/Mean		0.02-0.28	0.10

10.2 Organic carbon

The organic carbon status of the soil was medium and ranged from 0.20 to 1.63 per cent with a mean value of 0.57 per cent. Nedumangad taluk recorded the highest mean organic carbon content of 0.82 per cent. The per cent of soils coming under low, medium and high categories were 33.33, 65.28 and 1.39 respectively.

Table 118. Status of organic carbon (per cent) in different taluks of Thiruvananthapuram

Sl. No.	Taluks	No. of samples	Range	Mean	Per cent sample category			NIV	Fertility rating
					Low	Medium	High		
1	Chirayinkeezhu	18	0.20-0.95	0.57	38.89	61.11	0	1.61	Medium
2	Nedumangad	18	0.52-1.63	0.82	0	94.44	5.56	2.06	Medium
3	Neyyattinkara	18	0.33-1.01	0.66	27.78	72.22	0	1.72	Medium
4	Thiruvananthapuram	6	0.23-0.71	0.23	66.67	33.33	0	1.33	Low
# Range/Mean		60	0.20-1.63	0.57	33.33	65.28	1.39	1.68	Medium

10.3 Available nitrogen

The available nitrogen status in the surface soils ranged from 125.44 to 702.46 kg ha⁻¹ with a mean value of 285.03 kg ha⁻¹. The per cent samples under low, medium and high categories were 50.00, 44.44 and 5.56 respectively. Among the four taluks, Thiruvananthapuram recorded the highest per cent of samples under low available N. The mean value of nutrient index for available nitrogen was 1.56. The fertility rating was medium for available nitrogen.

Table 119. Status of available nitrogen (kg ha^{-1}) in different taluks of Thiruvananthapuram

Sl. No	Taluku	No. of samples	Range	Mean	Per cent sample category			NIV	Fertility rating
					Low	Medium	High		
1	Chirayinkeezhu	18	150.53-702.46	315.69	55.56	33.33	11.11	1.56	Medium
2	Nedumangad	18	238.34-577.02	407.68	16.67	77.78	5.55	1.89	Medium
3	Neyyattinkara	18	125.44-589.57	278.76	61.11	33.33	5.56	1.44	Medium
4	Thiruvananthapuram	6	137.98-388.86	137.98	66.67	33.33	0.00	1.33	Low
# Range/Mean		60	125.44-702.46	285.03	50.00	44.44	5.56	1.56	Medium

10.4 Available phosphorus

The available Bray-P content ranged from 1.88 to 63.13 kg ha^{-1} with a mean value of 14.65 kg ha^{-1} . The per cent of soils under low, medium and high categories were 45.83, 33.34 and 20.83 respectively. Among the four taluks, Thiruvananthapuram recorded the highest per cent of samples under low available P. The mean value of nutrient index for available phosphorus was 1.75. The fertility rating for available phosphorus was medium.

Table 120. Status of available phosphorus (kg ha^{-1}) in different taluks of Thiruvananthapuram

Sl. No	Taluku	No. of samples	Range	Mean	Per cent sample category			NIV	Fertility rating
					Low	Medium	High		
1	Chirayinkeezhu	18	1.88-49.38	17.99	22.22	55.56	22.22	2.00	Medium
2	Nedumangad	18	3.75-63.13	18.93	50.00	33.33	16.67	1.67	Medium
3	Neyyattinkara	18	2.50-53.75	16.67	44.44	27.78	27.78	1.83	Medium
4	Thiruvananthapuram	6	5.00-38.13	5.00	66.67	16.67	16.66	1.50	Medium
# Range/Mean		60	1.88-63.13	14.65	45.83	33.34	20.83	1.75	Medium

10.5 Available potassium

The available potassium status in surface soils of different taluks ranged from 22.40 to 546 kg ha^{-1} . Considering the mean values, the highest value of 159.91 kg ha^{-1} was recorded in Nedumangad taluk and the lowest mean value of 22.40 kg ha^{-1} in Thiruvananthapuram taluk. The per cent samples under low, medium and high

categories were 62.50, 31.95 and 5.56 respectively. The mean nutrient index value of available K was 1.48. The fertility rating for available K was medium.

Table 121. Status of available potassium (kg ha⁻¹) in different taluks of Thiruvananthapuram

Sl. No	Taluks	No. of samples	Range	Mean	Per cent sample category			NIV	Fertility rating
					Low	Medium	High		
1	Chirayinkeezhu	18	25.20-546.00	100.64	83.33	11.11	5.56	1.22	Low
2	Nedumangad	18	44.80-490.00	159.91	50.00	38.89	11.11	1.61	Medium
3	Neyyattinkara	18	28.00-369.60	139.84	33.33	61.11	5.56	1.72	Medium
4	Thiruvananthapuram	6	22.40-162.40	22.40	83.33	16.67	0.00	1.17	Low
# Range/Mean		60	22.40-546.00	105.70	62.50	31.95	5.56	1.48	Medium

10.6 Available sulphur

The available S content ranged from 1.40 to 52.47 mg kg⁻¹ with mean value of 8.32 mg kg⁻¹. The mean available S status was found to be low in Thiruvananthapuram taluk (1.64 mg kg⁻¹) and high in Nedumangad taluk (14.51 mg kg⁻¹). It was observed that 72.22 per cent of samples were deficient and 27.78 per cent were adequate in respect to available S content.

Table 122. Status of available sulphur (mg kg⁻¹) in different taluks of Thiruvananthapuram

Sl. No.	Taluks	No. of samples	Range	Mean	Per cent sample category	
					Deficient	Adequate
1	Chirayinkeezhu	18	2.06 - 43.85	11.42	66.67	33.33
2	Nedumangad	18	2.37 - 51.56	14.51	55.56	44.44
3	Neyyattinkara	18	1.40 - 33.89	5.72	83.33	16.67
4	Thiruvananthapuram	6	1.64 - 52.47	1.64	83.33	16.67
# Range/Mean		60	1.40 - 52.47	8.32	72.22	27.78

10.6 Available micronutrients

The DTPA-Zn content ranged from 0.15 to 45.38 mg kg⁻¹ with a mean value 3.69 mg kg⁻¹. The DTPA-Fe content varied from 5.45 to 239.03 mg kg⁻¹ with a mean value of 41.19 mg kg⁻¹, Fe was found to be sufficient in all the taluks. The availability of Cu ranged from 0.05 to 5.10 mg kg⁻¹ with a mean value of 0.88 mg

kg⁻¹. The Mn availability in the soils ranged from 0.50 to 62.10 mg kg⁻¹ with a mean of 9.04 mg kg⁻¹. The boron content ranged from 0.10 to 5.80 mg kg⁻¹ with a mean value of 1.64 mg kg⁻¹. The nutrient index value ranged from 1.50 to 1.94 for Zn, 1.83 to 2.00 for Cu, 1.94 to 2.00 for Mn and 1.67 to 1.89 for B. The index value for Fe was 2.00. Notably low to medium fertility rating was recorded for Zn and medium for Fe, Cu, Mn and B in most of the taluks (Appendix III).

Table 123. Status of available micronutrients (mg kg⁻¹) in different taluks of Thiruvananthapuram

Sl. No.	Taluks	No. of samples	Micronutriments status (Range)				
			Zn	Fe	Cu	Mn	B
1	Chirayinkeezhu	18	0.15-45.38 (4.60)	5.45-137.43 (38.14)	0.05-3.28 (0.71)	1.53-23.13 (6.59)	0.35-5.80 (1.30)
2	Nedumangad	18	0.25-19.30 (4.19)	8.58-239.03 (63.26)	0.23-2.50 (1.13)	0.50-22.28 (7.89)	0.45-5.80 (1.99)
3	Neyyattinkara	18	0.33-6.20 (2.89)	7.50-102.73 (25.01)	0.30-5.10 (1.00)	1.75-62.10 (14.68)	0.35-3.95 (1.71)
4	Thiruvananthapuram	6	0.18-4.40 (0.18)	6.93-95.45 (6.93)	0.05-0.35 (0.05)	1.45-4.60 (1.45)	0.10-3.65 (0.10)
# Range/Mean		60	0.15-45.38 (3.69)	5.45-239.03 (41.19)	0.05- 5.10 (0.88)	0.50-62.10 (9.04)	0.10- 5.80 (1.64)

*Values in parenthesis indicate mean

Table 124. Per cent sample category of available micronutrient status in different taluks of Thiruvananthapuram

Taluks	No of samples	Zn		Fe		Cu		Mn		B	
		D (%)	A (%)	D (%)	A (%)	D (%)	A (%)	D (%)	A (%)	D (%)	A (%)
Chirayinkeezhu	18	16.67	83.33	0	100	5.56	94.44	0.00	100	11.11	88.89
Neyyattinkara	18	5.56	94.44	0	100	0.00	100	0.00	100	11.11	88.89
Nedumangad	18	5.56	94.44	0	100	0.00	100	5.56	94.44	11.11	88.89
Thiruvananthapuram	6	50.00	50.00	0	100	16.67	83.33	0.00	100.00	33.33	66.67
Mean	60	19.45	80.55	0	100	5.56	94.44	1.39	98.61	16.67	83.34

D = Deficient, A = Adequate

Fig. 107 Status of pH in the soils of Thiruvananthapuram



Fig. 108 Status of electrical conductivity in the soils of Thiruvananthapuram



Fig. 109 Status of organic carbon in the soils of Thiruvananthapuram

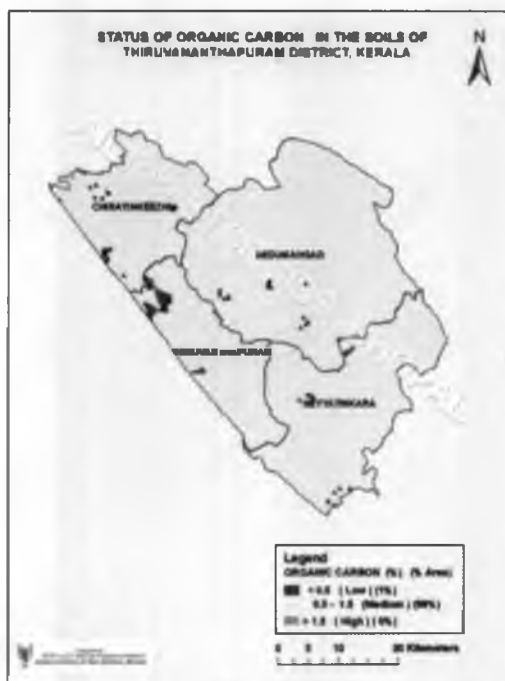


Fig. 110 Status of nitrogen in the soils of Thiruvananthapuram

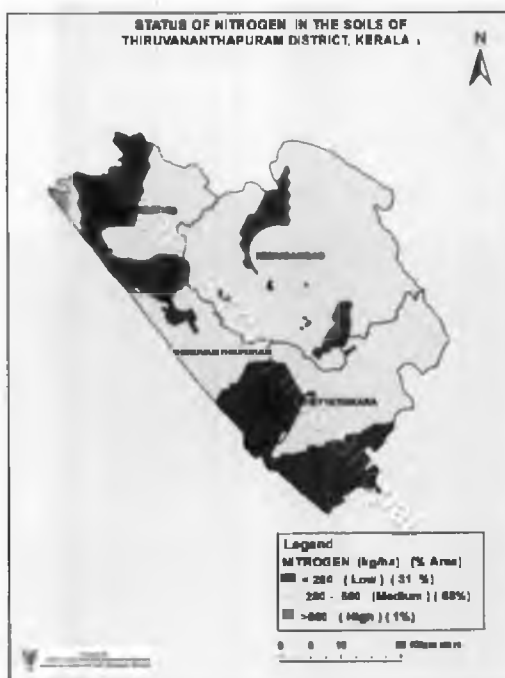


Fig. 111 Status of phosphorus in the soils of Thiruvananthapuram

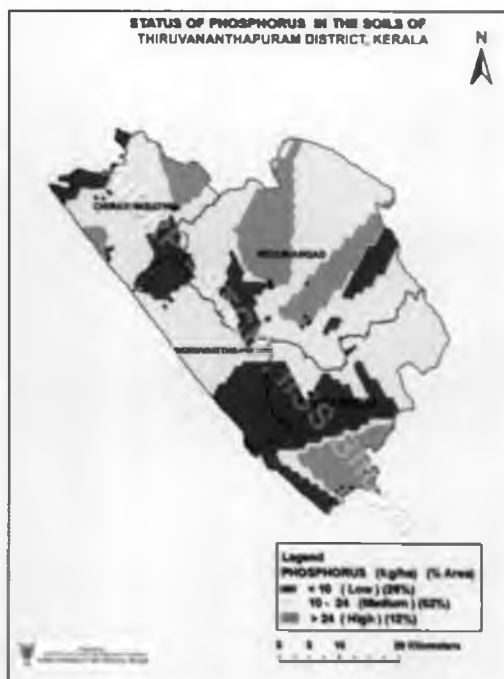


Fig. 112 Status of potassium in the soils of Thiruvananthapuram

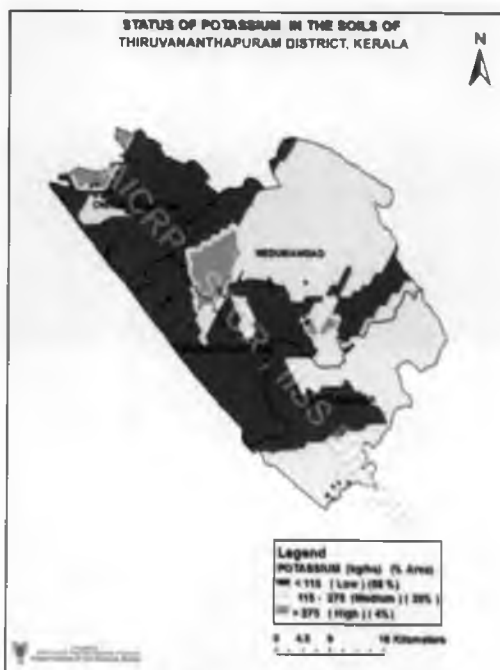


Fig. 113 Status of sulphur in the soils of Thiruvananthapuram



Fig. 114 Status of iron in the soils of Thiruvananthapuram



Fig. 115 Status of manganese in the soils of Thiruvananthapuram



Fig. 116 Status of copper in the soils of Thiruvananthapuram



Fig. 117 Status of zinc in the soils of Thiruvananthapuram



Fig. 118 Status of boron in the soils of Thiruvananthapuram



Table 125. Fertilizer recommendations for the farmers of Thiruvananthapuram district based on GPS and GIS based soil fertility maps

Main crop: Paddy, Banana

Recommendations/strategies for soil amendment (for correction of soil acidity/sodicity/salinity etc.)	Ninety seven per cent of soils were acidic, so liming is required based on the pH values. Liming can be done using dolomite or CaCO ₃ .
Recommendations/strategies for organic matter (this should include application of manures, residues, microbial culture for decomposition like Trichoderma etc.)	With regard to organic carbon ninety eight per cent of samples were low to medium. Maintenance of organic carbon by the application of organic manure as compost of banana waste. Application of FYM, compost, vermicompost, etc can be done. Biofertilizers can be applied.
Recommendations/strategies for NPK management	Nitrogen – About 94 per cent of samples were in low to medium class. So fertilizer application has to be done as per general recommendation. Phosphorus – 46 per cent of samples showed low status. Apply rock phosphate as per general recommendation. Potassium – 94 per cent of samples were in low to medium class. Apply potassic fertilizers like MOP.
Recommendations/strategies for secondary/micronutrient management	Sulphur – 55 to 83 per cent samples were deficient in different taluks. There is need for S application as elemental sulphur, factamphos etc. Zinc – 6 to 50 per cent samples were deficient. So application is required as Zn SO ₄ . Boron – 17 per cent samples were deficient. So application of borax or solubor is required.
Training requirements	1) Training on Soil testing methodologies and STCR to the STL personnel. 2) Training should be conducted for explaining the need for soil testing methods for correcting S, B and Zn deficiency.
Any other recommendations	Agricultural extension workers and fertilizer-based firms should create awareness among farmers on the importance of soil fertility maps.

Table 126. Nutrient uses based on resource base in Thiruvananthapuram

Sl. No.	Nutrients added	Resource base		
		Small	Medium	Large
1	Major nutrients	N - 20-70 kg/ha P ₂ O ₅ - 30-40 kg/ha K ₂ O - 15-20 kg/ha	N - 25-70 kg/ha P ₂ O ₅ - 25-40 kg/ha K ₂ O - 20-30 kg/ha	N - 25-60 kg/ha P ₂ O ₅ - 30-45 kg/ha K ₂ O - 30-40 kg/ha
2	Secondary nutrients	Lime - 100 kg/ha	Lime - 150 kg/ha	MgSO ₄ - 10 kg/ha Lime - 100-150 kg/ha
3	Micro nutrients		Borax - 5 kg/ha Micro food - 2-5 kg/ha	Borax - 5 kg/ha Micro food 2-5 kg/ha
4	Organic manures	FYM - 2.5-5 kg/ha	FYM - 2.5-5 kg/ha	FYM - 2.5-10 kg/ha Groundnut cake - 4-5 kg/ha Vermicompost - 10-60 kg/ha

Conclusion

The samples collected from Thiruvananthapuram district was having an average pH of 5.48 and electrical conductivity 0.10 dS m⁻¹. Only 5.56 per cent samples showed high nitrogen content. In the case of phosphorus, 45.83 per cent samples showed low range. In the case of available potassium, about 62.50 per cent of samples were in the low range. For organic carbon, 65.28 per cent samples came under medium category. The soil samples were adequate in the content of micronutrients except zinc and boron. Sulphur deficiency was noticed to the extent of 72.22 per cent of samples.

Plate: 1 Training sessions to Research fellows



Plate : 2 Views from Wayanad



Interaction with Krishi Bhavan Officials



Soil sample collection in cardamom field



Tea estate

Plate : 3 Views from Kozhikode



Interaction with Krishi Bhavan officials



Visit to 'ATMA' demonstration plot



Soil sample collection

Plate : 4 Views from Palakkad



Interaction with Krishi Bhavan officials



Interacting with a sugarcane farmer



Soil sample collection from paddy field

Plate : 5 Views from Ernakulam



Interaction with Krishi Bhavan officials

Continued...



Soil sampling in rubber plantation



Snake gourd cultivation

Continued....



Cabbage cultivation



Mixed farming



Soil sample collection from pineappale field

Plate : 6 Views from Alappuzha



Interaction with Krishi Bhavan officials



Soil sample collection

Plate :7 Views from Thiruvananthapuram



Interaction with Krishi Bhavan officials



Anthurium cultivation



Soil sampling from banana field

Plate : 8 Views from the Southern Regional Work Shop of AICRP on STCR held at College of Horticulture during March 1 - 2, 2013



Appendix I

Methods used for analysis of soil samples

Sl. No	Parameter	Method of analysis
1	pH	1:2.5 soil water suspension – pH meter (Jackson, 1958)
2	Electrical conductivity	1:2.5 soil water suspension – conductivity meter (Jackson, 1958)
3	Organic carbon	Wet oxidation method (Walkley and Black, 1934)
4	Available nitrogen	Alkaline permanganate method (Subbiah and Asija, 1956)
5	Available phosphorus	Bray No.1 extractant method (Bray and Kurtz, 1945)
6	Available potassium	1 N Neutral ammonium acetate method (Jackson, 1958)
7	Sulphur	Turbidity method (Chesnin and Yien, 1951)
8	Zinc, Copper, Iron and Manganese	DTPA – extraction – AAS (Lindsay and Norvell, 1973)
9	Boron	Hot water extraction – spectrophotometer (Jackson, 1958)

Appendix II

Nutrient index values and fertility rating

1. Fertility classes

(a) pH and electrical conductivity (EC)

Classes	pH	Classes	EC (dS m ⁻¹)
Acidic	< 6.6	Normal	< 0.9
Neutral	6.6 - 7.4	Medium	0.9 - 2.1
Alkaline	> 7.4	Saline	> 2.1

(b) Organic carbon (OC) and major nutrients

Category	OC	N	P	K
	%	kg ha ⁻¹	kg ha ⁻¹	kg ha ⁻¹
Low (L)	< 0.50	< 280	< 10	< 115
Medium (M)	0.5 - 1.5	280 - 560	10 - 24	115-275
High (H)	> 1.5	> 560	> 24	> 275

(c) Secondary and micronutrients

Category	S	Zn	Fe	Cu	Mn	B
	ppm					
Deficient (D)	< 10	< 0.6	< 5.0	< 0.12	< 1.0	< 0.5
Adequate (A)	> 10	> 0.6	> 5.0	> 0.12	> 1.0	> 0.5

2. Classes based on nutrient index value (NIV)

Major nutrients		Micronutrients	
Classes	Values	Classes	Values
Low	< 1.66	Very low	< 1.33
Medium	1.66 - 2.33	Low	1.34 - 1.66
High	> 2.33	Medium	1.67 - 2.00
		Adequate	2.01 - 2.33
		High	2.34 - 2.66
		Very high	> 2.66

Appendix III

Nutrient index values (NIV) and fertility rating of soil available micronutrients in different taluks.

Sl. No	Name of the taluks	Nutrient index value					Fertility rating				
		Zn	Fe	Cu	Mn	B	Zn	Fe	Cu	Mn	B
Kannur district											
1	Thaliparambu	1.63	2.00	2.00	2.00	1.80	Low	Medium	Medium	Medium	Medium
2	Thalassery	1.57	2.00	1.97	1.93	1.53	Low	Medium	Medium	Medium	Low
3	Kannur	1.83	2.00	2.00	1.83	1.67	Medium	Medium	Medium	Medium	Medium
Overall Mean		1.68	2.00	1.99	1.92	1.66	Medium	Medium	Medium	Medium	Low
Wayanad district											
4	Vythiri	1.83	2.00	2.00	2.00	1.83	Medium	Medium	Medium	Medium	Medium
5	Mananthavady	2.00	2.00	2.00	2.00	1.67	Medium	Medium	Medium	Medium	Medium
6	Sulthan Bathery	1.92	2.00	2.00	2.00	1.92	Medium	Medium	Medium	Medium	Medium
Overall Mean		1.92	2.00	2.00	2.00	1.81	Medium	Medium	Medium	Medium	Medium
Malappuram district											
7	Nilambur	1.67	2.00	2.00	2.00	1.88	Medium	Medium	Medium	Medium	Medium
8	Tirur	1.64	1.89	2.00	1.97	1.67	Low	Medium	Medium	Medium	Medium
9	Ponnani	1.92	1.92	2.00	2.00	2.00	Medium	Medium	Medium	Medium	Medium
10	Eranad	1.47	1.97	2.00	2.00	1.94	low	Medium	Medium	Medium	Medium
11	Tirurangadi	1.75	1.96	2.00	2.00	1.79	Medium	Medium	Medium	Medium	Medium
12	Perinthalmanna	1.63	1.96	2.00	2.00	1.88	Low	Medium	Medium	Medium	Medium
Overall Mean		1.68	1.95	2.00	2.00	1.86	Medium	Medium	Medium	Medium	Medium

Sl. No	Name of the taluks	Nutrient index value					Fertility rating				
		Zn	Fe	Cu	Mn	B	Zn	Fe	Cu	Mn	B
Kozhikode district											
13	Kozhikode	1.83	2.00	2.00	2.00	2.00	Medium	Medium	Medium	Medium	Medium
14	Vadakara	1.90	2.00	2.00	2.00	2.00	Medium	Medium	Medium	Medium	Medium
15	Koyilandy	1.88	2.00	1.98	2.00	2.00	Medium	Medium	Medium	Medium	Medium
Overall Mean		1.87	2.00	1.99	2.00	2.00	Medium	Medium	Medium	Medium	Medium
Palakkad district											
16	Alathur	1.94	2.00	2.00	2.00	1.82	Medium	Medium	Medium	Medium	Medium
17	Chittur	1.78	1.94	2.00	2.00	1.82	Medium	Medium	Medium	Medium	Medium
18	Palakkad	1.94	2.00	2.00	2.00	1.61	Medium	Medium	Medium	Medium	Low
19	Ottappalam	1.94	2.00	2.00	2.00	1.67	Medium	Medium	Medium	Medium	Medium
20	Mannarkad	1.89	2.00	2.00	2.00	1.72	Medium	Medium	Medium	Medium	Medium
Overall Mean		1.90	1.99	2.00	2.00	1.73	Medium	Medium	Medium	Medium	Medium
Ernakulam district											
21	Muvattupuzha	2.00	2.00	2.00	1.97	1.43	Medium	Medium	Medium	Medium	Low
22	Aluva	1.88	2.00	2.00	2.00	1.38	Medium	Medium	Medium	Medium	Low
23	Kunnathunadu	1.93	2.00	2.00	2.00	1.43	Medium	Medium	Medium	Medium	Low
24	Kanayannur	2.00	2.00	2.00	1.94	1.28	Medium	Medium	Medium	Medium	Very Low
25	Kothamagalam	1.92	2.00	2.00	2.00	1.54	Medium	Medium	Medium	Medium	Low
26	Paravur	2.00	2.00	2.00	2.00	1.50	Medium	Medium	Medium	Medium	Low
27	Perumbavur	2.00	2.00	2.00	1.83	1.83	Medium	Medium	Medium	Medium	Medium
28	Kochi	2.00	2.00	2.00	1.83	1.22	Medium	Medium	Medium	Medium	Very Low
Overall Mean		1.97	2.00	2.00	1.95	1.45	Medium	Medium	Medium	Medium	Low

Sl. No	Name of the taluks	Nutrient index value					Fertility rating				
		Zn	Fe	Cu	Mn	B	Zn	Fe	Cu	Mn	B
Thrissur district											
29	Thrissur	1.77	1.98	2.00	1.98	1.68	Medium	Medium	Medium	Medium	Medium
30	Thalappilly	1.82	1.99	2.00	1.99	1.85	Medium	Medium	Medium	Medium	Medium
31	Mukundapuram	1.90	2.00	2.00	1.97	1.80	Medium	Medium	Medium	Medium	Medium
32	Chavakkad	1.79	2.00	1.96	1.92	1.63	Medium	Medium	Medium	Medium	Low
33	Kodungallur	1.83	2.00	2.00	1.72	1.83	Medium	Medium	Medium	Medium	Medium
Overall Mean		1.82	1.99	1.99	1.92	1.76	Medium	Medium	Medium	Medium	Medium
Alappuzha district											
34	Ambalapuzha	2.00	2.00	2.00	1.83	1.33	Medium	Medium	Medium	Medium	Very Low
35	Karthikapilly	2.00	2.00	2.00	1.67	1.50	Medium	Medium	Medium	Medium	Low
36	Mavelikkara	1.92	2.00	2.00	2.00	1.50	Medium	Medium	Medium	Medium	Low
37	Cherthala	2.00	2.00	2.00	1.50	1.33	Medium	Medium	Medium	low	Very low
38	Chengannur	2.00	2.00	2.00	2.00	1.50	Medium	Medium	Medium	Medium	Low
39	Kuttanad	2.00	2.00	2.00	2.00	1.58	Medium	Medium	Medium	Medium	Low
Overall Mean		1.99	2.00	2.00	1.83	1.46	Medium	Medium	Medium	Medium	Low
Thiruvananthapuram district											
40	Chirayinkeezhu	1.83	2.00	1.94	2.00	1.89	Medium	Medium	Medium	Medium	Medium
41	Nedumangad	1.94	2.00	2.00	1.94	1.89	Medium	Medium	Medium	Medium	Medium
42	Neyyattinkara	1.94	2.00	2.00	2.00	1.89	Medium	Medium	Medium	Medium	Medium
43	Thiruvananthapuram	1.50	2.00	1.83	2.00	1.67	Low	Medium	Medium	Medium	Medium
Overall Mean		1.80	2.00	1.94	1.99	1.84	Medium	Medium	Medium	Medium	Medium

Appendix IV

Indian Institute of Soil Science
Nabibagh, Berasia Road, Bhopal-462038
Village details proforma

District: Tehsil:
Block: Mandal/sub-division:
Name of Panchayath: Name of village:

a) Details of area in (ha) of the village in 2009-2010

Geographical area: Cultivated area:
Irrigated area: Rainfed area:

b) Major soil types:

c) i. Major crops and area under crops of the village

- 1.
- 2.
- 3.

ii) Major cropping systems per cent of area of the village

- 1.
- 2.
- 3.

d) Type of fertilizers being used

N	Urea/DAP/Others
P	DAP/SSP/others
K	MOP/SOP/others
S	Zinc sulphate /Gypsum/others
Amendment s	Gypsum/lime/others
Micronutrients	

e) Distribution of cultivators according to holding size (in ha/acres):

Holding size (in ha/acres): Number of cultivators

- i) < 1 acre
- ii) 1-2 acres
- iii) > 2acres

f) Transport

Name and distance (km) from nearest

1. Motorable road

2. Railway station

Name of the investigator:

Signature of the investigator

Date:

Appendix V

PROFORMA

Indian Institute of Soil Science
Nabibagh, Berasia Road, Bhopal-462038
Farmer details proforma

1. Name of farmer: _____ Father's name: _____
Village: _____
Tehsil: _____
District: _____ Block/Mandal: _____
Contact number (landline/Mobile): _____
2. Group: Large (> 2acre) / medium (1-2 acres) /small (< 1acre)
3. Area of the sample field : _____ Total land: _____
4. Latitude – longitude of the sampling point _____
5. Irrigation: Well/tubewell/canal/pipeline _____
6. Type of soil : _____ Soil depth: _____
7. acidic/alkaline /normal soil: _____
8. Soil testing data (if any) _____
9. Fertility status: poor/medium fertility/ high fertility _____
10. Rain fall: _____
11. a) Crops grown in previous season

Sl No	Name of the crop	Irrigated area	Rain fed area	Type of fertilizer applied	Rate of fertilizer (ha)
1					
2					
3					

11. b) Crops to be sown during current season

Sl No	Name of the crop	Irrigated area	Rain fed area	Type of fertilizer applied	Rate of fertilizer (ha)-
1					
2					
3					

12. Drainage: good/medium/poor:
13. Use of S/ micronutrients/ amendments:

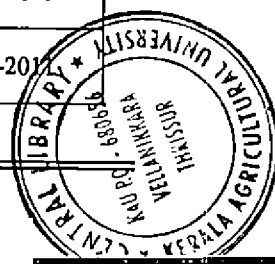
Name of the investigator:
Date:

Signature of investigator

Appendix VI

Scientists, technical officers and research fellows who had worked in the "GPS and GIS based Model Soil Fertility Maps for Selected Districts for Precise Fertilizer Recommendation to the Farmers of India" project

SL No	Name	Post	Date of joining	Date upto which worked (Completion of Project/ Leaving)
1.	Dr. M.A. Hassan	Team Leader and Centre i/c, AICRP on STCR	01-06-2010	20-8-2010
2.	Dr. Betty Bastin	Team Leader and Centre i/c, AICRP on STCR (Co PI, 01.06.10 - 20.08.10)	01-06-2010	31-03-2013
3	Dr. Beena.V.I	Team Associate and Co PI., AICRP on STCR	21-05-2011	31-03-2013
4.	Mr. P.R. Sathian	Farm Superintendent, AICRP on STCR	01-06-2010	31-03-2013
5.	Mr. M. Anantha Krishnan	Farm Officer, AICRP on STCR	01-06-2010	31-03-2013
6.	Mr. K.A. Vinod	Lab Assistant, AICRP on STCR	01-06-2010	31-03-2013
7.	Albin M John	Research Fellow	09-06-2010	01-09-2010
8.	Raigo Antony	Research Fellow	09-06-2010	01-09-2010
9.	A.M. Reji	Research Fellow	11-06-2010	31-12-2012
10.	Sarath. K	Research Fellow	14-06-2010	21-08-2010
11.	Athira Kuttan	Research Fellow	02-09-2010	31-10-2012
12.	Sajitha.K.S	Skilled Assistant	08-11-2010	31-03-2013
13.	Nisha Abraham	Research Fellow	01-03-2011	31-03-2013
14.	Sreenath. P.V.	Research Fellow	07-03-2011	31-03-2013
15.	Manoj. P.H.	Research Fellow	08-03-2011	12-07-2011



Appendix VII
GPS - GIS (AICRP on STCR) PROJECT TEAM

SCIENTISTS



TECHNICAL OFFICERS



RESEARCH FELLOWS AND ASSISTANTS

