FERTILITY INVESTIGATION AND TAXONOMY OF THE SOILS OF BANANA RESEARCH STATION, KANNARA

By

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THESIS

Submitted in partial fulfilment of the
requirement for the degree

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DECLARATION

I hereby declare that this thesis entitled **Fertility investigation and taxonomy of the soils of Banana Research Station Kannara** is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree diploma associateship fellowship or any other similar title of any other University or Society

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CERTIFICATE

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SREEREKHA L

To My Parents

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Introduction

INTRODUCTION

Soil which can be defined as the soul of infinite life is a valuable resource which is being depleted regardless of the fact that it is a non renewable resource Priority should be given to the judicious use of this nature s gift without impairing it s productivity For this scientific knowledge of the soil is a prerequisite Economic maximisation of production per unit area to feeding the ever increasing population should not lead to over exploitation

Soil fertility investigation is the process by which nutritional problems are diagnosed and fertilizer recommendations are made The Banana Research Station with it s achievements in the collection of germplasm and crop improvement programmes stands unique but at the same time detailed investigations on the fertility status of the soil and attempts of classification of soils is lacking Being the cropping pattern similar to the homesteads of Kerala such an investigation of fertility assumes paramount importance

Objectives of the present investigation were to study the soil profile features of all the six blocks of the Banana Research Station Kannara in terms of morphology and physico-chemical characters in order to place them under soil taxonomy to analyse the surface soil samples of each block for fertility parameters so as to group them into fertility classes and to prepare the soil fertility map

This investigation will project the fertility status of individual blocks which will help to recommend the minimum inputs with maximum returns This study will provide the basic information on the morphological physical and chemical characteristics of the soils and to classify them under soil taxonomy The fertility investigation will assist to prepare the fertility map of the station which will be a permanent record It is also hoped that this study will enable to find out the possible reasons for the trend of declining productivity with special reference to soil factors

Review of Literature

REVIEW OF LITERATURE

Fertility investigation and taxonomy of soil the importance of which need no emphasis is an area of research where subject matter specilists have been treading over the years An attempt is made in this chapter to review the work carried out till recently in India and elsewhere in a systematic manner

1 Taxonomy

The physical and chemical properties of many arable soils have been improved by man s agricultural activities The classification of the soils studied has changed as a result of man s influence (Conry 1972)

Comparison of the traditional field classification and a numerical classification of same soils was done by Conventry and Williams (1983) certain soil attributes played an important role in both classifications The most striking difference between them was the relative importance of soil colour attributes from which it might be argued that field pedologists had assigned to colour a weight out of proportion to it s real importance in soil classification The increasing availability of computer programmes for numerical classification has consequently engendered a search for objective classification

Classification of soils in a catena from Dadra and Nagar Haveli was done by Challa and Gaikawad (1986) Temperature and soil moisture regimes were taken into account Other characteristics such as pH clay content cation exchange capacity presence of coarse fragments were also considered

Classification of mid shiwalik soils in different physiographic units was attempted by Singh *et al* (1990) Soils differed from one another at family level owing to their development on strongly sloping to moderately steep and gentle slopes

Taxonomy of the soils m a toposequence of central Himalayas by Singh *et al* (1993) suggests a good correlation between physiography and soils in that topo-sequence Clay distribution presence or absence of diagnostic horizon moisture regime characteristics and peculiarities of chroma texture were considered as the criteria for classification

Selecting several aspects such as parent rock physiography drainage slope erosion and permeability of soil temperature and moisture regime as criteria soils of Tamil Nadu Bhavani Command area were classified by Paramasivam and Gopalaswamy (1993)

2 **Physical properties**

2 1 Soil colour

Durairaj (1961) correlated colour with various properties of soil He observed that the reciprocal of chroma of soil colour is highly correlated with the clay content

The colour of the laterite soil varied from red to yellow depending upon the degree of acidity and hydration of ferric hydroxide (Mandal 1971 and Ratnam *et al* 1972)

The studies conducted by Govindarajan and Rao (1978) revealed that in most of the laterites the surface soil showed a red colour changing to reddish yellow and finally yellow in deeper layers

Kemp (1985) examined relationships between soil colours and the amount of extractable iron or of individual iron oxides present in < 2 μm fractions of samples and colour was expressed in terms of a redness rating

2 2 Particle size analysis

Gopalaswamy (1969) had observed a decrease in the sand fraction with the depth of soil profile

Ushakumari (1983) reported that the soils of Kerala exhibited on appreciable variation in texture ranging from clay to loam The laterites and red loams were very similar in texture and all types of soils exhibited a downward migration of clay

Ushakumari *et al* (1987) studied the influence of physio-chemical characteristics on the structural status of five Kerala soils The red loams had shown striking similarity to laterites in texture

Shouse *et al* (1990) studied the spatial distribution of soil particle size and aggregate stability index in a clay soil Particle size determination was carried out by the hydrometer method hydrous mica had much smaller transmission pore volumes and water storage volumes

2 4 Water holding capacity

Williams *et al* (1983) reported the influence of texture structure and clay mineralogy on soil moisture characteristic Field texture was found to be very important

Moisture retention characteristics of laterite soils of Kerala was studied by Thulaseedharan and Nair (1984) The water content of 2 mm sieved soil showed significant positive correlations with clay and silt and negative correlation with coarse and fine sand fractions The effect of organic carbon content was not significant Similar results were reported by Mathew and Nair (1985) by conducting studies in red and forest soils of Kerala Prameela and Nair (1985) reported similar results in alluvial soils of Kerala

Wolsten and Genuchten (1988) used texture and other soil proper ties to predict the unsaturated soil hydraulic functions Soil properties such as bulk density percentage of silt clay and organic matter were used to predict the hydraulic functions

2 5 Bulk density and particle density

Nair *et al* (1966) noticed that absolute specific gravity and appar ent specific gravity appeared to be a function of coarser particles of the soil

Sharma *et al* (1980) m the investigation of the effects of organic matter clay and silt content on some physical parameters have observed that clay content showed a significant negative correlation with bulk density wher eas silt showed no correlation with bulk density

Ushakumari (1983) noticed that clay content in general decreased the bulk density of soil

Effect of land reclamation practices on physical properties of an acid oxisol was studied by Makarim *et al* (1988) Bulk density decreased due to various cultivation practices

2 6 Volume expansion

By the studies of Sharma *et al* (1980) it is revealed that clay content showed a significant negative correlation with volume of expansion

3 Chemical properties

3 1 Soil reaction

Alexander and Durairaj (1968) studied the influence of soil reaction on certain soil properties and availability of major nutrients in Kerala soils The loss on ignition organic carbon total nitrogen lime requirement and cation exchange capacity of acid soils were found to be negatively correlated with the soil pH Positive correlations exist between soil reaction and cation saturation percentage calcium saturation percentage and available phosphorus

Correlation studies on the effect of pH and organic carbon on the availability of nutrients in acid soils by Chibba and Sekhon (1985) revealed that pH is related with the estimation of available nitrogen only

Mısra *et al* (1989) whıle characterısıng some acıd soıls of Orıssa found out that Inceptısols Alfisols and Entısols of Orıssa wıth a pH range of 4-6 2 have potentıal acıdıty 1 3 11 6 cmol (+) kg 1 The pH dependant acıdıty was more than 83 per cent of potentıal actıdıty and was maınly associated wıth ınorganıc fractıons of soıl such as oxıdes of ıron alumınıum and clay

3 2 Total elemental composıtıon of soıl

Koshy and Brıtomuthunayagam (1961) notıced that level of total phosphorus of soıl profiles of Kerala varıed from 0 024 to 0 256 per cent

Alexander and Duraıraj (1968) found that total nıtrogen ın most of the acıd soıls was comparatıvely hıgh Total phosphorus content was also found to be much hıgher No sıgnıficant correlatıon was observed between soıl reactıon and total P Total potassıum showed poor status and no strıct relatıon was observed wıth soıl pH Sesquıoxıde content was hıgh and the contents showed a general mcrease wıth the reductıon m pH

Venugopal (1969) reported that the percentage of total CaO was m the range of 0 02 to 2 03 ın dıfferent soıls of Kerala Lowest value was recorded for sandy soıl and hıghest for black soıl Total MgO varıed from trace amounts to 2 69 percentage Mınımum value was observed for laterıtes and maxımum for black soıl

Hassan (1977) observed that total nıtrogen content of wet land soıls of rıbbon valleys of Kerala ranged from 0 075 0 2% In the profiles a de crease ın total nıtrogen was observed and thıs decrease paralleled the organıc matter content Calcium and magnesium status of laterite soils were found to be very poor both in the surface and subsurface layers of soil profiles Total Ca increased with depth while Mg showed a reverse trend

Puranik *et al* (1990) found out that total P content was influenced by the physical properties of soil Total P is positively correlated with bulk density porespace volume expansion waterholding capacity moisture equiv alent colloids CEC and silt/clay ratio It is negatively correlated with particle density and SiO_2/R_2O_3 ratio

Schulten *et al* (1993) observed that total N content was largest in fine silt and medium silt and smallest in coarse silt and sand fractions

3 3 Available nutrient status of the soil

Alexander and Durairaj (1968) noticed that due to low mineraliza tion in acid soils inspite of high total nitrogen content available nitrogen status is very poor with an increase in the hydrogen ion concentration organic carbon content showed an increase

Reports of Singh and Brar (1973) revealed the higher correlation values of organic carbon per cent with the nitrogen uptake and yield They showed that organic carbon content is a better index for available nitrogen

Ekambaram *et al* (1975) observed the decrease of water soluble and exchangeable potassium with increase in the depth of soil profile

Sawant *et al* (1981) studied phosphorus and potassium availability as affected by organic matter and different moisture regimes Paddy straw application was found to reduce the P_2O_5 availability in the laterites whereas the moisture saturation increased the availability of P_2O_5 in the laterites Potassium availability increased with the compost and paddy straw application but availability of K was negatively correlated with the moisture

Bastin (1985) reported that the organic carbon content of red soils of Kerala ranged from 0 17 to 0 74% and decreased steadily with depth in the profile

Investigations of Chibba and Sekhon (1985) revealed the decline of available nitrogen with depth of the profile Most of the acid soils were found to respond to the application of nitrogenous fertilizers Available P showed no definite trend with the depth but available K was high in the surface soil

Chaudhury *et al* (1990) reported that organic carbon content did not bear any relationship with quantity intensity parameters of potassium

Studies of Chen and Barber (1990) revealed the effect of pH on P availability Increase in the soil pH generally decreased P concentration in the soil solution Addition of P caused a curvilinear increase in the P concentration in the soil solution The increase was much greater in the Mollisol than in the Ultisol and Oxisol probably due to higher P content in the soil solution of Mollisol Predicted P uptake also decreased with increase in the soil pH

In the reports of Puranik *et al* (1990) the influence of physical properties of the soil on the utilization and adsorption of nutrients is revealed Moisture regime and labile pool of soil P has predominant role Inorganic P is positively correlated with bulk density pore space volume expansion water holding capacity moisture equivalent colloids and CEC of soils But it is negatively correlated with particle density silt/clay ratio and SiO_2/R_2O_3 ratio

According to Schulten *et al* (1993) organic carbon content was found to be higher in fine silt and medium silt than coarse silt and sand fractions

3 4 Cation exchange properties

Ekambaram *et al* (1975) found out that the cation exchange capacity of red non-calcareous soil of Coimbatore varied from 17 7 meq/100 g to 23 8 meq/100 g

Venugopal and Koshy (1976) reported that the occurrence of bases in Kerala soils decreased in the order of calcium > magnesium > potassium > sodium The CEC ranged from 1 62 meq/100 g for a laterite to 49 56 meq/100 g for a black soil In the laterite profiles calcium formed the predominant exchangeable base followed by magnesium The relationship between cation exchange capacity and the different size fractions of soil is revealed in another study by Venugopal and Koshy (1976) CEC increased from coarse sand to clay Correlation between CEC and clay was positive and highly significant The relationship between organic matter and CEC was positive but not significant

Sharma *et al* (1980) reported that clay content of the soil showed significant positive correlation with CEC, silt showed significant negative correlation It was also found that 77 4 per cent of the variation in CEC was attributable to clay content alone

Bastin (1985) reported that effective CEC showed significant positive relationship with organic matter The exchangeable base content was in the order Ca > Mg > Na > K Among the acid generating cations exchangeable hydrogen content was higher than exchangeable aluminium The percentage base unsaturation observed in the soils was consistant with the changes in exchange acidity

Challa and Gaikawad (1986) noted that the soils of the Piedmont plain have relatively high clay content and CEC as compared with soils of flat topped hills hill slopes and flood plain

Ushakumari *et al* (1987) found out that CEC of soils is important in maintaining the structure of the laterite black red loam soils and coastal alluvium but not in river alluvium

Misra *et al* (1989) found out that exchangeable aluminium and percentage aluminium saturation increased with a decrease in soil pH

3 5 Phosphorus fixing capacity (P F C)

Koshy and Britomuthunayagam (1961) found out that more phosphate is fixed per gram of clay than per gram of silt

Nad *et al* (1975) reported that clay and free iron oxide contents of the soil were the major factors determining the P F C The ranges of P fixation was 44 to 72 per cent for black 12 to 47 per cent for alluvial 21 to 55 per cent for laterite and 38 to 85 2 per cent for red soils

Kothandaraman and Krishnamurthy (1978) in their studies of P F C of Tamil Nadu soils observed that P F C of soils ranged from 20 to 183 mg P/100 g soil with a mean value of 85 mg P/100 g soil The highest value was recorded in the high level laterite and the lowest in alluvial soil P F C was positively correlated with clay total sesquioxides and total alumina The relationship of P F C with clay total sesquioxides iron oxides free iron oxides and organic carbon were more close in acid soils than neutral and alkaline soils

Bastin (1985) found out that P F C of red soils varied from 86 1 to 136 1 mg P/100 g High P F C was attributed to the high content of silt clay total Ca total Fe and sesquioxides

Naik *et al* (1988) in the investigations regarding p fixation and subsequent release in Oxisols had noticed that the recovery of applied P decreased with increased period of contact with the soil Application of sodium citrate to soil gave higher recovery of applied P than $CaCO_3$ and farm yard manure

Yosef *et al* (1988) reported that P concentration in the solution phase stabilized within 24 to 48 hours after the introduction of P into the system Increased electrical conductivity decreased P concentrations in kaolin ite as well as montmorillonite clays P adsorption by Ca clay exceeded that by K clay

The effect of partially acidulated rock phosphate in minimising the P F C of an acid alfisol was studied by Marwaha and Sood (1989) They reported that field application of 10 or 20% acidulated rock phosphate had a favourable effect on the P F C of soil in comparison with the highly water soluble sources

Subrahmanyan and Kumaraswamy (1989) observed that most of the applied P was fixed as Ca P and P fixation was greater in soils that had not received phosphatic fertilizers

Phonde *et al* (1990) observed that P F C of lateritic soils was higher (94 99 percentage) than medium black soil (77 05 per cent) P F C of laterite soils was positively correlated with total sesquioxides free iron oxides and cation exchange capacity and negatively correlated with the clay content

3 6 Fractions of iron

Balaguru and Mosi (1972) while studying the soils of Tamil Nadu observed that total iron was negatively correlated with soil reaction and avail able iron had no such reaction with soil pH and organic matter Total and available forms of iron decreased with depth Total iron was in the range 2 5 6 1 percentage

Studies on the vertical distributions of iron by Jadhav *et al* (1978) revealed that total iron varied from 5 28 7 2 percentage and distribution of iron was irregular

Ghosh and Banerjee (1979) found out that of the different forms free iron oxides were most abundant All forms of iron were negatively correlated with the clay content

Bhattacharya *et al* (1983) citrate bicarbonate dithionite extractable iron content in red soils of Karnataka derived from granite gneiss ranged from 0 88 to 4 37 per cent

Arduino *et al* (1984) reported that the relative ages of soils can be estimated from the amounts of iron extracted by dithionite and oxalate The larger the proportion of total iron extracted by the reagents especially the dithionite the older the terrace

Kemp (1985) established relation between soil colours and the amounts of extractable iron Oxalate extractable iron dithionate extractable iron and goethite contents were not significantly correlated with redness rating of colour There was a strong correlation between redness rating and haematite content of clay size fractions

Bastin (1985) found out that dithionate extractable iron (Fed) showed positive and significant correlation with fine sand Correlation of Fed with coarse sand silt and clay fractions were positive but not significant Fed expressed as percentage of total iron (often referred to as degree of freeness of iron) was used as the index for determining the age of the profile and the maximum range obtained was 50 14 to 93 03 per cent Oxalate extractable iron recorded low values compared to Fe_d and ranged from 0 001 to 0 004 per cent Correlations of oxalate iron with fine sand was negative but not signifi cant while with coarse sand silt clay and total iron were positive but not significant Both oxalate extractable iron and active iron ratio (Fe_o/Fe_d) did not show any trend of variation in the profile

Wang *et al* (1987) compared Hydroxylamine and Ammonium oxalate solutions as extractants for iron and found out that oxalate appeared to be slightly more effective in extracting pedogenic amorphous material

Ghabru *et al* (1990) reported that the presence of higher propor tions of Fe_d in the solum is the indication of greater silicate weathering

Jeanroy *et al* (1991) observed that soil yellowing process promotes net iron losses and relative alumina accumulations

3 7 Micronutrients

Lal and Biswas (1974) reported that the parent material influenced micronutrient elements of the soil profile Manganese iron and copper were uniformly distributed in the profiles of relatively less weathered desert and old alluvial soils Zinc and boron tended to increase with an increase in the calci um carbonate along the depth Manganese and iron were found to be translo- cated with clay In the well drained soils micronutrients was concentrated in the surface horizon whereas in the poorly drained soils (black soils) they were contained in the lower horizon

Praseedom and Koshy (1975) reported that total zinc content of Kerala surface soils varied from 3 5 ppm in red soil to 72 0 ppm in the alluvial soil

Studies on the status of available micronutriants in soils of Kerala by Rajagopal *et al* (1977) revealed that soils are characterized by the presence of iron in the available form

Gupta *et al* (1980) in a study of the alluvial profiles of Haryana found the available copper content was significantly correlated with organic carbon content and clay

Sahni *et al* (1980) reported significant positive relationship of organic carbon with available zinc and copper and of pH with copper

Studies of Chavan *et al* (1980) revealed that lateritic soils contain more amounts of available zinc and manganese than neutral and alkaline soils but reverse was the case with available boron and molybdenum Parent materi al had no apparent effect on the availability of micronutrients

Chibba and Sekhon (1985) reported that DTPA extractable micronutrients in the surface soil was in the range of 4 4 to 36 8 ppm for iron 3 1 to 22 5 ppm for manganese 0 48 to 1 56 ppm for zinc and 0 33 to 1 00 ppm for copper Available zinc and copper were noted to be maximum in the sur face soil The relation between all DTPA extractable micronutrients and organ ic carbon was significant

Sharma *et al* (1985) found out that available zinc and iron were not found to be correlated with any of the soil properties studied but manganese and copper varied positively with clay silt and organic carbon content

Katyal and Sharma (1991) reported that changes in pH lime organic matter size fractions (clay) and soil moisture regime had a strong influence on the micronutrient distribution

4 Fertility investigation of soil

Raychaudhuri and Reddy (1963) studied the fertility status and productivity potential of some red soils of Bangalore and rated them on the basis of stone index Organic carbon percentage was in general found to be low pH varied from 5 6 to 7 3 and was noted to be good for plant growth Available P_2O_5 is low whereas available K_2O was high in the surface which increased with depth indicating the accumulation of clay fractions containing potash bearing minerals

Suitability of soil test method for available N was found out by Singh and Tripathi (1970) The alkaline $KMnO_4$ method was found to be the best, as it showed the highest correlation with N uptake by paddy plants Available N in soils at transplanting time and N content of plants at tillering stage may be well utilized for fertilizer recommendation

Ghosh and Hassan (1980) made an assessment of the nitrogen fertility status of soils of India The index of available N have been the percentage of organic carbon in the plough layer

Mohanty and Filipovski (1981) attempted a fertility potential clas sification using factor analysis technique Based on four independant unrelated factors in the order of importance termed as inherent potentiality factors organic matter factor PO_4 factor and K supplying factor

Changes in the indices of soil fertility under continuous cropping was noticed by Maida and Chilma (1981)

Evaluation of crop productivity potential of soils was done by Tamgadge *et al* (1986) Field experiments were conducted on different crops and soil orders and the crop productivity potential was evaluated at the sub-group level

Divakar *et al* (1986) tested the entire horticultural areas of all the twelve blocks of a hill district in U P for available N P K and pH values It is recommended that acidic soils should be reclaimed by lime application at appropriate rates Areas with low available P and K should be dressed with appropriate quantities of P and K fertilizers regularly Areas with medium levels of N P K should be fertilized with moderate doses of fertilizer ac cording to the crops grown

Olsen *et al* (1987) conducted trials to compare the much debated soil testing philosophies the sufficiency concept and the build up and main tenance approach The sufficiency level calls for the cut off levels above which no fertilizer is recommended The build up/maintenance approach aims at a rapid build up to a high soil test with the annual replacement of an amount the crop is likely to remove regardless of the soil test level The comparison revealed no significant yield differences but do reveal large differences in kinds amounts and costs of fertilizers sufficiency approach is the best one since it result in the least probability of environmental contamination by nutri ents The other concept does not take into account the inherent capacity of majority of temperate soils to supply significant amounts of most nutrients having it s most likely application m the tropical and subtropical areas

Effect of cultivation on organic carbon N and P of some Kenyan red soils was examined by Mochoge and Beese (1988) Organic carbon and nitrogen showed a decreasing trend in the layer of three cultivated soils For P the cultivated soils had slightly higher amounts of thin the plough layer

Brar *et al* (1988) studied the characteristics as well as nutrient status of soils of S W Districts of Punjab Based on the nutrient index values worked out soil fertility map was prepared which can be used for efficient fertility management of soil which is of vital importance to crop yield without any detrimental effects on the long term soil productivity

Application of the soil fertility capability classification to acid soils was attempted by Mathan (1990)

For specific cropping sequences prediction of post harvest soil test values based on the initial soil test values was carried out by Rao and Singh (1992) which will enable in formulating fertilizer recommendations for cropping sequence based on the initial soil test values and will also improve the overall fertilizer use efficiency

Materials and Methods

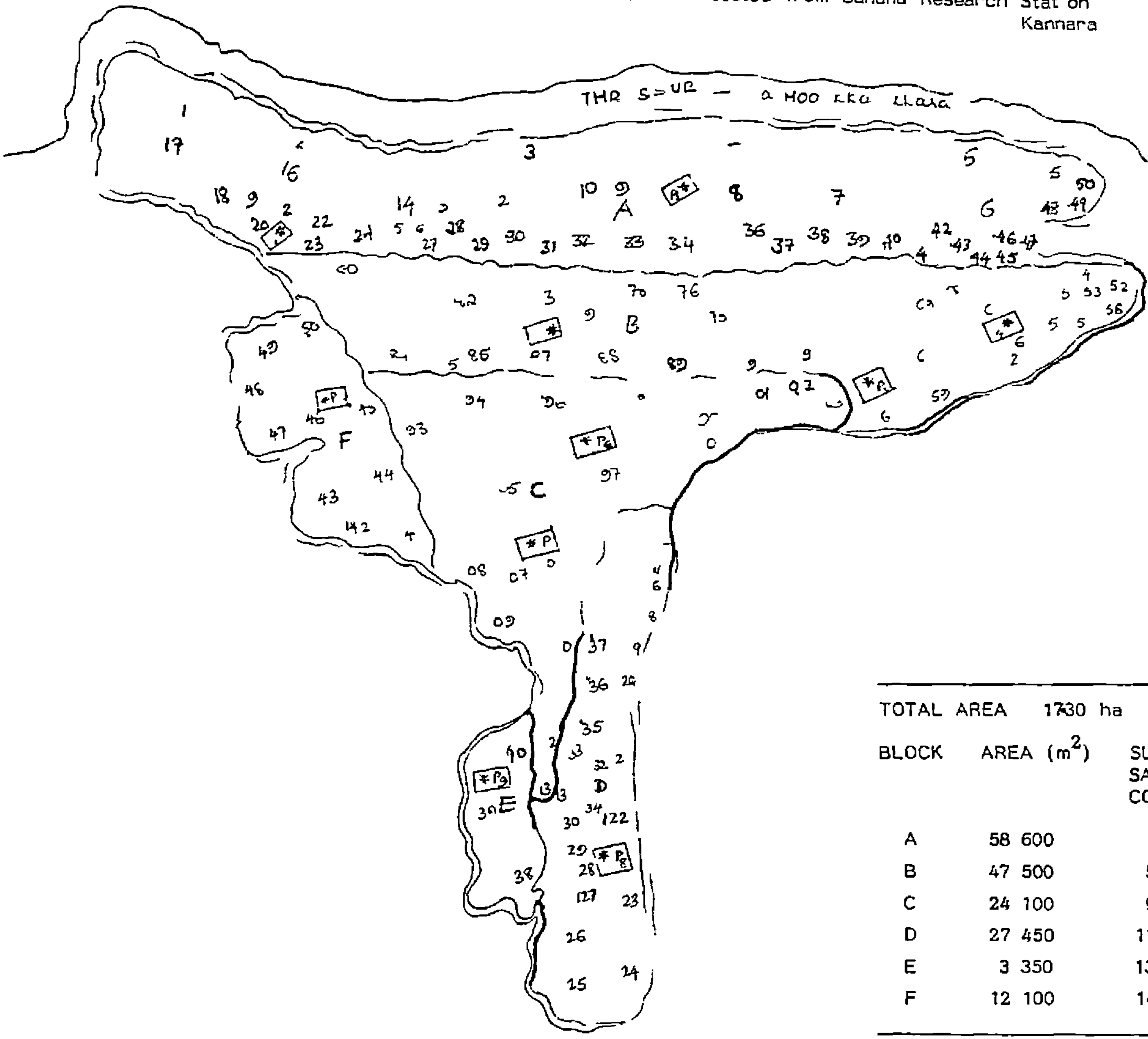
MATERIALS AND METHODS

Soil profile features of all the six blocks of Banana Research Sta tion Kannara were investigated to study the morphological and physico-chemical properties inorder to place them under soil taxonomy Surface soil samples for each block were analysed for fertility parameters Field plan of the Banana Research Station Kannara is given in the Fig 1

The Banana Research Station which considers the main stream of research in the global scale such as collection *in situ* conservation and exploi tation of banana germplasm and the location specific problems m Kerala is located at Marakkal Kannara Pananchery Panchayat of Thrissur Taluk in the Thrissur District The station is 20 km from Thrissur town at 10° N latitude and 70° E longitude at an altitude of 55 6 m above the mean sea level The average rainfall of Kannara is around 2500 mm with a break up of 1672 mm during the south west monsoon 800 mm during north east monsoon and 28 mm during summer The temperature of this location ranges from $26^{\circ}C$ (mean minimum) to $31^{\circ}C$ (mean maximum) The soil is mostly laterite with medium fertility status and pH of 6 0

The total area of the Banana Research Station Kannara is 17 3 ha divided into six blocks The area is upland with undulating topography and the cropping pattern is similar to the homesteads of Kerala However the predomi nant position goes to coconut arecanut and banana with paddy tapioca and other tubers and vegetables (especially amaranthus) as the subsidiary crops

F g 1 Details of so l samples collected from Banana Research Stat on Kannara



TOTAL AREA 1730 ha

BLOCK	AREA (m^2)	SURFACE SAMPLES COLLECTED		PROFILES TAKEN		
A	58 600	1	51	P_1	P_2	
B	47 500	52	92	P_3	P_4	P_5
C	24 100	93	113	P_6	P_7	
D	27 450	114	137	P_8		
E	3 350	138	140	P_9		
F	12 100	141	150	P_{10}		

1 **Field studies**

In areas representative of the blocks and the soils with peculiar characteristics profile pits were dug and soil site description was recorded according to the methods given by the National Bureau of Soil Survey and Land Use Planning Site characteristics were described in respect of location physiography and drainage Details of vegetation and land use was also record ed Morphological description of the profiles are presented in Appendix I

1 1 Collection of soil samples

After morphological examination of the profiles soil samples representing different horizons of ten profiles located in six blocks were col lected for further laboratory analyses To estimate the soil fertility of the area surface samples 0-15 cm were collected from each block The particulars of samples collected are given in Table 1

2 **Laboratory studies**

2 1 Preparation of samples

The soil samples collected were air dried in shade ground with a wooden mallet and passed through 2 mm sieve Sieved samples were used for further analyses

2 2 Physical properties

Particle size analysis was carried out by the hydrometer method porosity water holding capacity bulk density and particle density were found out by Keen Raczkowski measurements (Piper 1942)

3 Chemical properties

Chemical properties of the samples were determined by standard analytical procedures and expressed on moisture free basis

3 1 Analysis of profile samples

Total nitrogen was determined by micro-kjeldhal method (Jackson 1958) Total P_2O_5 K_2O CaO MgO Na_2O and sesquioxides were determined in the perchloric nitric acid (1 2) digest (Hesse 1971) Total P_2O_5 content was determined by vanadophosphoric yellow colour method (Jackson 1958) and total K_2O and Na_2O by flame photometry using an EEL flame photometer Total CaO and MgO was determined using IL 257 atomic absorption spectrophotometer Sesquioxides were determined from the soil digest and measured gravimetrically (Hesse 1971) Cation exchange capacity was determined as the sum of exchangeable bases and exchange acidity whereas effective CEC was estimated as the sum of exchangeable bases and KCl extractable Al as suggested by Reeuwijk (1992)

Exchangeable cations Ca Mg K and Na were determined in the neutral 1N NH_4OAc extract Exchangeable Ca and Mg were determined by EDTA titration method as outlined by Hesse (1971) Exchangeable K and Na were determined by flame photometry using an EEL flame photometer (Jackson 1958) Exchange acidity and KCl extractable Al were estimated in the 1N KCl extracts (Soil Survey Laboratory Methods Manual 1992)

Soil reaction was determined in a 1 2 5 soil water suspension using the pH meter and electrical conductivity of the supernatant solution using the conductivity meter Organic carbon was determined by Walkley and Black s method as described by Jackson (1958)

Free iron oxides were extracted using Holmgren procedure and amorphous iron by Ammonium oxalate reagent as suggested by Reeuwijk (1992) Total iron was estimated in the perchloric nitric (1 2) digest by color imetry (Hesse 1971)

3 2 Analysis of surface samples

Of the physial properties textural class was determined by hy drometer method and water holding capacity was found out by Keen Racz kowski measurements (Piper 1942)

Soil reaction electrical conductivity exchangeable cations CEC KCl extractable Al and organic carbon were found out as described in section 3 1

Available N was determined by alkaline permanganate method (Subbiah and Asija 1956) Available P_2O_5 was extracted by Bray 1 extractant (0 03 N NH_4F in 0 025 N HCl) and determined by the ascorbic acid method (Watanabe and Olsen 1965) Available potassium was extracted by 1N NH_4OAc and determined using EEL flame photometer (Jackson 1958)

P fixing capacity was determined by Waugh and Fitts method (Ghosh *et al* 1983) The micronutrients iron manganese copper and zinc were extracted using DTPA (Lindsay and Norwell 1978) and estimated using an atomic absorption spectrophotometer

3 3 Soil fertility map

A soil fertility map was prepared by calculating the nutrient indices for available N P and K as suggested by Biswas and Mukherjee (1987)

3 4 Statistical analysis

Simple correlation coefficients between the various physico-chemical characteristics of surface soils were calculated as suggested by Snedecor and Cochran (1967)

3 5 Soil taxonomy

The classification of pedons under taxonomy upto the subgroup level have been attempted according to the specifications suggested by the Soil Survey Staff (1987)

Results and Discussion

RESULTS AND DISCUSSION

1 Profile morphology

Profiles selected for the study are representative of the soils of the Banana Research Station Kannara Abbreviated morphological description of the profiles of various blocks are given in Table 1 Detailed description is given in the Appendix I

Two profiles taken in the A block showed wide variations in several morphological aspects Surface horizon of the first profile of A block (P_1) was dark reddish brown The hue turned yellowish in the deeper layers Dominant colour hue was 5 YR For the second profile (P_2) in the same block surface soil was dusky red Hue was 2 5 YR in surface layers but it turned to 10 R in the sub surface layers

Textural class of the soils varied for each horizon loamy to sandy clay in the first profile and silty to clayey in the second profile Structure of the surface layer was medium weak subangular blocky for the first profile whereas for the second one structure turned to very friable and granular nature Medium weak subangular blocky was the predominant structure In both cases consistence was very friable sticky and plastic for the first profile and it changed to friable slightly sticky and slightly plastic to lower layers of the same profile For the second profile consistence of the surface soil was very friable slightly sticky slightly plastic and to subsurface horizons it changed to firm very sticky and very plastic in nature

Table 1 Morphological description of the profiles

Horizon	Depth	Munsell colour Moist	Texture	Structure	Consistence	Boundary	Remarks
1	2	3	4	5	6	7	8
				A BLOCK			
P1							
Ap L1	0 11	5YR 3/3	cl	m1 sbk	Mfr Ws Wp	cs	Few fine roots
A21 L2	11 20	5YR 3/3	cl	m2 sbk	Mfr Ws Wp	cs	Few fine roots
A3 L3	20 72	2 5YR 3/2	sicl	m1 sbk	Mfr Ws Wp	gw	Few fine roots
B1 L4	72 106	5YR 4/6	scl	m1 sbk	Mfr Ws Wp	gw	Few fine roots
B21 L5	106 140	5YR 4/6	scl	m2 sbk	Mfr Wss Wsp	dw	
B22 L6	140 165	5YR 4/4	sc	m1 sbk	Mfr Ws Wp	dw	
B3 L7	165+	5YR 4/4	sc	m1 sbk	Mfr Wss Wsp		
P2							
Ap L1	0 13	2 5YR 3/2	sicl	gf gr	Mfr Wss Wps	cs	Few coarse roots
A1 L2	13-31	2 5YR 3/4	cl	fgr	Mfr Ws Wp	cw	Very fine few roots
A2 L3	31 60	2 5YR 3/6	c	m1 sbk	Mfr Ws Wp	gw	Few fine roots
B1 L4	60 90	10R 3/4	c	m2 sbk	Mfr Ws Wp	gw	Few fine roots
B12 L5	90 116	10R 3/4	c	m2 sbk	Mfr Ws Wp	dw	Few fine roots
B2 L6	116 133+	10R 3/6	c	m2 sbk	Mfi Wvs Wvp		Gneissic gravel present
				B-BLOCK			
P3							
Ap L1	0 15	5YR 3/3	sic	m1 sbk	Sh vfr Ss	cs	Coarse roots common
A21 L2	15 32	7 5YR 4/4	sic	m2 sbk	Sh fr Sp	as	Few fine roots
B1 L3	32 72	7 5YR 5/8	sic	m2 sbk	1 fr ssp	as	Very fine few roots
B21 L4	72 105	7 5YR 5/8	cl	m2 sbk	s fr p	as	Very fine few roots
B22 L5	105+	7 5YR 5/8	c	m2 sbk	s fr p		

Contd

Table 1 Continued

1	2	3	4	5	6	7	8
P4							
Ap L1	0 26	7 5YR 3/2	sicl	m1 sbk	sh vfr ss sp	gw	Medium roots common
A1 L2	26 43	7 5YR 3/2	cl	m1 sbk	sh fr s p	cw	Few coarse roots
B1 L3	43 89	5YR 3/3	sc	m2 sbk	h vfr s p	gw	Few fine roots
B2 L4	89 106	7 5YR 4/4	sc	m2 sbk	h ofr s p	gw	
P5							
Ap L1	0 19	5YR 3/3	cl	m2 sbk	sh fr ss sp	cs	Fine roots common
A1 L2	19 40	5YR 3/4	sic	m2 sbk	sh fi s p	cw	Few fine roots
B1 L3	40 70	5YR 3/3 7 5YR 6/8(r)	sic	c2 sbk	sh vfi s p	dw	
B12 L4	70 100	5YR 3/4	sic	c2 sbk	sh efi s p	dw	Fine gravel
B13 L5	100 140	5YR 3/3	sic	m2 sbk	l fi s p		Gravel present
				C BLOCK			
P6							
Ap L1	0 32	5YR 4/4	cl	m1 sbk	l vfr s ps	gw	Few coarse roots
A1 L2	32 43	7 5YR 4/4	sicl	m2 sbk	lm vfr ps	aw	Few fine roots
B1 L3	43 74	2 5YR 3/6(r)	sicl	m3 sbk	sh fi ps	gs	Fine gravel present
B2 L4	74 146	7 5YR 5/8(r)	sicl	c2 sbk	h vfi ps		Gravel present
P7							
Ap L1	0 28	5YR 5/6	sicl	m1 sbk	sh fr s p	cs	Few fine roots
B1 L2	28 49	7 5YR 5/8	cl	m2 sbk	sh fi s p	gw	
B2 L3	49 67	2 5YR 7/8	sil	m3 sbk	h fi s p	gw	Fine gravel present
B22 L4	67 114	2 5YR 4/6	sicl	m3 sbk	h vfi s p	dw	Fine gravel present
B3 L5	114 145	2 5YR 5/8	sicl	m3 sbk	h vfi s p		Fine gravel present

Contd

Table 1 Continued

1	2	3	4	5	6	7	8
				D-BLOCK			
P8							
Ap L1	0 19	7 5YR 4/4	sicl	m2 sbk	s fr ss p	cs	Fine roots common
A1 L2	19 47	7 5YR 5/4	sicl	m2 sbk	sh fr ss sp	cs	Few very fine roots
B1 L3	47 69	7 5YR 4/4	si	m2 sbk	sh vfr ss sp	gs	
B21 L4	69 90	5YR 3/3	si	m1 sbk	sh vfr ss sp	gw	
B22 L5	90 135	5YR 3/4	si	m1 sbk	sh vfr ss sp		
				E BLOCK			
P9							
Ap L1	0 25	7 5YR 3/2	sicl	m1 sbk	l fr ss sp	cs	Medium roots common
B1 L2	25 56	7 5YR 4/4	sicl	m2 sbk	s fr ss sp	gw	
B21 L3	56 73	5YR 4/6	sil	m1 sbk	s fr s sp	gw	
B22 L4	73 109+	5YR 3/3	sil	m1 sbk	s vfr ss sp		
				F BLOCK			
P10							
Ap L1	0 34	7 5YR 5/6	sil	m1 sbk	h fr s p	gw	Few medium roots
B1 L2	34 48	5YR 5/8	sicl	m1 sbk	vh fi s p	cw	
B21 L3	48 104	5YR 4/6 2 5YR 4/8(r)	sic	m2 sbk	vh fi s p	gw	Coarse fragments present
B22 L4	104-108	5YR 4/6 2 5 YR 4/8(r)	sic	m3 sbk	vh vfi s p		Coarse fragments

Symbols as suggested by Soil Survey Staff (1992)

Boundary between different horizons showed wide variation from clear smooth to distinct wavy nature

For the first profile in B block (P_3) the colour of the soil varied widely Surface layer was dark reddish brown with the predominant hue of 5 YR To the lower layers prevailing hue was 7 5 YR with strong brown co lour For the second profile taken in the same block (P_4) surface layer showed a predominant hue of 7 5 YR The hue turned yellowish (5 YR) in one of the sub surface layers For the third profile (P_5) in B block predominant hue of the surface soil was 5 YR and remained as such in lower layers

Texture of the layers varied much from silty clay to clay in the case of P_3 and from silty clay loam to sandy clay for P_4 and clay to silty clay in the case of P_5 Strucutre of the horizons of P_3 and P_4 varied from medium subangular blocky to moderate subangular blocky and that of P_5 ranged from moderate subangular blocky to coarse moderate sub angular blocky

Consistence of P_3 varied from slightly hard very friable slightly sticky to friable and plastic in the lower layers For P_4 the consistence varied from slightly hard very friable slightly sticky and slightly plastic in the sur face layers and for the subsurface layers hardy very friable to sticky and plastic For P_5 consistence varied from slightly hard firm slightly sticky slightly plastic in the surface layer and to firm slightly plastic in lower layers

Two profiles namely P_6 and P_7 were taken in C block The predominant hue of the surface layer was 5 YR in both cases It changed to dark red (2 5 YR) and then to strong brown (7 5 YR) in sub horizons the case of P_6 For P_7 subsurface layers were yellow and red (2 5 YR)

Texture for P_6 varied from clay loam to silty clay loam But for P_7 texture was predominantly silty clay loam Structure of P_6 varied from medium weak subangular blocky to coarse moderate subangular blocky For P_7 the surface layers had the same structure but lower horizons were medium strong subangular blocky

Consistence of P_6 was loose very friable and slightly plastic in surficial layer and it changed to hard very friable and slightly plastic in lower layer For P_7 consistence was slightly hard friable and slightly plastic m uppermost layer but changed to hard very friable and slightly plastic in the lower layer Boundary varied widely in both profiles

One profile was taken in D block namely P_8 Predominant hue was 7 5 YR in the upper layers and turned to 5 YR in the lower layers Texture varied from silty clay loam in the surface layers to silty in the lower most layers Structure ranged from medium moderate subangular blocky to medium weak subangular blocky Consistence varied from soft friable slightly sticky slightly plastic to slightly hard very friable slightly sticky slightly plastic Boundary was clear and smooth for surface layers and changed to gradual and wavy for lower horizons

In the E block one profile namely P_9 was taken In the upper layers predominant hue was 7 5 YR and it changed to 5 YR in the lower lay ers Texture varied from silty clay loam to silty loam and the structure was predominantly medium weak subangular blocky Consistence of surface layer was loose friable slightly sticky and slightly plastic and it changed to soft very friable and slightly sticky slightly plastic Boundary was clear smooth in the upper layer and it changed to gradual wavy in the lower layers

In the F block one profile namely P_{10} was taken Predominant hue was 7 5 YR in the surface layer it changed to 5 YR in the lower layers The lowermost layers were mottled in appearance Texture varied from silty loam to silty clay and structure ranged from medium weak subangular blocky to medium strong subangular blocky Consistence was hard friable sticky and plastic for surface layers and changed to very hard very firm sticky and plastic for the sub horizon Boundary varied from gradual wavy to clear wavy

Soil in all the blocks were deep and coarse fragments were present at greater depth except for P_1 P_5 and P_6 Drainage was medium well and no flooding was noticed for P_2 P_3 P_4 P_7 P_8 and P_9 But for p_1 occassional flooding impermeable drainage and ponded run off was observed P_5 P_6 and P_{10} had mottled layers in the subsurface layers which indicate the ill drained nature of the profile

Influence of parent material on the genesis and mineralogy of red and laterite soils are noticed by Sahu *et al* (1983) Climatic parameters are the foremost in explaining variations in mineralogy and structural composition (Nahson 1991) For the soil profiles in various blocks the wide variations can be explained to be due to the influence of parent material moisture regime drainage topography as well as vegetation Difference in soil development between the sequences is reported to be due to the effect of climate and vegetation by Harrison *et al* (1990) Colour of the soil is of much significance Schwertmann and Taylor (1977) reported that in well drained soil of tropics rapid decomposition of organic matter occurs which leads to haematite formation that is bright red in colour and cause pigmentation of soil

In the present investigation free iron oxide content of the soil was found to increase with the depth The increase in bright red colour of the sub surface horizons can be explained in such a way Webster (1965) has associated red colours with the content of free iron oxides

Mandal (1971) reported that colour of the laterite soils varied from red to yellow depending on their acidity Ratnam *et al* (1972) reported that colour of the soil depends on degree of hydration of ferric hydroxide The studies of Govindarajan and Rao (1978) revealed that colour of the laterites at the surface in most cases is red changing to reddish yellow and finally yellow in deeper layers Such a typical colour change can be observed in P_{10} of F block

Structure of the soil was mainly subangular blocky which confirms with the reports of Venugopal (1980) that good soil structure is an indication of well drained soil conditions All the profiles investigated are medium to well drained (except P_1) with relatively large amount of sesquioxides which act as cementing agents and hence the conditions are conducive for the development of good structure These results agree with the findings of Bastin (1985)

2 Physical properties of the profile soil samples

2 1 Particle size distribution (Table 2 and Fig 2)

2 1 1 Clay content (per cent)

The clay content increased with depth in all the profiles except P_7 in C Block and P_8 in D Block In P_7 and P_8 the clay content initially increased then

Table 2 Particle size distribution and physical constants of the profile soil samples

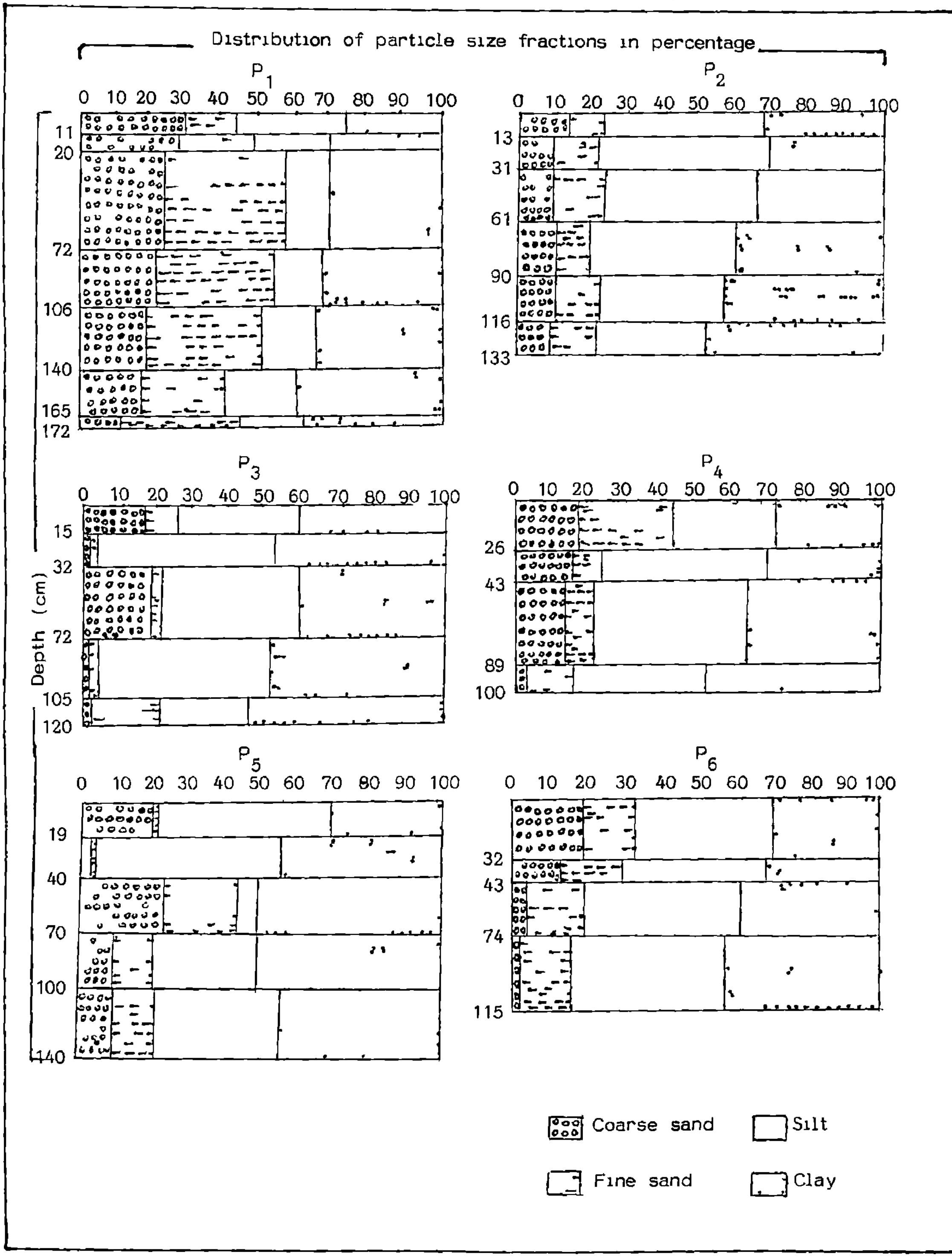
Sample No		Clay %	Silt %	Coarse sand %	Fine sand %	Textural class	Apparent density	Absolute density	Maximum water holding capacity %	Percent pore space %	Volume expansion %
1		2	3	4	5	6	7	8	9	10	11
						A BLOCK					
P1	L1	25 99	30 00	29 15	14 17	l	1 53	2 61	26 36	37 33	8 91
	L2	29 99	21 99	26 51	20 93	scl	1 56	2 40	30 81	43 39	17 77
	L3	29 99	12 00	23 44	34 27	scl	1 44	1 69	29 52	37 42	18 70
	L4	31 99	14 00	21 42	2 49	scl	1 08	1 29	21 08	22 48	9 94
	L5	34 00	14 79	18 46	32 35	scl	1 52	2 05	21 59	31 73	8 75
	L6	36 00	18 39	16 27	25 34	sc	1 60	2 09	17 72	28 23	7 54
	L7	38 00	17 19	10 45	34 06	sc	1 63	1 90	8 94	18 74	5 69
P2	L1	31 99	43 99	14 26	9 56	si	1 58	2 20	21 87	32 12	9 00
	L2	26 90	47 99	11 39	10 13	si	1 28	1 68	17 59	30 85	6 08
	L3	34 00	41 98	11 38	11 94	si	1 35	1 81	24 05	33 51	11 70
	L4	40 89	40 00	10 08	9 56	sic	1 54	1 74	30 02	14 87	29 88
	L5	41 90	34 08	10 53	12 17	c	1 44	1 52	16 86	10 45	6 40
	L6	47 98	30 00	8 97	12 45	c	1 37	1 02	15 78	9 30	16 41
						B BLOCK					
P3	L1	41 91	34 07	17 04	9 27	c	1 44	2 64	37 07	48 86	8 70
	L2	45 99	50 00	2 00	1 02	sic	1 42	2 59	37 18	48 42	8 37
	L3	40 00	37 99	18 26	3 46	si	1 38	2 32	34 74	44 86	18 80
	L4	47 99	47 98	1 31	2 41	sic	1 39	1 47	26 44	15 47	15 61
	L5	51 99	24 00	2 04	19 00	c	1 41	1 54	14 28	24 09	14 27
P4	L1	27 99	27 99	17 02	26 59	scl	1 72	2 72	21 89	47 50	19 66
	L2	29 99	45 98	15 26	8 35	l	1 43	2 25	27 49	41 70	12 38
	L3	35 99	41 99	13 20	8 51	si	1 48	1 91	17 51	41 78	12 18
	L4	41 91	36 87	2 45	12 57	c	1 15	1 25	14 67	28 69	10 42

Contd

Table 2 Continued

1		2	3	4	5	6	7	8	9	10	11
P5	L1	29 00	48 79	19 49	1 33	l	1 40	2 65	37 80	51 72	8 08
	L2	43 99	51 99	2 14	1 38	sic	1 39	2 46	28 75	55 58	9 35
	L3	49 99	5 99	23 45	20 06	sc	1 48	1 78	16 61	33 81	18 34
	L4	50 19	29 39	9 07	11 05	c	1 36	1 45	16 78	19 94	22 20
	L5	43 99	34 79	9 24	11 58	c	1 13	1 16	12 68	14 49	17 39
						C BLOCK					
P6	L1	27 99	37 99	19 08	14 33	l	1 36	1 74	40 89	17 56	19 85
	L2	22 99	39 91	13 49	16 53	l	1 46	2 14	27 06	41 60	14 59
	L3	35 99	43 13	3 06	16 35	cl	1 47	1 78	11 68	36 08	12 99
	L4	41 91	42 04	1 31	14 45	sic	1 59	2 12	9 87	36 21	11 99
P7	L1	31 99	43 99	13 06	10 46	si	1 53	2 34	28 62	39 49	8 04
	L2	39 99	41 90	12 37	5 32	cl	1 24	1 91	39 17	37 40	7 51
	L3	37 99	39 00	10 27	11 25	si	1 39	1 82	24 22	31 98	14 37
	L4	23 99	60 00	9 06	6 56	sil	1 39	1 59	16 37	21 78	15 30
	L5	29 99	59 99	6 15	3 47	cl	1 33	1 54	23 87	20 12	20 62
						D-BLOCK					
P8	L1	27 99	28 00	29 36	14 06	l	1 60	2 49	28 73	44 52	17 00
	L2	45 98	27 99	16 08	9 54	c	1 33	1 93	35 51	42 04	20 30
	L3	39 99	39 99	9 16	10 46	si	1 20	1 33	26 85	26 53	37 35
	L4	17 99	65 98	7 43	8 09	sil	1 01	1 00	21 18	24 61	26 51
	L5	28 00	35 91	15 04	20 38	l	1 30	0 99	19 15	13 62	26 63
						E BLOCK					
P9	L1	17 99	36 00	29 08	16 33	l	1 29	2 16	45 24	39 79	9 70
	L2	32 00	30 00	18 49	19 03	si	1 34	2 05	36 76	37 81	15 06
	L3	45 91	25 99	13 60	14 12	c	1 39	1 77	23 87	33 65	22 55
	L4	47 98	35 99	8 39	7 23	c	1 40	1 52	12 19	18 69	16 82
						F BLOCK					
P10	L1	25 99	29 99	21 33	22 28	l	1 31	2 03	45 26	34 76	18 94
	L2	31 99	38 00	12 32	17 19	si	1 33	1 78	27 59	35 27	17 75
	L3	41 90	34 08	6 60	17 22	c	1 43	1 35	19 89	26 78	20 07
	L4	47 99	40 00	5 22	6 39	sic	1 46	1 85	27 55	39 86	19 40

Fig 2 Particle size distribution of the profile soil samples



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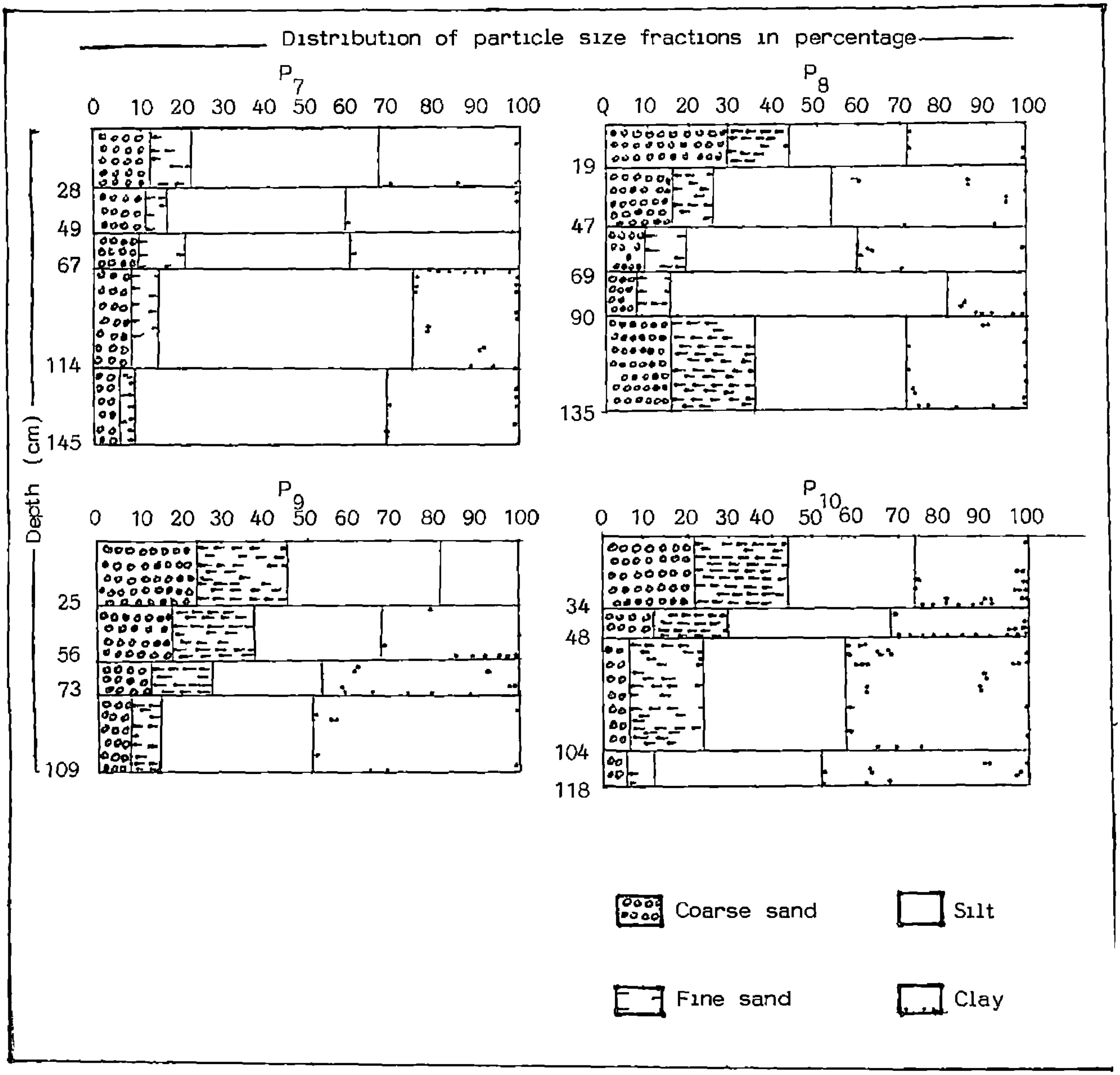


Distribution of particle size fractions in percentage
P7
0 10 20 30 40 50 60 70 80 90 100
28
49
67
114
145
P8
0 10 20 30 40 50 60 70 80 90 100
19
47
69
90
135
Depth (cm)
P9
0 10 20 30 40 50 60 70 80 90 100
25
56
73
109
P10
0 10 20 30 40 50 60 70 80 90 100
34
48
104
118
Coarse sand
Silt
Fine sand
Clay

decreased and finally again increased The clay content in the surface layer varied from 17 99 (P_9 L_1) in E Block to 41 91 (P_3 L_1) in B Block Maximum clay content was obtained in the profiles of B Block

2 1 2 Silt content (per cent)

There was no definite trend in the distribution of the silt fraction The content of silt ranged from 12 0 (P_1 L_3) in A Block to 65 98 (P_8 L_4) in D Block In the P_1 profile of A Block the silt content was just half compared to the clay content with depth The profile P_3 recorded almost equal content of clay and silt in all layers More content of silt was obtained in P_4 P_6 P_7 P_8 and P_{10} in the deepest layer than the surface layer

2 1 3 Sand fractions (per cent)

In P_1 the coarse sand was decreased with depth but fine sand increased The fine sand content was more than the coarse fraction in the deeper layers The fine sand varied from 1 02 (P_3 L_2) to 34 27 (P_1 L_3) whereas the highest coarse sand recorded was only 29 36 in P_8 L_1 The sand fractions were very less comparing to the clay and silt content in P_3 and P_5 profiles of B Block

2 1 4 Textural class

The texture of the soil varied with depth in all profiles This variation was also noticed in different blocks also The profile P_1 in the A Block was entirely different from other profiles In the surface soil the fine sand fraction was less silt coarse sand and clay content were almost the same But in the lower layers the fine sand content was increased and the texture changed from loam to sandy clay loam and finally sandy clay The texture changed to clayey in the deeper layers in all the three profiles of B Block The same pattern was noticed in E Block also

In most of the profiles the textural class variation from loamy to clay in the subsurface horizon is an indication of clay illuviation under tropical conditions as a result of intense weathering the feldspar are completely trans formed to clays (Radwanski and Ollier 1959) Ushakumari (1983) observed the downward movement of clay in red loam and laterite soils of Kerala The illuviation of clay to the lower layers of the profile was also reported by Bastin (1985) The results of the present study are in confirmity with the above observations Prema (1992) reported that the soil type of Banana Research Station Kannara is laterite and texture is sandy loam

2 2 Physical constants of the profile soil sample (Table 2)

2 2 1 Apparent density (g cm ^{3})

Apparent density of various blocks was found to be almost similar The maximum apparent density recorded was 1 72 (P_4 L_1) in B block and minimum was 1 01 (P_8 L_4) in D block In profiles P_6 P_9 and P_{10} the appar ent density increased with depth but there was a slight decreasing trend in other profiles

Makarim *et al* (1988) reported that the apparent density was reduced due to the cultural practices There is no cultivation in the E and F block This may be the reason for the slight increase in the apparent density of the profile with depth All other profiles which showed a decreasing trend is having continuous cultivation This is in conformation with the results of Nair *et al* (1966) that apparent specific gravity appeared to be a function of the coarser particles in the soil

2 2 2 Absolute density (g cm ^{3})

Absolute density of various blocks ranged widely Maximum value recorded was 2 72 (P_4 L_1) in the B block and minimum value was 0 99 (P_8 L_5) in D block In profiles P_2 P_5 P_7 P_8 and P_9 absolute density showed a decreasing trend with depth In other profiles no general trend was noticed

Decrease in the content of coarser particles with depth can be attributed to the decreasing trend of absolute density with depth Nair *et al* (1966) reported similar results

2 2 3 Maximum waterholding capacity (per cent)

Range in the values of maximum waterholding capacity was 45 26 (P_{10} L_1) to 8 94 (P_1 L_7) The values showed a decreasing trend with the depth of the profile except for profiles P_4 P_7 P_8 and P_{10} The decrease of water holding capacity with depth may be due to the decrease in the organic matter content with soil depth

Thulaseedharan and Nair (1984) showed a significant correlation with clay and silt fractions and negative relations with coarse and fine sand fractions In the present study also the maximum water holding capacity was recorded in the pro files where maximum content of clay and silt was obtained

2 2 4 Pore space (per cent)

The maximum pore space was recorded in the profile samples of B Block (55 58) in P_5 L_2 The other two profiles of the same block also record ed the pore space of about 50 per cent A decreasing trend of pore space was noticed in most of the profiles studied This decrease may be due to the compaction of the sub soil Nair *et al* (1966) conducted the studies on Keen Raczkowski measurements and their relation to soil test values in cultivated soils of Kerala Porosity is found to be related to the finer soil fractions both in quantity and quality A medium range of pore space in the soils is explained by relatively fair distribution of organic matter in these soils In Block B the sand fractions are less compared to clay and silt which is an indication of finer fractions and higher pore space values

2 2 5 Volume expansion (per cent)

There was no general trend in the values of the volume expansion P_3 and P_4 profiles of B Block recorded a similar trend up to the third layer Out of 10 profiles 6 profiles obtained the value in the range of 8 10 whereas other profiles recorded the values in the range of 17 20 in top layer The maximum value obtained in P_8 L_3 (37 35) and the minimum in P_1 L_7 (5 69)

3 Chemical characters

3 1 Soil reaction electrical conductivity and organic carbon (Table 3)

3 1 1 Soil reaction

Soil pH was in the acidic range varying from the maximum value of 6 69 for F block P_{10} L_4 and the minimum value of 5 13 for A block P_1 L_1

The acidic range of pH can be explained by the heavy rainfall of the region (Venugopal 1980) Heavy rainfall leads to intense leaching of bases and consequent increase in acidity

3 1 2 Electrical conductivity (dS m^{-1})

Electrical conductivity value was found to be maximum in B block 0 18 (P_5 L_5) The minimum value was observed in A block 0 01 (P_2 L_1 and P_2 L_2) No definite trend was observed with the depth

All the soil samples are low in the electrical conductivity and so plant growth was not found to be affected

3 1 3 Organic carbon (percentage) (Fig 3)

Organic carbon content was maximum in the surface layers of D E and F blocks The maximum value recorded was 0 91 Minimum value recorded was 0 01 (P_2 L_6) A block The organic carbon content showed a definite decrease with the depth of the profile Organic carbon content is found to be a better index for

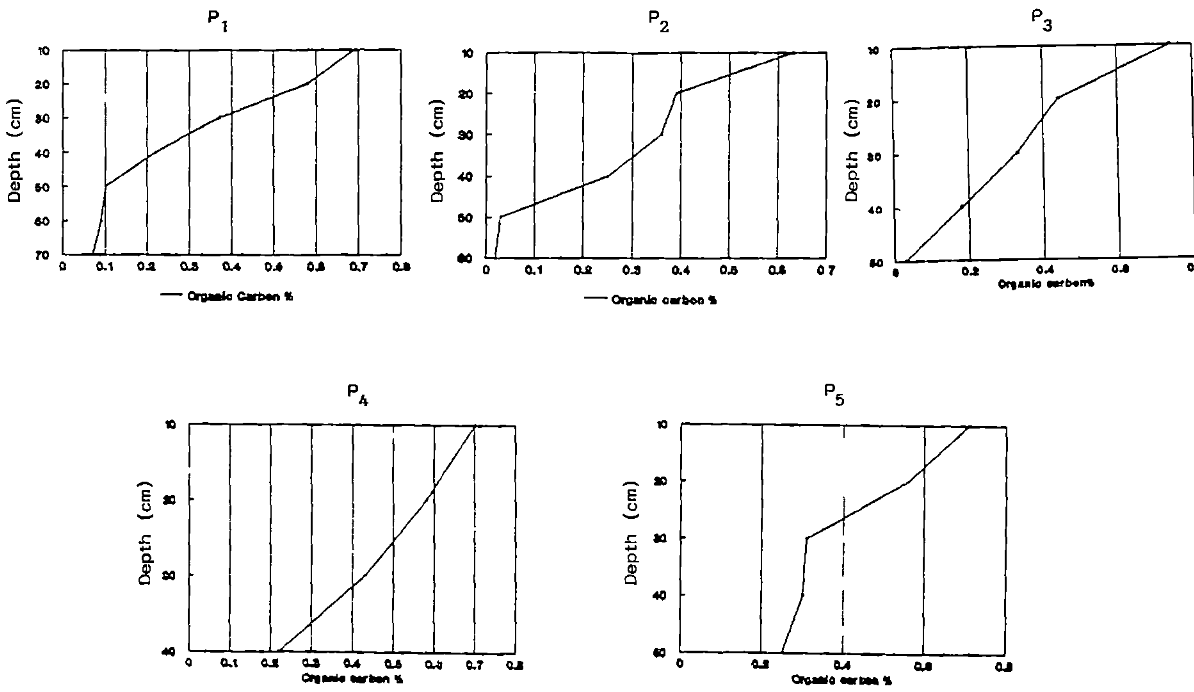
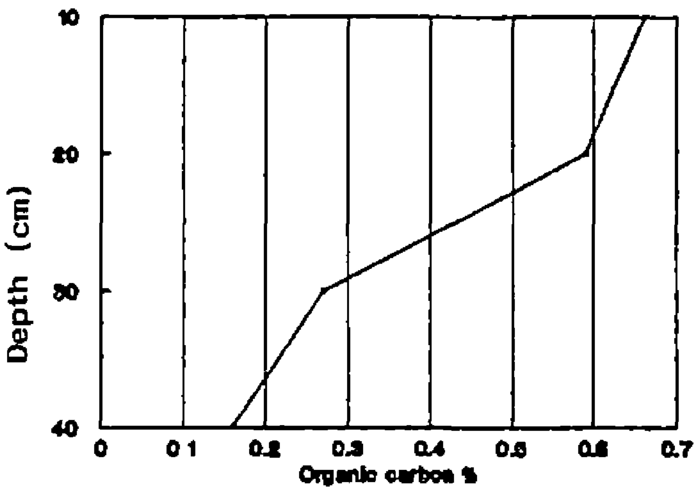
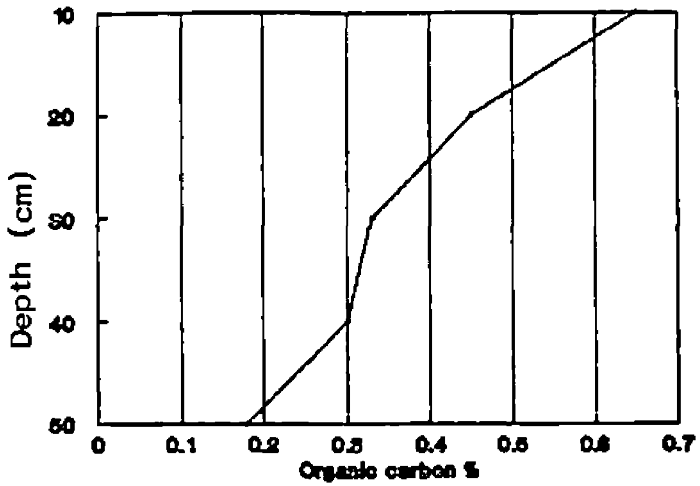


Fig 3 Distribution of organic carbon in soil profiles

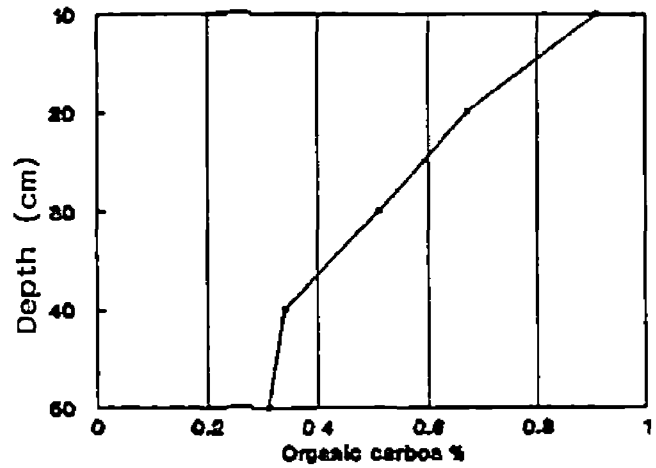
P_6



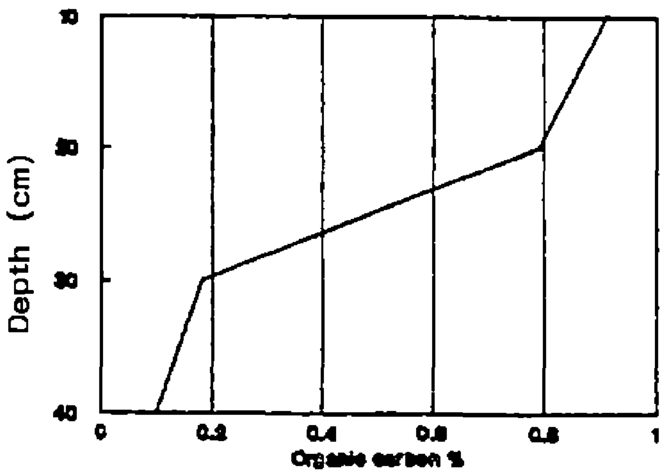
P_7



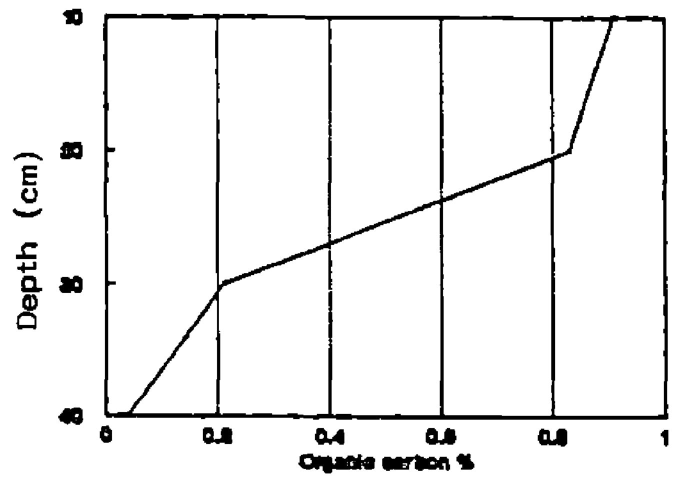
P_8



P_9



P_{10}



available nitrogen A decrease in organic carbon content with depth was reported by Thiyagarajan (1978)

3 2 Total elemental composition (per cent) (Table 3)

3 2 1 Total nitrogen (per cent)

Maximum nitrogen content noticed was 0 36 (P_8 L_1) for D block and minimum was 0 02 (P_2 L_6) for A block Decrease of the total nitrogen content with the depth of the soil profile was observed Maximum and minimum values for organic carbon was also obtained for the same soil samples

Total nitrogen content of most of the acid soils are reported to be high due to low mineralization in acid soil (Alexander and Durairaj 1968) Venugopal (1969) reported that total nitrogen content of various soils of Kerala ranged between 0 01 to 0 54 percentage Decrease in the total nitrogen content with depth was observed This is also reported by Hassan (1977) while investigating the fertility status of Kerala soils Raguraj (1981) also reported the same result in the soils of Madurai district

3 2 2 Total P_2O_5 (per cent)

Total P_2O_5 content was maximum in B block 0 27 (P_5 L_3) Minimum value was recorded as 0 06 in P_1 L_5 and P_{10} L_3 No general trend was observed with depth The P_2O_5 content was more in the B D and E blocks

Total phosphorus content was comparatively high No significant correlation was reported by Alexander and Durairaj (1968) between soil pH

Table 3 Soil reaction electrical conductivity and organic carbon of the profile soil samples and it s total elemental composition

Sample No		pH	EC dS m 1	Organic (%)	N	P_2O_5	K_2O	Na_2O	CaO	MgO	Sesquioxides
								(Per cent)			
1		2	3	4	5	6	7	8	9	10	11
						A BLOCK					
P1	L1	5 13	0 10	0 69	0 28	0 08	0 34	0 11	0 296	0 312	26 9
	L2	5 22	0 10	0 69	0 22	0 10	0 27	0 05	0 316	0 354	23 4
	L3	5 78	0 09	0 37	0 11	0 18	0 22	0 05	0 470	0 483	29 1
	L4	6 07	0 07	0 22	0 08	0 08	0 24	0 05	0 665	0 676	30 4
	L5	6 33	0 07	0 10	0 06	0 06	0 29	0 03	0 732	0 814	31 2
	L6	6 50	0 06	0 09	0 03	0 11	0 31	0 05	0 756	0 791	32 7
	L7	6 42	0 06	0 07	0 03	0 11	0 34	0 05	0 760	0 714	24 9
P2	L1	5 88	0 01	0 63	0 22	0 12	0 29	0 16	0 272	0 314	24 9
	L2	5 68	0 01	0 39	0 17	0 12	0 26	0 05	0 381	0 407	15 4
	L3	5 58	0 04	0 36	0 11	0 08	0 59	0 05	0 431	0 456	18 4
	L4	5 33	0 03	0 25	0 08	0 15	0 34	0 05	0 452	0 514	26 6
	L5	5 66	0 02	0 03	0 06	0 10	0 39	0 05	0 471	0 485	34 1
	L6	5 69	0 02	0 02	0 02	0 13	0 39	0 05	0 483	0 571	27 1
						B-BLOCK					
P3	L1	5 95	0 03	0 74	0 20	0 15	0 31	0 05	0 074	0 084	26 8
	L2	6 05	0 06	0 44	0 14	0 15	0 29	0 03	0 132	0 162	27 4
	L3	6 12	0 08	0 33	0 11	0 14	0 34	0 05	0 175	0 186	24 6
	L4	6 31	0 08	0 18	0 06	0 15	0 36	0 05	0 181	0 195	31 0
	L5	6 44	0 12	0 03	0 03	0 19	0 43	0 11	0 231	0 141	21 2
P4	L1	6 24	0 13	0 70	0 25	0 23	0 27	0 05	0 032	0 114	23 6
	L2	6 04	0 10	0 58	0 24	0 26	0 29	0 05	0 075	0 172	18 7
	L3	5 10	0 14	0 43	0 15	0 20	0 36	0 04	0 087	0 181	22 9
	L4	5 14	0 11	0 22	0 08	0 22	0 43	0 005	0 161	0 197	24 8

Contd

Table 3 Continued

1		2	3	4	5	6	7	8	9	10	11
P5	L1	6 07	0 14	0 71	0 20	0 20	0 29	0 05	0 147	0 161	28 1
	L2	6 07	0 14	0 71	0 17	0 23	0 34	0 03	0 165	0 194	30 7
	L3	5 74	0 08	0 56	0 14	0 27	0 39	0 05	0 181	0 186	26 6
	L4	5 85	0 09	0 30	0 11	0 26	0 41	0 05	0 320	0 324	29 3
	L5	5 95	0 18	0 25	0 10	0 20	0 48	0 05	0 346	0 352	31 5
					C BLOCK						
P6	L1	6 63	0 14	0 66	0 20	0 16	0 29	0 11	0 176	0 181	30 8
	L2	5 95	0 08	0 59	0 14	0 09	0 31	0 11	0 121	0 161	31 1
	L3	5 99	0 07	0 27	0 08	0 16	0 34	0 05	0 361	0 391	29 6
	L4	6 13	0 08	0 16	0 06	0 07	0 69	0 11	0 147	0 162	28 7
P7	L1	6 05	0 06	0 65	0 22	0 15	0 24	0 05	0 038	0 145	31 4
	L2	5 72	0 07	0 45	0 20	0 07	0 29	0 11	0 046	0 132	28 5
	L3	5 55	0 06	0 33	0 17	0 20	0 34	0 11	0 532	0 614	30 6
	L4	5 97	0 07	0 30	0 11	0 16	0 34	0 11	0 471	0 532	29 6
	L5	5 98	0 08	0 18	0 07	0 07	0 39	0 12	0 636	0 717	31 7
					D-BLOCK						
P8	L1	5 59	0 08	0 91	0 36	0 23	0 39	0 05	0 012	0 132	15 9
	L2	5 50	0 07	0 67	0 34	0 20	0 43	0 05	0 047	0 168	23 7
	L3	5 82	0 08	0 51	0 22	0 24	0 43	0 05	0 125	0 171	20 4
	L4	5 51	0 09	0 34	0 17	0 16	0 36	0 05	0 146	0 194	25 4
	L5	6 04	0 08	0 31	0 11	0 18	0 39	0 05	0 181	0 281	16 3
					E BLOCK						
P9	L1	6 18	0 06	0 91	0 22	0 19	0 24	0 11	0 132	0 167	16 3
	L2	6 36	0 06	0 79	0 17	0 25	0 31	0 11	0 241	0 281	27 2
	L3	6 39	0 06	0 18	0 11	0 23	0 43	0 11	0 361	0 374	24 5
	L4	6 30	0 06	0 10	0 06	0 16	0 39	0 11	0 471	0 496	22 7
					F BLOCK						
P10	L1	6 17	0 05	0 91	0 20	0 12	0 27	0 11	0 013	0 184	32 6
	L2	6 35	0 05	0 83	0 17	0 09	0 29	0 12	0 125	0 128	31 5
	L3	6 28	0 05	0 21	0 11	0 06	0 31	0 15	0 217	0 218	28 4
	L4	6 69	0 05	0 04	0 03	0 13	0 34	0 16	0 318	0 321	29 1

and total P_2O_5 content Total P_2O_5 content was found to be lower than total K_2O content Similar results were reported by Nair (1973) and Bastin (1985)

3 2 3 Total K_2O (per cent)

Maximum value noted was 0 69 (P_6 L_4) in C block Minimum value was found to be 0 22 (P_1 L_3) for A block No general trend was observed with depth for P_1 P_2 P_3 P_8 and P_9 While with the rest of the profiles a regular increase was noted with the depth

Increase in the content of K_2O with depth for some of the profiles examined was reported by Bastin (1985) and irregular pattern of variation with depth was reported in some other profiles investigated Low reserves of major nutrients in acid soils was considered as a reflection of the fine sand miner alogy and parent geology of the soils Fine sand fraction of laterite soils of Kerala has quartz as the dominant mineral with few weatherable minerals The acid crystalline rocks from which soils of Kerala are derived are also low in weatherable minerals Low values obtained may be due to the above given reasons

3 2 4 Total Na_2O (per cent)

Total Na_2O content was more or less the same in all the profiles No general trend was observed with depth Maximum content was 0 16 (P_2 L_1) in A block and P_{10} L_4 in F block Minimum content observed was 0 03 (P_1 L_5) in A block The low values indicate lower salinity of the soil and the favourable conditions for plant growth

3 2 5 Total CaO (per cent)

Maximum value was observed for A block P_1L_7 0 760 The minimum was obtained for D block P_8L_1 0 012 For total CaO a regular increase in the CaO content with depth was observed except for P_6 and P_7 The total CaO content was within the range of 0 012 to 0 760 Similar variation in total Cao content was observed by Venugopal (1969) and Bastin (1985) The low values of Ca may be due to the occurrence of low levels of $CaCO_3$ in tropical soils and the low weatherability of the parent rock

3 2 6 Total MgO (per cent)

Total MgO content was noticed to be maximum in the A block The maximum value was 0 814 (P_1L_5) Minimum value observed was 0 128 ($P_{10}L_2$) F block No regular pattern of distribution was noticed for the total MgO content According to Bastin (1985) the low reserves can be explained by the nature of parent material from which the soils are derived In the red and laterite soils of Kerala quartz is the dominant mineral with a few weatherable minerals The soils of Kerala are derived from the acid crystalline rocks which are poor in weatherable minerals

3 2 7 Sesquioxide (per cent)

Maximum and minimum values of sesquioxide were recorded in the P_2 profile of A block as 34 1 (P_2 L_5) and 15 4 (P_2 L_2) respectively For all profiles investigated intermediate layers showed maximum accumulation The sesquioxide content was very high for all the samples analysed

Bhattacharya *et al* (1983) attributed the higher values of total Fe_2O_3 at lower depths of soil to pedogenic factors like weathering fluctuating water table temperature fluctuation and seasonal pH change of the under ground water Nair (1973) and Bastin (1985) pointed out that kaolinite clays fix sesquioxides descending in the profile as a result of elluviation process The maximum content of sesquioxide in the subsurface layers is confirmed by these results

3 3 Exchangeable characteristics of the soil (Table 4)

3 3 1 Exchange acidity (cmol (+) kg ^{1})

Exchange acidity was maximum for B block 2 2 (P_4 L_3) and minimum for B block (P_3 L_4 P_3 L_5) E block (P_9 L_3 P_9 L_4) and F block (P_{10} L_3 P_{10} L_4) Minimum value noted was 0 1 Exchange acidity was highest for the surface samples and showed a decreasing trend with depth for some profiles except P_4 P_5 P_6 P_7 and P_8 In these profiles maximum acidity was noticed in the subsurface layer Exchange acidity represents the total sum of hydrogen and aluminium the acid generating cations

3 3 2 Exchangeable hydrogen (cmol(+) kg ^{1})

Maximum value was 0 5 P_8 L_1 and P_5 L_3 The minimum value was 0 1 A general decreasing trend with depth except for P_5 and P_6 With increase in depth pH value was higher and so the value of exchangeable hydrogen was less

3 3 3 Exchangeable aluminium (cmol(+) kg ^{1})

For P_1 P_2 P_5 and P_{10} only in the surface layers exchangeable Al was

Table 4 Exchangeable characteristics of the profile soil samples

Sample No		Exchange acidity	Exchangeable H	Al	Exchangeable Ca	Mg	Cations K	Na	CEC	ECEC	Base saturation %	Base unsaturation %
					- in cmol (+) kg 1							
					A BLOCK							
P1	L1	0 6	0 3	0 3	1 25	0 50	0 27	0 13	2 75	2 35	78 17	21 83
	L2	0 5	0 3	0 2	2 25	0 50	0 20	0 15	3 60	3 30	86 11	13 89
	L3	0 3	0 3	-	3 00	1 00	0 21	0 15	4 66	4 36	93 56	6 44
	L4	0 2	0 2		1 75	1 50	0 18	0 09	3 72	3 42	94 62	5 38
	L5	0 2	0 2		2 00	0 75	0 17	0 09	3 21	3 01	93 77	6 23
	L6	0 2	0 2		3 25	0 25	0 14	0 09	3 93	4 50	94 91	5 09
	L7	0 2	0 2		2 25	1 25	0 15	0 09	3 94	4 52	94 92	5 08
P2	L1	0 6	0 3	0 3	1 50	0 75	0 26	0 11	3 22	2 92	81 34	18 66
	L2	0 8	0 4	0 4	1 75	0 75	0 19	0 11	3 60	3 20	77 78	22 22
	L3	0 3	0 3		1 75	0 75	0 22	0 13	3 15	3 85	90 47	9 53
	L4	0 2	0 2	-	3 00	1 00	0 32	0 13	4 65	4 45	95 70	4 30
	L5	0 2	0 2		3 00	0 50	0 21	0 15	4 05	3 85	95 07	4 93
	L6	0 2	0 2	-	3 00	0 75	0 28	0 13	4 36	4 16	95 41	4 59
					B-BLOCK							
P3	L1	0 2	0 2		2 75	0 25	0 33	0 11	3 64	3 44	94 51	5 09
	L2	0 2	0 2		2 50	1 25	0 24	0 11	4 30	4 10	95 35	4 65
	L3	0 2	0 2		3 00	1 00	0 32	0 13	4 65	4 45	95 70	4 30
	L4	0 1	0 1	-	3 75	2 25	0 34	0 16	6 64	6 54	98 49	1 51
	L5	0 1	0 1		3 75	0 50	0 43	0 19	4 97	4 87	97 99	2 01
P4	L1	0 4	0 4	-	1 75	1 50	0 42	0 11	4 18	3 78	90 44	9 56
	L2	0 5	0 3	0 2	2 50	0 50	0 51	0 11	4 12	3 82	87 87	12 13
	L3	2 2	0 1	2 1	2 50	0 25	0 39	0 13	5 47	5 37	59 74	40 26
	L4	0 8	0 1	0 7	2 50	0 75	0 36	0 10	4 51	4 41	82 25	17 75
P5	L1	0 3	0 2	0 1	1 75	0 50	0 26	0 12	2 93	2 73	93 18	6 82
	L2	0 6	0 3	0 3	1 75	0 75	0 26	0 13	3 49	3 19	82 79	17 21

Contd

Table 4 continued

1	2	3	4	5	6	7	8	9	10	11	12
L3	0 7	0 5	0 2	3 50	1 00	0 51	0 17	5 89	5 39	88 11	11 89
L4	0 2	0 2		5 00	1 50	0 42	0 13	7 25	7 15	97 24	2 76
L5	0 2	0 2		4 75	1 00	0 40	0 20	6 54	6 34	96 94	3 06
						C BLOCK					
P6 L1	0 2	0 2		2 5	1 0	0 41	0 11	4 22	4 02	95 26	4 74
L2	0 4	0 3	0 1	3 5	0 75	0 39	0 07	5 11	4 81	92 17	7 83
L3	0 2	0 2		3 5	0 75	0 35	0 08	4 88	4 68	95 90	4 10
L4	0 3	0 2	0 1	4 0	0 25	0 33	0 09	4 97	4 77	93 96	6 04
P7 L1	0 5	0 3	0 2	2 0	0 50	0 24	0 13	3 37	3 07	85 18	14 82
L2	0 2	0 2		2 5	0 25	0 37	0 07	2 89	2 69	93 07	6 93
L3	0 3	0 2	0 1	3 0	0 25	0 55	0 17	4 28	4 08	92 98	7 02
L4	0 2	0 2		3 5	1 0	0 46	0 09	5 25	5 05	96 19	3 81
L5	0 2	0 2		4 0	1 0	0 28	0 12	5 60	5 40	96 43	3 57
						D-BLOCK					
P8 L1	1 1	0 5	0 6	2 0	0 5	0 46	0 14	4 20	3 70	73 83	26 17
L2	1 5	0 4	1 0	3 5	0 5	0 41	0 08	5 99	5 59	74 96	25 04
L3	0 4	0 3	0 1	2 5		0 42	0 09	3 41	3 11	88 26	11 74
L4	1 2	0 3	0 9	2 25		0 32	0 07	3 84	2 94	68 72	31 28
L5	0 2	0 2		2 25	0 5	0 33	0 09	3 27	3 17	96 94	3 06
						E BLOCK					
P9 L1	0 2	0 2		2 75	1 00	0 23	0 14	4 32	4 12	95 37	4 63
L2	0 1	0 1	-	3 25	1 25	0 51	0 09	5 20	5 10	98 08	1 92
L3	0 1	0 1		3 75		0 25	0 09	4 19	4 09	97 61	2 39
L4	0 1	0 1		4 25	1 00	0 49	0 08	5 92	5 82	98 31	1 69
						F BLOCK					
P10 L1	0 3	0 2	0 1	2 25	0 25	0 14	0 09	3 03	2 83	90 09	9 91
L2	0 2	0 2		3 00	1 00	0 16	0 13	4 49	4 29	95 55	4 45
L3	0 1	0 1		2 75	0 25	0 17	0 09	3 35	3 25	97 02	2 98
L4	0 1	0 1		3 75	0 50	0 17	0 09	4 60	4 50	97 83	2 17

noticed For P_3 and P_9 exchangeable Al was absent For others irregular distribution was noticed The maximum value obtained was 2 1 (P_4 L_3) for the B block Minimum value observed was zero for many samples

According to Misra *et al* (1989) exchangeable Al and percentage Al saturation increased with a decrease in pH This is confirmation with the increase in Al content with depth in P_4 of B block The content of exchangeable Al was much lower than that of hydrogen Since pH was more or less in the neutral range the proportion of Al in the soil was less Iyer (1979) and Bastin (1985) also reported similar results

3 3 4 Exchangeable calcium magnesium potassium and sodium (cmol (+) kg $^{-1}$)

Exchangeable calcium content was maximum for P_5 Maximum value noticed was 5 0 (P_5 L_4) in B block Minimum value observed was 1 25 (P_1 L_1) in A block In most of the profiles an increasing trend of exchangeable Ca with depth was noticed

For magnesium maximum value (2 25) was noted in B block for P_3 L_4 Minimum value obtained was 0 25 for many samples

Exchangeable potassium was found to be maximum in the C block 0 55 (P_7 L_3) Minimum value noticed was 0 14 for P_1 L_6 (A block) and P_{10} L_1 (F block) No definite trend was observed with the depth

Exchangeable sodium was maximum for B block 0 20 (P_5 L_5) Minimum value observed was 0 07 (P_7 L_2 and P_6 L_2) for C block and P_8 L_4 for D block No definite trend was observed with depth Low content of exchangeable sodium was recorded in all the profiles

Predominant cation was found to be calcium followed by magnesium The exchangeable bases were in the order of Ca > Mg > K > Na Venugopal and Koshy (1976) reported the predominance of Ca followed by Mg Prema and Jose (1994) reported that in red laterite and brown hydromorphic soils of Kerala the ex changeable Ca ranged from 0 41 to 14 85 exchangeable Mg from 0 082 to 3 264 exchangeable K ranged from 0 21 to 0 503 and exchangeable Na from 0 009 to 0 313 cmol (+) kg^{1} In the present study also the exchangeable Ca Mg K and Na obtained was within this range

The studies of Jessymol and Mariam (1993) revealed that the water soluble exchangeable and non exchangeable potassium increased upon the incuba tion of the soil after adding K fertilizers

3 3 5 Cation exchange capacity and effective cation exchange capacity (cmol (+) kg^{1})

Maximum cation exchange capacity (7 25) was observed in P_5 L_4 of B block and the minimum value of 2 75 was seen in P_1 L_1 of A block

The effective CEC had a maximum value of 6 54 (P_3 L_4) in B block The minimum value observed was 2 35 (P_1 L_1) in A block

A general increase in the value of CEC and ECEC was observed with the depth of the profile Intermediate layers showed a higher value Prema and Jose (1994) reported that the CEC of laterite and red soils varied from 1 51 to 24 1 Cation exchange capacity was found to increase with the accumulation of clay Correlation between CEC and clay accumulation was reported to be positive and significant by Venugopal and Koshy (1976) and Sharma *et al* (1980) ECEC was found to vary widely The limit of 4 cmol (+) kg^{-1} of soil reported by Coleman and Thomas (1967) was taken into consideration According to their study ECEC values higher than 4 cmol (+) kg^{-1} has sufficient cation saturation to prevent leaching loss The low values of ECEC for surface layer samples suggest the adoption of proper management practices to prevent the leaching losses

3 3 6 Base saturation and base unsaturation (per cent)

Contribution of exchangeable bases towards the CEC as indicated by the base saturation is very high The maximum value noticed was 98 49 (P_3 L_4) in B block The minimum value was 59 74 (P_4 L_3) in B block These two samples recorded exchange acidity values of 0 1 and 2 2 respectively which are the lowest and highest exchange acidity values Bastin (1985) reported similar results

Base unsaturation values recorded a maximum value of 40 26 for P_4 L_3 in B block and a minimum value of 1 51 for P_3 L_4 in B block These two soils recorded highest and lowest exchange acidity values respectively The findings agree with the observations of Parsons and Balster (1966)

3 4 Fractions of iron (Table 5 and Fig 4)

3 4 1 Oxalate extractable iron Fe_0 (per cent)

The oxalate extractable iron designated as active iron was very low The maximum value obtained was 1 17 (P_1 L_1) in A block The minimum value observed was 0 14 (P_{10} L_4) in F block The Fe_0 content showed a decreasing trend with the depth of the profile except P_3 P_4 P_5 and P_9 Low values of Fe_0 in acidic soils was reported by Juo *et al* (1974) and Alexander (1974) Bastin (1985) reported

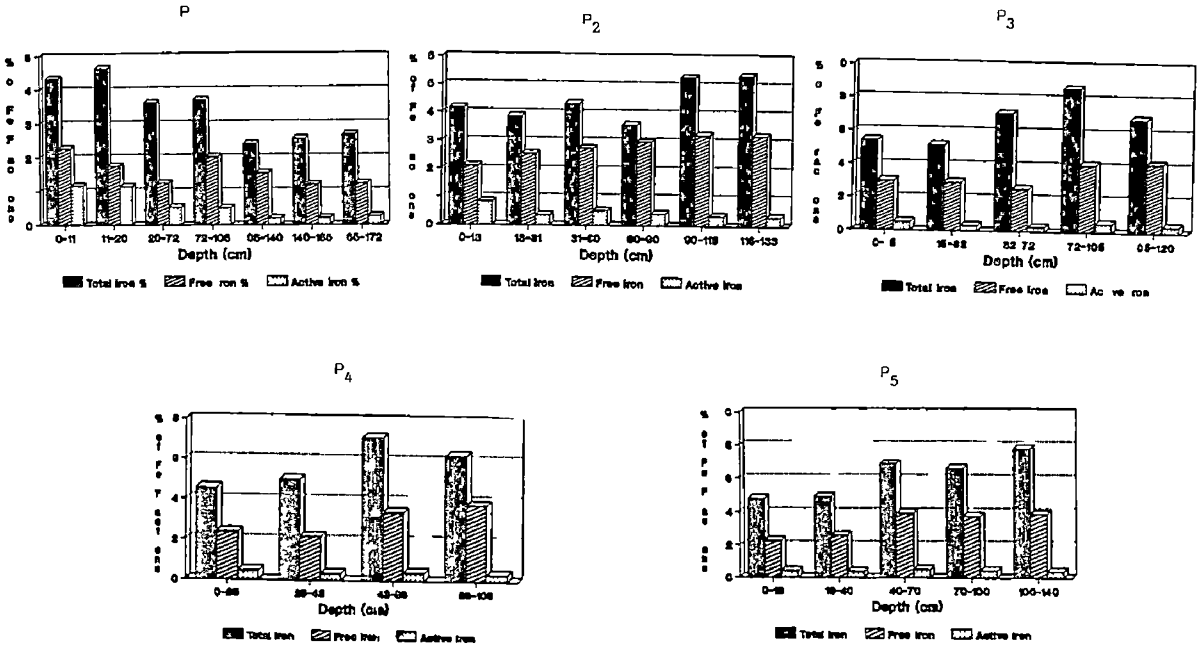
Table 5 Iron oxide fractions in the profile soil samples

Sample No	Active iron $Fe_{(o)}$ %	Free iron $Fe_{(d)}$ %	Total iron $Fe_{(t)}$ %	Fe_d/Fe_t x 100	Active iron ratio $Fe_{(o)}/Fe_{(d)}$
A BLOCK					
P1 L1	1 17	2 27	4 33	52 37	0 51
L2	1 14	1 75	4 64	37 70	0 67
L3	0 53	1 24	3 60	34 58	0 42
L4	0 50	2 02	3 69	54 81	0 24
L5	0 20	1 54	2 40	64 36	0 13
L6	0 21	1 19	2 55	46 51	0 18
L7	0 25	1 23	2 67	45 98	0 20
P2 L1	0 84	2 10	4 15	50 52	0 40
L2	0 36	2 55	3 87	65 87	0 14
L3	0 53	2 75	4 33	63 48	0 19
L4	0 43	2 98	3 57	83 62	0 14
L5	0 36	3 23	5 29	61 05	0 11
L6	0 34	3 21	5 35	59 94	0 11
B BLOCK					
P3 L1	0 50	2 98	5 38	55 43	0 17
L2	0 32	2 91	5 13	56 59	0 11
L3	0 28	2 57	7 07	36 30	0 11
L4	0 52	4 06	8 61	47 14	0 13
L5	0 40	4 15	6 79	61 09	0 10
P4 L1	0 48	2 38	4 55	52 30	0 20
L2	0 34	2 17	4 98	43 58	0 16
L3	0 41	3 41	7 13	47 85	0 12
L4	0 33	3 78	6 24	60 59	0 09
P5 L1	0 42	2 26	4 77	47 40	0 18
L2	0 39	2 60	4 92	52 81	0 15
L3	0 51	3 94	6 89	59 14	0 13
L4	0 45	3 75	6 61	56 74	0 12
L5	0 40	3 89	7 81	49 81	0 10

Cont

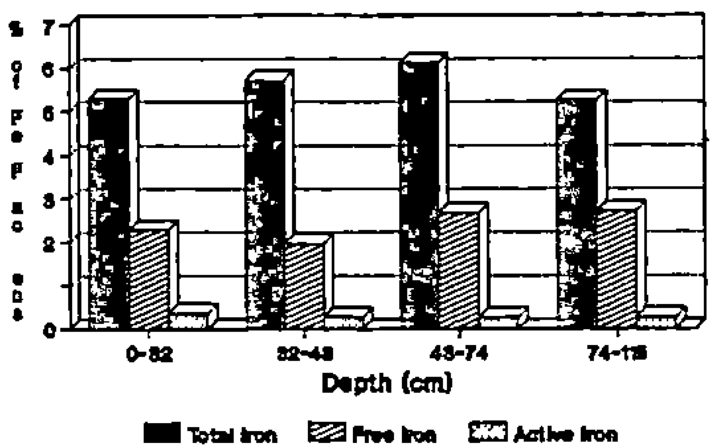
Table 5 Continued

1	2	3	4	5	6
			C BLOCK		
P6 L1	0 36	2 28	5 29	43 02	0 16
L2	0 28	1 97	5 72	34 53	0 14
L3	0 27	2 67	6 12	43 72	0 10
L4	0 27	2 71	5 26	51 46	0 10
P7 L1	0 60	2 41	5 26	45 85	0 25
L2	0 55	2 72	5 69	47 84	0 20
L3	0 42	3 47	5 60	62 09	0 12
L4	0 40	2 95	9 10	32 43	0 14
L5	0 25	2 41	9 48	25 45	0 11
			D BLOCK		
P8 L1	0 35	2 66	6 12	43 47	0 13
L2	0 43	3 15	6 24	50 49	0 14
L3	0 29	3 14	6 89	45 54	0 09
L4	0 20	1 93	6 27	30 79	0 11
L5	0 27	2 45	6 58	37 29	0 11
			E BLOCK		
P9 L1	0 44	3 29	6 64	49 54	0 13
L2	0 56	3 50	7 01	50 00	0 16
L3	0 30	3 66	7 50	48 77	0 08
L4	0 21	3 63	6 82	53 15	0 06
			F BLOCK		
P10 L1	0 31	2 97	5 32	55 78	0 10
L2	0 30	3 01	4 48	67 12	0 10
L3	0 16	2 66	4 76	55 81	0 06
L4	0 14	2 69	5 21	51 60	0 05

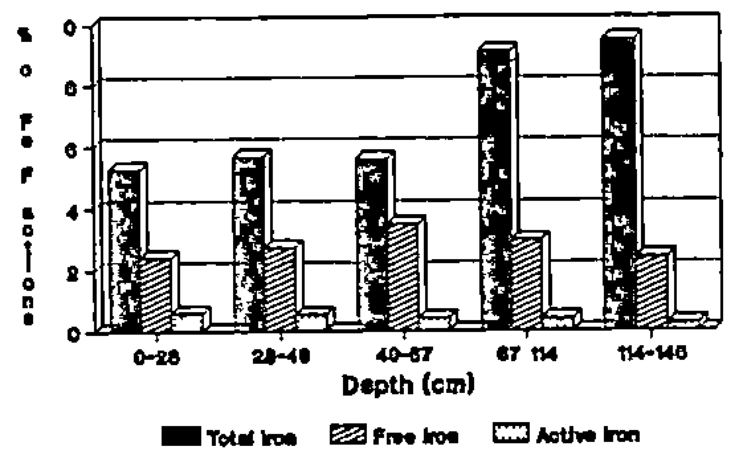


Fg 4 Distribution of fractions of iron in the soil profiles

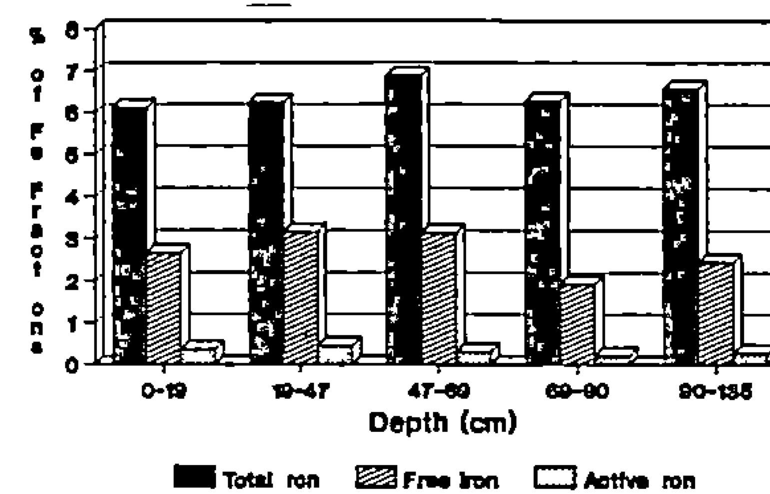
P_6


0-32
32-43
43-74
74-115
Depth (cm)
Total Iron
Free Iron
Active Iron

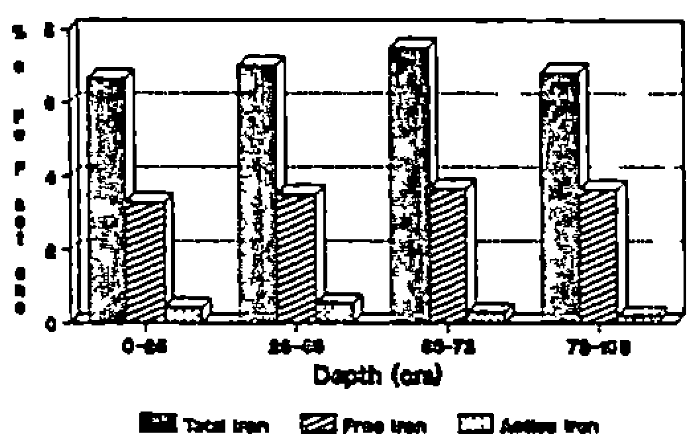
P_7


0-26
26-40
40-67
67 114
114-146
Depth (cm)
Total Iron
Free Iron
Active Iron

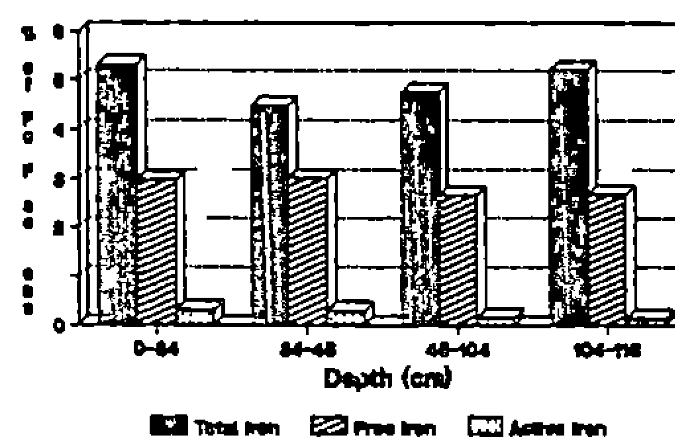
P_8


0-19
19-47
47-69
69-90
90-135
Depth (cm)
Total Iron
Free Iron
Active Iron

P_9


Depth (cm)
Total Iron
Free Iron
Active Iron

P_{0}


0-34
34-48
48-104
104-116
Depth (cm)
Total Iron
Free Iron
Active Iron

that Fe_0 values are much lower for the red soils of Kerala

3 4 2 Dithionite extractable iron Fe_d (per cent)

Dithionite extractable iron had a much higher value compared to oxalate extractable iron The maximum value for Fe_d was 4 15 (P_3 L_5) for B block Minimum value recorded was 1 19 (P_1 L_6) for A block Irregular variation with the depth was noticed Fe_d was reported to be as the most abundant form by Ghosh and Banerjee (1979) Ghabru *et al* (1990) reported that the presence of higher propor tions of Fe_d in the solum is an indication of greater silicate weathering The soil in the profiles selected are highly weathered The first profile indicated lower value because the soil in that area was deposited material and not subjected to much *in situ* weathering process

Arduino *et al* (1984) reported that relative age of soils can be estimated from the amount of iron extracted by the dithionite reagent Larger the proportion of Fe_d fraction more aged will be the terrace From the values of Fe_d it can be esti mated that soil profile taken in A block especially P_1 was very young and weather ing is yet to occur The P_2 is found to be the oldest one as estimated by the dithion ite iron content

3 4 3 Total iron (Fe_t) (per cent)

The distribution was quite irregular The maximum value 9 48(P_7 L_5)was observed in C block The minimum value was 2 40 (P_1 L_5) in A block

Total iron distribution was reported to be irregular by Jadhav *et al* (1978)

3 4 4 Degree of freeness of iron

The degree of freeness of iron is the dithionite extractable iron expressed as the percentage of total iron The maximum value recorded was 83 62 (P_2 L_4) in A block The minimum value observed was 25 45 (P_7 L_5) in C block The degree of freeness of iron was used as an index for determining the age of the profile and therefore P_2 of A block can be considered to be the oldest one followed by P_{10} of F block Arduino *et al* (1984) used this method to determine the age of profiles in Italy

3 4 5 Active iron ratio

The active iron ratio is the ratio of oxalate extractable iron to the total iron (Fe_o/Fe_t) Since the amout of iron extracted by oxalate reagent was so meagre the active iron ratio was also very less The maximum value recorded was 0 67 (P_1 L_2) for A block The minimum value recorded was 0 05 (P_{10} L_4) for F block Active iron ratio did not give any trend of variation in the profile Venugopal (1980) and Bastin (1985) also reported less active iron ratio in red soils of Kerala

4 Analysis of surface samples

4 1 Physical properties

4 1 1 Particle size distribution and waterholding capacity (per cent) (Table 6)

In all the blocks there were wide variations in the texture of the soil from loamy to silty Predominant textural class of A block was silty The clay per cent varied from 26 00 to 49 99 with an average value of 36 51 A wide range was obtained in the case of silt which varied from 16 00 to 48 79 The mean value of

Table 6 Particle size distribution and waterholding capacity of the surface soil samples

Sample No	Clay	Silt	Coarse sand	Fine sand	Waterholding capacity	Textural class
			as percentage			
1	2	3	4	5	6	7
			A BLOCK			
1	29 99	43 99	17 26	7 75	24 90	l
2	31 29	40 69	15 64	12 35	25 17	si
3	34 00	41 98	12 34	11 07	25 95	si
4	32 00	41 98	16 24	8 78	25 13	si
5	33 99	44 79	14 64	5 84	24 98	si
6	35 99	41 24	13 20	8 82	25 00	si
7	32 00	39 98	14 63	12 45	25 53	si
8	41 91	34 07	12 48	11 54	25 33	c
9	39 99	39 59	10 23	9 48	25 77	si
10	30 00	48 79	11 22	9 14	25 42	l
11	41 91	42 07	9 65	5 52	25 16	sic
12	31 29	42 69	13 26	11 85	26 13	si
13	33 99	43 99	13 26	8 14	24 24	si
14	40 00	38 79	13 27	7 17	21 33	si
15	49 98	29 60	14 58	5 13	23 76	c
16	47 98	30 00	11 01	10 98	24 95	c
17	49 99	26 00	12 65	10 49	22 14	c
18	41 90	36 08	14 22	7 01	21 93	c
19	38 00	35 99	13 67	11 77	20 47	si
20	46 00	22 00	16 63	14 94	24 32	c
21	35 99	27 99	19 66	15 59	22 17	si
22	40 00	17 99	22 36	18 81	23 23	sl
23	33 99	43 99	14 69	6 53	26 70	si
24	43 98	40 00	11 26	4 76	24 93	c
25	37 99	37 99	16 59	6 53	22 18	si
26	33 99	30 00	24 98	10 14	23 43	si
27	28 00	41 99	18 50	10 72	24 32	l
28	39 99	37 99	16 59	6 43	26 33	si

Contd

Table 6 Continued

1	2	3	4	5	6	7
29	31 99	36 00	18 47	12 85	24 12	si
30	37 98	16 00	24 69	20 41	25 65	sc
31	33 99	38 00	16 59	10 83	26 32	si
32	26 00	43 99	18 60	10 83	30 15	l
33	31 99	42 00	17 43	8 09	29 13	si
34	38 00	41 99	14 26	5 06	25 61	cl
35	35 99	40 00	15 64	7 68	22 71	si
36	33 99	37 99	16 23	10 89	21 91	si
37	35 99	45 99	9 50	6 98	26 73	cl
38	31 99	42 00	15 38	10 94	21 35	si
39	33 99	41 99	13 29	9 93	23 56	si
40	35 99	35 99	14 69	12 53	24 93	si
41	33 99	43 99	13 50	7 82	25 17	si
42	37 99	35 99	15 48	9 75	24 32	si
43	38 00	40 79	12 60	7 81	23 14	2i
44	35 99	39 99	14 80	8 62	22 17	si
45	43 98	37 99	9 87	8 14	23 14	c
46	33 99	39 99	12 58	12 84	22 17	si
47	35 99	43 99	14 23	4 99	25 23	si
48	37 99	37 99	12 65	10 47	24 19	si
49	33 99	45 99	11 02	8 30	22 99	si
50	31 99	41 99	12 35	12 77	23 01	si
51	34 00	43 98	11 32	10 02	24 14	si
Mean	36 51	38 37	14 70	9 77	24 35	si
			B BLOCK			
52	27 99	23 99	29 58	17 54	21 33	scl
53	31 99	23 99	26 50	16 81	22 14	scl
54	29 99	29 99	16 49	22 72	23 00	si
55	27 99	23 99	25 67	21 63	22 12	scl
56	25 99	27 99	29 68	15 83	23 43	scl
57	31 99	33 99	17 60	15 84	22 14	si

Contd

Table 6 Continued

1	2	3	4	5	6	7
58	29 99	25 99	26 97	16 06	22 15	scl
59	28 00	26 00	24 90	20 13	23 23	scl
60	25 99	24 20	27 47	21 19	24 25	scl
61	28 99	29 99	21 34	19 65	22 98	si
62	29 99	27 99	25 89	15 52	21 18	scl
63	29 99	24 00	24 16	21 35	23 15	scl
64	27 99	28 00	26 34	17 11	22 15	scl
65	31 99	30 00	24 67	12 73	21 16	si
66	35 99	32 00	21 35	9 96	22 19	si
67	33 99	33 99	22 38	8 94	21 35	si
68	35 99	26 00	24 31	13 20	24 69	si
69	31 99	25 99	25 38	16 03	23 19	si
70	29 99	25 99	24 91	18 40	24 14	scl
71	27 99	24 00	26 80	20 60	24 13	scl
72	23 99	29 99	27 34	17 97	23 44	scl
73	29 99	22 00	29 57	17 80	21 25	scl
74	25 99	31 99	23 92	17 50	25 26	l
75	29 99	31 99	21 35	16 03	27 14	si
76	33 99	25 99	24 62	14 79	26 26	si
77	29 99	27 99	23 69	17 72	22 15	scl
78	27 99	23 99	24 16	23 24	23 24	scl
79	21 99	31 99	24 67	20 74	22 16	scl
80	29 99	27 99	26 43	14 94	26 25	si
81	23 99	31 99	26 34	17 07	25 26	l
82	27 99	37 41	27 39	10 62	24 39	l
83	31 99	25 99	23 14	18 25	25 15	si
84	33 99	31 99	19 64	13 78	21 45	si
85	35 99	31 99	20 34	11 08	22 14	si
86	37 99	25 99	29 73	11 63	21 00	si
87	29 99	30 99	14 20	15 15	23 16	si
88	25 99	31 99	20 11	21 30	21 15	l
89	27 99	26 00	23 65	21 76	24 24	scl
90	29 99	31 99	21 60	15 71	20 26	l
91	27 99	35 99	20 30	14 98	22 46	l
92	29 99	23 99	28 61	16 75	24 33	scl
Mean	29 82	28 50	23 80	16 31	23 08	scl

Contd

Table 6 Continued

1	2	3	4	5	6	7
			C BLOCK			
93	31 99	35 99	19 74	11 58	23 15	si
94	25 99	37 99	23 46	11 85	21 87	l
95	33 99	27 99	21 40	15 91	24 82	si
96	35 99	33 99	19 48	9 74	26 11	si
97	27 99	35 99	26 54	8 68	22 47	l
98	30 00	31 99	23 19	14 18	24 35	si
99	29 99	35 99	20 46	12 75	22 01	l
100	27 99	41 99	19 81	9 48	21 99	l
101	29 99	41 99	16 25	11 16	22 02	l
102	35 99	37 99	17 26	8 06	24 83	si
103	27 99	31 99	28 47	10 81	21 01	l
104	23 99	39 99	21 23	14 18	22 01	l
105	29 99	25 99	26 73	16 48	21 03	l
106	25 99	33 99	21 60	17 71	21 02	l
107	31 99	19 99	29 14	18 14	23 11	scl
108	23 99	35 99	26 17	12 64	22 19	l
109	31 99	35 99	21 23	10 09	25 65	si
110	21 99	28 19	29 87	19 25	22 14	scl
111	25 99	25 99	29 30	18 11	24 44	scl
112	27 99	25 99	24 60	20 68	23 15	scl
113	27 99	29 99	25 40	13 86	22 67	scl
114	23 99	31 99	24 11	19 14	21 84	l
Mean	28 81	33 09	23 43	13 84	22 90	si
			D BLOCK			
115	25 99	25 99	26 34	20 97	25 73	SCL
116	22 00	31 99	24 36	20 95	21 17	l
117	24 00	26 19	29 34	19 35	23 14	scl
118	29 99	31 99	26 54	10 57	22 01	l
119	27 99	35 99	26 15	8 56	22 30	l
120	22 00	37 99	25 19	13 84	22 67	l

Contd

Table 6 Continued

1	2	3	4	5	6	7
121	24 00	26 19	29 48	19 34	24 13	scl
122	29 99	24 00	26 49	18 62	25 00	scl
123	21 99	35 99	23 68	17 57	24 98	si
124	31 99	31 99	20 48	14 76	23 20	si
125	25 94	31 99	21 51	19 37	22 29	l
126	23 99	31 99	27 19	17 60	21 40	l
127	31 99	27 99	24 38	14 50	23 20	si
128	27 99	23 99	28 16	18 15	20 17	scl
129	29 99	27 99	24 20	16 70	21 27	scl
130	21 99	24 19	27 30	20 71	22 20	sl
131	29 99	24 00	29 68	15 08	21 21	scl
132	27 99	33 99	24 70	12 11	22 19	l
133	25 99	33 99	23 94	14 92	26 35	l
134	29 99	27 99	21 33	19 64	21 36	scl
135	25 99	25 99	26 47	20 27	23 15	scl
136	23 99	29 99	24 91	19 89	22 34	scl
137	27 99	31 99	21 52	17 49	21 36	l
Mean	26 69	29 76	25 36	17 00	21 72	l

E BLOCK

1	2	3	4	5	6	7
138	29 99	33 99	19 40	15 70	23 15	si
139	29 99	31 99	19 69	17 52	21 26	si
140	33 99	29 00	20 33	15 73	24 16	si
Mean	31 33	29 99	19 81	16 32	22 85	si

F BLOCK

1	2	3	4	5	6	7
141	31 99	21 99	25 43	19 66	20 79	scl
142	27 99	22 20	27 64	21 28	21 34	scl
143	25 99	28 00	27 16	18 03	21 19	scl
144	24 00	27 99	27 60	19 39	21 35	scl
145	29 99	25 99	25 19	17 87	20 56	scl
146	33 99	27 99	19 48	17 56	22 50	si
147	29 99	33 25	19 46	13 79	24 19	l
148	31 99	27 99	26 13	13 11	26 05	si
149	23 99	26 19	28 74	20 35	22 35	scl
150	27 99	23 20	28 43	19 24	23 56	scl
Mean	28 79	26 48	25 53	18 03	22 69	scl

silt was 38 37 For coarse sand and fine sand the range was 9 50 to 24 98 and 4 76 to 20 41 respectively The mean value of coarse sand was more than that of fine sand The average water holding capacity was 24 35

Texture of the B block was sandy clay loam Out of fourty one surface samples collected the maximum and minimum content of clay recorded were 37 99 and 21 99 respectively with an average values of 29 82 The mean value of silt obtained was 28 50 The coarse sand recorded more value (23 80) than fine sand (16 31) The average water holding capacity was 23 08

C block was having predominant silty textural class The clay content varied from 21 99 to 35 99 The average value was 28 81 per cent A wide variation of silt content was observed which ranged from 19 99 to 41 99 with a mean value of 33 09 Silt content was more than the clay content The coarse sand recorded a much higher value (23 43) than fine sand (13 84) The average value for water holding capacity was 22 90

For D block the textural class was loamy The range of values obtained for clay silt coarse sand and fine sand were more or less the same The mean values obtained were 26 69 29 76 25 36 and 17 0 for clay silt coarse sand and fine sand respectively The water holding capacity recorded a mean value of 21 72

Three surface soil samples were collected from E block The textural class was silty The mean values obtained were 31 33 29 99 19 81 16 32 and 22 85 for clay silt coarse sand fine sand and water holding capacity respectively The soils of F block were predominantly sandy clay loam

The soil samples of A C and E blocks had shown similarity in the textural class being predominantly silty while considering the average values The maximum clay and silt content were obtained for A block coarse and fine sand were maximum for F block Soils of A block recorded maximum water holding capacity and the least value was observed for D block This may be due to the maximum content of clay and silt observed for the A block The clay content was least for D block which had the smallest water holding capacity Though silt content was high in the D block it could not add much to the water holding capacity

Significant positive correlation was obtained for the clay content and water holding capacity of the soil (r − 0 428*) but there was no significant correlation of water holding capacity with the silt and organic carbon content

Nair *et al* (1966) had observed that finer particles are contributing to the water holding capacity and organic carbon showed no significant correlation with moisture retention The results of Prameela and Nair (1985) also support observations of present study Mathew and Nair (1985) observed that organic carbon failed to show any influence on moisture retention

4 2 Chemical properties

4 2 1 Exchangeable characteristics of the soil (Table 7)

4 2 1 1 Exchangeable acidity (cmol (+) kg ^{1})

The exchangeable acidity varied from 0 2 to 1 1 with a mean value of 0 65 in the A block The range was from 0 3 to 1 5 for B block but obtained an average value of 0 64 The average values of C and D blocks were 0 6 and 0 74

Table 7 Exchangeable characteristics of the surface soil samples

Sample No	Exchangeable Acidity	H	Al	Ca	Mg	K	Na	CEC	ECEC	Base saturation %	Base unsaturation %
	in cmol (+) kg -1										
						A BLOCK					
1	0 4	0 2	0 2	3 75	0 25	0 40	0 119	4 92	4 72	91 87	8 13
2	0 4	0 2	0 2	3 50	0 25	0 31	0 174	4 632	4 432	91 36	8 64
3	0 2	0 2		3 25	0 25	0 30	0 130	4 132	4 132	95 16	4 84
4	0 6	0 2	0 4	2 75	0 25	0 29	0 114	4 009	3 809	85 03	14 97
5	1 0	0 3	0 7	3 50	0 25	0 36	0 141	5 252	4 952	80 96	19 04
6	0 9	0 2	0 7	2 75	0 25	0 29	0 111	4 303	4 103	77 29	22 71
7	0 9	0 2	0 7	2 75	0 25	0 29	0 114	4 309	4 109	79 11	20 89
8	1 1	0 4	0 7	2 50	0 50	0 29	0 114	4 509	4 009	75 60	24 40
9	1 1	0 5	0 6	2 50	0 50	0 36	0 130	4 591	4 091	76 04	23 96
10	1 0	0 2	0 8	2 50	0 25	0 32	0 130	4 201	4 001	76 20	23 80
11	0 5	0 2	0 3	2 75	0 25	0 36	0 136	3 997	3 797	87 49	12 51
12	0 7	0 7		2 75	0 25	0 40	0 136	4 237	3 537	83 48	16 52
13	1 1	1 1	-	3 20	0 25	0 22	0 114	4 889	3 789	77 50	22 50
14	0 8	0 4	0 4	3 20	0 25	0 21	0 109	4 568	4 168	82 49	17 51
15	0 5	0 2	0 3	2 50	0 25	0 27	0 114	3 630	3 430	86 23	13 77
16	0 6	0 2	0 4	2 50	0 25	0 23	0 119	3 730	3 530	83 19	16 81
17	1 1	0 4	0 7	2 50	0 50	0 20	0 209	4 514	4 114	75 63	24 37
18	1 0	0 4	0 6	4 00	0 25	0 20	0 103	5 552	5 152	81 99	18 01
19	1 0	0 3	0 7	3 50	0 50	0 16	0 869	6 030	5 730	83 42	16 58
20	0 7	0 1	0 6	4 00	0 50	0 16	0 932	6 293	6 893	88 88	11 12
21	0 6	0 2	0 4	4 25	0 25	0 31	0 168	5 576	5 976	89 24	10 76
22	0 5	0 2	0 3	3 25	0 25	0 32	0 163	4 478	4 278	88 83	11 17
23	0 7	0 3	0 4	3 50	0 25	0 19	0 103	4 746	4 446	85 25	14 75
24	0 7	0 3	0 4	2 50	0 75	0 18	0 977	5 107	4 707	86 29	13 71
25	0 6	0 3	0 3	2 50	0 75	0 16	0 923	4 934	4 634	87 84	12 16
26	0 7	0 2	0 5	2 50	0 75	0 20	0 130	4 279	4 079	83 64	16 36
27	0 8	0 3	0 5	2 50	0 75	0 24	0 141	4 429	4 129	81 94	18 06
28	0 6	0 2	0 4	2 50	0 25	0 26	0 136	3 743	3 543	83 97	16 03
29	0 5	0 2	0 3	2 50	0 25	0 40	0 130	3 781	3 581	86 78	13 22
30	0 4	0 2	0 2	2 50	0 25	0 56	0 206	3 917	4 117	89 79	10 21

Contd

Table 7 Continued

1	2	3	4	5	6	7	8	9	10	11	12
31	0 7	0 2	0 5	2 20	0 25	0 51	0 174	3 836	3 636	81 75	18 25
32	0 7	0 2	0 5	2 75	0 25	0 31	0 141	4 149	3 949	83 13	16 87
33	0 5	0 2	0 3	3 00	0 25	0 40	0 109	4 160	4 060	90 38	9 62
34	0 4	0 2	0 2	2 75	0 25	0 40	0 152	3 953	3 753	89 88	10 12
35	0 5	0 4	0 1	2 75	0 50	0 48	0 163	4 394	3 994	88 62	11 38
36	0 4	0 2	0 2	2 75	0 25	0 36	0 174	3 935	3 735	89 83	10 17
37	0 5	0 2	0 3	3 00	0 50	0 56	0 152	4 713	4 513	89 39	10 61
38	0 5	0 3	0 2	2 75	0 25	0 52	0 174	4 195	3 995	88 08	11 92
39	0 6	0 2	0 4	3 00	0 25	0 32	0 174	4 339	4 139	90 34	9 66
40	0 4	0 2	0 2	2 50	0 50	0 48	0 152	4 033	3 833	90 08	9 92
41	0 5	0 2	0 4	3 00	0 25	0 20	0 152	4 202	4 102	85 78	14 22
42	0 5	0 2	0 4	3 25	0 25	0 12	0 152	4 372	4 172	86 28	13 72
43	0 6	0 2		3 50	0 5	00 24	0 163	4 753	4 153	87 38	12 62
44	0 4	0 2	0 2	2 50	0 15	0 52	0 174	4 345	4 145	90 79	9 21
45	0 4	0 2	0 2	3 50	-	0 24	0 163	4 303	4 103	90 70	9 30
46	0 4	0 2	0 2	2 25	0 75	0 28	0 174	3 856	3 656	89 63	10 37
47	0 7	0 2	0 5	2 75	0 75	0 18	0 163	4 540	5 340	84 58	15 42
48	0 7	0 2	0 5	2 50	0 50	0 19	0 147	4 033	3 833	82 64	17 36
49	0 6	0 1	0 5	2 75	0 25	0 23	0 130	3 955	3 855	84 83	15 17
50	0 05	0 2	0 3	2 75	-	0 44	0 141	3 832	3 632	86 95	13 05
51	0 8	0 2	0 6	2 25	1 25	0 72	0 152	5 173	4 973	84 53	15 47
Mean	0 65	0 13	0 41	2 89	0 41	0 32	0 21	4 44	4 03	85 45	14 55
						B-BLOCK					
52	0 8	0 2	0 6	3 0	1 00	0 76	0 184	5 745	5 545	86 07	13 93
53	0 8	0 2	0 6	3 75	0 50	0 60	0 195	5 846	5 646	86 31	13 69
54	0 6	0 1	0 5	3 50	0 25	0 48	0 152	4 983	4 883	87 96	12 04
55	0 6	0 2	0 4	2 50	0 75	0 56	0 136	4 547	4 347	86 80	13 20
56	0 4	0 2	0 2	3 00	1 00	0 60	0 152	5 153	4 953	92 24	7 76
57	0 8	0 2	0 6	2 75	1 00	0 48	0 206	5 237	5 037	84 72	15 28
58	0 7	0 3	0 4	3 25	1 00	0 61	0 174	5 734	5 434	87 79	12 21
59	0 3	0 3		275	1 50	0 17	0 195	4 918	4 618	93 90	6 10

Contd

Table 7 Continued

1	2	3	4	5	6	7	8	9	10	11	12
60	0 3	0 3	-	3 25	1 75	0 32	0 228	5 843	5 543	94 86	5 04
61	0 5	0 2	0 3	3 00	0 25	0 29	0 163	4 202	4 002	88 10	11 90
62	0 7	0 2	0 5	2 75	0 50	0 20	0 152	4 298	4 098	83 71	16 29
63	0 7	0 2	0 5	3 25	1 00	0 22	0 141	5 309	5 109	86 81	13 19
64	0 6	0 2	0 4	3 00	1 00	0 27	0 152	5 018	4 818	88 04	11 96
65	0 5	0 2	0 3	2 75	1 00	0 17	0 147	4 570	4 370	85 06	14 94
66	0 5	0 2	0 3	3 00	1 00	0 24	0 141	4 585	4 685	95 64	4 36
67	0 6	0 2	0 4	3 75	0 50	0 27	0 163	5 283	5 083	88 64	11 36
68	0 6	0 2	0 4	3 50	0 25	0 26	0 141	4 754	4 554	87 38	12 62
69	0 9	0 2	0 7	2 25	1 25	0 28	0 163	4 846	4 646	81 43	18 57
70	0 5	-	0 5	2 50	1 00	0 22	0 174	4 389	4 389	88 61	11 39
71	0 7	0 1	0 6	2 25	0 75	0 20	0 174	4 079	3 979	82 84	17 16
72	0 8	0 1	0 7	2 50	0 75	0 19	0 163	4 406	4 306	81 84	18 16
73	0 7	0 2	0 5	2 75	0 25	0 19	0 185	4 074	3 874	82 82	17 18
74	0 5	0 2	0 3	2 75	0 25	0 19	0 152	3 838	3 638	86 97	13 03
75	0 4	0 1	0 3	3 50	0 50	0 19	0 174	4 767	4 667	91 61	8 39
76	0 8	0 1	0 7	2 50	0 75	0 18	0 152	4 382	4 282	81 74	18 26
77	0 5	0 2	0 3	2 75	0 50	0 19	0 185	4 124	3 924	87 87	12 13
78	1 2		1 2	2 75	0 50	0 19	0 174	4 817	4 817	75 09	24 91
79	1 5	0 2	1 3	3 75	0 25	0 20	0 174	5 870	5 670	74 45	25 55
80	0 8	0 2	0 6	3 00	0 25	0 27	0 163	4 486	4 286	82 17	17 83
81	0 8	0 2	0 6	3 00	0 50	0 27	0 174	4 794	4 594	83 31	16 69
82	0 8	0 3	0 5	3 25	0 25	0 19	0 174	4 667	4 367	82 86	17 14
83	0 9	0 2	0 7	2 75	0 75	0 22	0 174	4 792	4 592	81 22	18 78
84	0 4	0 2	0 2	2 75	0 75	0 20	0 174	4 279	4 079	90 65	9 35
85	0 3	0 2	0 1	3 50	0 25	0 21	0 206	4 461	4 261	93 27	6 73
86	0 4	0 2	0 2	3 00	0 50	0 19	0 217	4 310	4 110	90 72	9 28
87	0 4	0 2	0 2	3 00	0 50	0 27	0 228	4 401	4 201	90 91	9 09
88	0 6	0 2	0 4	2 50	0 50	0 27	0 152	4 022	3 822	85 08	14 92
89	0 6	0 2	0 4	2 50	0 50	0 21	0 152	3 957	3 757	84 84	15 16
90	0 5	0 3	0 2	2 50	0 50	0 29	0 179	3 968	3 768	87 40	12 60
91	0 7	0 2	0 5	2 75	0 50	0 31	0 197	4 452	4 252	84 28	15 72
92	0 6	0 2	0 4	2 75	0 50	0 30	0 119	4 371	3 571	72 55	27 45
Mean	0 641	0 202	0 451	2 933	0 67	0 29	0 167	4 697	4 502	86 06	13 94

Contd

Table 7 Continued

1	2	3	4	5	6	7	8	9	10	11	12
						C BLOCK					
93	0 5	0 3	0 2	3 00	0 50	0 28	0 114	4 390	4 090	88 61	11 39
94	0 7	0 3	0 4	3 00	0 25	0 28	0 119	4 345	4 045	83 89	16 11
95	0 5	0 3	0 2	2 75	0 50	0 26	0 152	4 162	3 862	87 99	12 01
96	0 4	0 2	0 2	2 50	0 50	0 32	0 130	3 951	3 651	87 34	12 66
97	0 7	0 1	0 6	2 50	0 50	0 36	0 141	4 202	4 102	83 34	16 66
98	0 7	0 3	0 4	2 00	1 00	0 36	0 141	4 202	3 902	83 34	16 66
99	0 7	0 3	0 4	2 75	0 25	0 32	0 130	4 151	3 851	83 14	16 80
100	1 0	0 4	0 6	2 75	0 50	0 28	0 136	4 666	4 266	78 57	21 43
101	0 6	0 2	0 4	2 75	0 50	0 29	0 152	4 291	4 091	86 02	13 98
102	0 4	0 2	0 2	4 50	1 00	0 27	0 163	6 333	6 133	93 68	6 32
103	0 05	0 3	0 2	2 75	0 50	0 26	0 174	4 181	3 881	88 04	11 96
104	0 7	0 3	0 4	2 50	0 75	0 26	0 119	4 332	4 032	83 84	16 16
105	0 4	0 2	0 2	2 75	0 50	0 36	0 152	4 163	3 963	90 39	9 61
106	0 6		0 6	2 25	0 50	0 26	0 174	3 7841	3 7841	84 14	15 86
107	0 8	0 3	0 5	2 50	0 50	0 26	0 141	4 198	3 898	80 94	19 06
108	0 8	0 1	0 7	2 25	0 50	0 26	0 152	3 965	3 765	79 82	20 18
109	0 8	0 3	0 5	2 25	0 50	0 26	0 141	3 951	3 651	79 75	20 25
110	0 2	0 2		4 75	0 25	0 27	0 152	5 625	5 425	96 44	3 56
111	0 3	0 3	-	2 50	0 75	0 30	0 152	3 997	3 697	92 49	7 51
112	0 5	0 3	0 2	2 75	0 50	0 22	0 130	4 098	3 798	87 80	12 20
113	1 1	0 5	0 6	2 75	0 50	0 26	0 163	4 773	4 273	76 95	23 05
114	0 3	0 2	0 1	5 00	0 25	0 24	0 163	5 951	5 551	94 96	5 04
Mean	0 6	0 27	0 36	0 29	0 5	0 28	0 15	4 44	3 83	85 98	14 02
						D-BLOCK					
115	0 3	0 2	0 1	4 25	1 00	0 11	0 212	5 859	5 459	91 47	8 53
116	0 2	0 2		4 25	1 00	0 11	0 163	5 722	5 522	96 50	3 50
117	0 2	0 2		4 25	1 00	1 00	0 163	6 608	6 408	96 97	3 03
118	0 3	0 2	0 1	3 00	0 75	0 11	0 201	4 363	4 163	97 60	2 40
119	0 4	0 2	0 2	3 50	0 25	0 22	0 195	4 560	4 560	91 23	8 77
120	0 4		0 4	3 00	0 75	0 26	0 168	5 575	5 575	92 83	7 17

Contd

Table 7 Continued

1	2	3	4	5	6	7	8	9	10	11	12
121	0 2	0 2		4 25	0 50	0 24	0 174	5 368	5 168	96 27	3 73
122	0 2	0 2		3 75	0 50	0 23	0 185	4 866	4 666	95 89	4 11
123	0 1	0 1		4 25	0 50	0 24	0 190	5 284	5 184	98 10	1 90
124	0 9	0 4	0 5	3 75	0 50	0 29	0 168	5 607	5 207	83 95	16 05
125	1 7	0 4	1 3	3 75	0 50	0 30	0 163	6 408	6 108	73 47	26 53
126	1 6	0 2	1 4	3 50	0 50	0 48	0 174	5 255	5 055	88 58	11 42
127	0 5	0 2	0 3	3 75	0 50	0 52	0 119	5 390	5 190	90 72	2 28
128	1 1	0 3	0 8	3 50	0 50	0 36	0 130	5 591	5 291	80 32	19 68
129	0 6	0 3	0 3	3 25	0 50	0 48	0 119	4 950	4 650	93 55	6 45
130	1 3	0 2	1 1	2 75	0 50	0 29	0 130	4 969	4 769	73 84	26 16
131	1 3	0 4	0 9	2 75	0 50	0 21	0 109	4 864	4 464	73 27	26 73
132	0 7	0 2	0 5	2 75	0 50	0 19	0 109	4 252	4 052	83 54	16 49
133	0 7	0 3	0 4	2 75	0 50	0 19	0 109	4 252	3 952	83 54	16 46
134	1 1	0 2	0 9	2 75	0 50	0 19	0 125	4 668	4 468	76 44	23 56
135	0 9	0 2	0 7	3 00	0 50	0 23	0 119	4 750	4 550	81 05	18 95
136	1 1	0 2	0 9	3 50	0 50	0 26	0 130	4 990	4 790	77 96	22 04
137	1 3	0 4	0 9	3 25	0 50	0 26	0 109	5 422	5 022	76 02	23 98
Mean	0 74	0 25	0 65	3 46	0 58	0 29	0 15	5 20	4 96	86 66	13 34
						E BLOCK					
138	0 2	0 2		3 25	0 50	0 26	0 109	4 222	4 122	97 63	2 37
139	0 5	0 3	0 2	3 25	0 50	0 26	0 114	4 621	4 321	89 18	10 82
140	0 2	0 2	-	3 25	0 50	0 21	0 103	4 258	4 058	95 30	4 70
Mean	0 3	0 28	0 2	3 25	0 5	0 24	0 109	4 367	4 167	94 04	5 96
						F BLOCK					
141	0 9	0 3	0 6	3 25	0 50	0 26	0 114	5 024	4 724	82 09	17 91
142	0 8	0 2	0 6	4 75	0 75	0 26	0 163	6 720	6 420	88 09	11 91
143	0 1	0 1		2 50	0 75	0 26	0 152	3 762	3 762	97 34	2 66
144	0 3	0 3		4 75	0 50	0 36	0 157	6 068	5 768	95 06	4 94
145	0 1	0 1	-	4 75	0 50	0 36	0 103	5 813	5 713	98 28	1 72
146	0 3	0 3		5 00	0 25	0 29	0 097	5 936	5 636	94 95	5 05
147	0 2	0 2		4 00		0 30	0 108	4 603	4 403	95 66	4 34
148	0 2	0 2		5 25	0 25	0 29	0 119	6 108	5 908	96 72	3 26
149	0 2	0 2		5 25	0 25	0 28	0 114	6 090	5 890	96 71	3 29
150	0 3	0 3		4 25	0 25	0 29	0 119	5 208	4 908	94 24	5 76
Mean	0 34	0 22	0 6	4 38	0 44	0 30	0 13	5 53	5 47	93 91	6 09

respectively But E and F blocks recorded less exchangeable acidity as 0 3 and 0 34 respectively

4 2 1 2 Exchangeable cations (cmol (+) kg^{1})

In all the blocks exchangeable aluminium was more than the exchange able hydrogen The mean values of exchangeable hydrogen and aluminium were 0 13 and 0 41 0 20 and 0 45 0 28 and 0 38 0 25 and 0 65 0 28 and 0 20 0 22 and 0 60 for blocks A B C D E F respectively The high content of exchange able aluminium in D block explains the highest exchange acidity in that block

Yuan (1963) used titration curves of 1 N KCl extracts of soils to deter mine exchangeable hydrogen and aluminium and found that very acid soils (less than pH 4 8) had more hydrogen than aluminium ions At higher pH values there were more aluminium than hydrogen ions and both became negligible above pH 5 8 The results of the present study was in conformity with this Mean pH value was above 4 8 in all the blocks hence got higher content of exchangeable aluminium than hydrogen

Exchangeable hydrogen showed a significant positive correlation with DTPA extractable zinc (r = 0 365*) whereas exchangeable aluminium showed a highly significant negative correlation with exchangeable calcium (r = 0 454*) and base saturation (r = 0 877*)

Among the cations calcium content was the highest For F block the exchangeable calcium was maximum accounting to 4 38 whereas a minimum value of 2 89 was recorded for A and C blocks Prema and Jose (1994) reported that the exchangeable calcium of red laterite and hydromorphic soils of Kerala vaies from 0 41 to 14 85

The exchangeable calcium was positively correlated significantly with cation exchange capacity (r = 0 752**) base saturation (r 0 586**) available nitrogen (r = 0 542**) and DTPA extractable iron (r = 0 364*) pH (r = 0 499**) and negatively correlated with available phosphorus (r 0 416*) and exchangeable aluminium (r = 0 454*)

In the case of exchangeable magnesium the range observed was from 0 41 in A block to 0 67 in B block Prema and Jose (1994) studied the magnesium status of Kerala soils and reported that the value ranges from 0 082 to 3 264 The values obtained in this study also agree with this There was a significant positive correlation with exchangeable sodium (r = 0 403*) and DTPA extractable manga nese (r = 0 506**)

A block recorded the highest value of exchangeable potassium and sodium as 0 32 and 0 21 respectively and the lowest values were 0 24 and 0 11 in the E block Exchangeable potassium was significantly correlated with available potassium (r = 0 675**) silt (r = 0 380*) and water holding capacity (r = 0 375*) and negatively correlated with DTPA extractable iron (r − 0 436*) and copper (r = 0 482**)

Exchangeable sodium was positively correlated with exchangeable magnesium (r − 0 403*) and was negatively correlated with available nitrogen (r = 0 376*) and DTPA extractable zinc (r = 0 436*)

The occurence of bases was in the order of calcium > magnesium > potassium > sodium The range of values of exchangeable cations obtained by Prema and Jose (1994) also agree with these observations

4 2 1 3 Cation exchange capacity (CEC) (cmol (+) kg ^{1}

The mean CEC ranged from 4 37 in E block to 5 53 in F block whereas effective cation exchange capacity (ECEC) vaired from 3 83 m C block to 5 47 in F block There was not much difference in the CEC and ECEC Since the hydrogen ions were less compared to aluminium ions

CEC was positively correlated with pH (r = 0 485**) exchangeable calcium (r 0 752**) base saturation (r = 0 363*) and negatively correlated with available phosphorus (r = 0 392*)

4 2 1 4 Base saturation and unsaturation (per cent)

The mean base saturation varied from 85 45 in A block to 94 04 in E block and these blocks showed the maximum and minimum base unsaturation Base saturation was positively correlated with pH (r = 0 451*) exchangeable calcium (r 0 586**) and cation exchange capacity (r = 0 363*) whereas negatively correlated with exchangeable aluminium (r = 0 877**) The findings agree with the observations of Parsons and Balster (1966) and Bastin (1985)

4 3 Phosphorus fixing capacity (P F C) (per cent) (Table 8)

Selected thirty surface samples for the estimation of P F C of the soils The B block recorded the maximum mean value of 96 90 The least value obtained in E block was 92 01

P F C was positively correlated with DTPA extractable manganese (r = 0 365*) and negatively correlated with pH of the soil (r = 0 403*)

Table 8 Phosphorus fixing capacity of the selected surface soil sample

Sample No	P F C (per cent)	Sample No	P F C (per cent)
A BLOCK		D BLOCK	
2	97 79	116	94 09
6	95 95	119	92 82
31	98 42	120	91 98
45	97 49	124	96 35
51	92 03	130	94 08
		136	95 03
Mean	96 34	Mean	94 06
B BLOCK		E BLOCK	
59	98 57	138	92 26
60	97 05	139	93 08
78	96 22	140	90 69
85	95 40		
92	97 26		
Mean	96 90	Mean	92 01
C BLOCK		F BLOCK	
98	98 34	141	93 55
100	90 16	142	94 65
102	90 49	144	92 68
112	93 92	146	91 37
113	93 87	149	96 73
		150	93 35
Mean	93 36	Mean	93 72

In the studies of P F C of soils of Tamil Nadu Kothandaraman and Krishnamoorthy (1978) observed that P F C of the soils ranged from 20 to 183 mg P/100 g of soil The highest value was obtained in the high level lateritic soils Bastin (1985) found that P F C was attributed to the high content of clay and silt The clay content of A and B blocks were higher than other blocks hence the high P F C Phonde *et al* (1990) observed that P F C of rice soils of laterite was higher (94 99 per cent) The results of the present study also agree with these observations

4 4 DTPA extractable micronutrient content (ppm) (Table 9)

The mean value of DTPA extractable iron varied from 29 87 in A block to 45 25 in E block followed by 43 78 in F block Correlation studies showed a significant positive correlation with extractable copper (r = 0 459**) pH (r = 0 676**) and exchangeable calcium (r − 0 364*) and negatively correlated with exchangeable potassium (r = 0 436*) organic carbon content (r 0 372*) silt (r = 0 597**) and clay (r = 0 592**)

Bastin (1985) reported that DTPA extractable iron varied from 19 87 to 50 57 for Bharanikavu series The results obtained come within this range

The highest amount of extractable manganese was recorded in B block as 39 73 followed by A and C blocks The lowest value recorded was 12 11 in D block The micronutrient trial conducted for Robusta variety during 1976 78 may be responsible for the higher content of manganese in the B block Manganese was positively correlated with water holding capacity (r = 0 374*) and exchangeable

Table 9 DTPA extractable micronutrients and available nutrients of the surface soil samples

Sample No	Fe	Mn (ppm)	Zn -	Cu	pH	E C dS m ^{1}	Available N ppm	Organic carbon per cent	Available P kg ha ^{1}	Available K kg ha ^{1}
						A BLOCK				
1	25 28	31 32	2 48	0 74	4 89	0 109	120	0 80	1125	266
2	24 14	29 32	2 32	0 60	4 00	0 162	110	0 62	11 67	210
3	24 31	21 16	2 38	0 24	4 47	0 085	120	0 61	15 84	182
4	32 56	40 36	2 16	0 32	4 46	0 110	110	0 87	15 21	168
5	31 47	42 36	2 80	0 72	4 49	0 196	110	0 74	16 46	182
6	20 08	30 50	1 45	0 74	4 41	0 076	130	0 74	17 92	266
7	21 10	31 18	1 46	0 76	4 43	0 072	130	0 74	8 54	195
8	24 36	30 72	1 38	0 64	4 54	0 135	110	0 94	10 00	182
9	25 34	31 67	1 75	0 85	4 28	0 130	130	0 41	14 38	224
10	27 62	30 74	1 79	0 76	4 71	0 082	80	0 68	13 34	238
11	26 34	30 71	1 72	0 66	4 78	0 068	100	0 88	14 17	252
12	21 31	40 14	1 81	0 79	4 54	0 066	100	0 62	13 96	252
13	32 30	41 60	1 14	0 24	4 47	0 205	100	0 78	14 79	140
14	31 42	43 64	1 12	0 17	4 48	0 277	90	0 71	15 21	154
15	45 24	30 26	1 96	0 54	4 37	0 205	100	0 86	15 84	168
16	28 31	31 84	1 31	0 82	4 61	0 280	100	0 63	14 38	182
17	27 24	26 20	1 14	0 88	4 56	0 351	110	0 81	22 30	196
18	23 16	24 32	1 02	0 74	4 50	0 072	110	0 78	22 50	196
19	21 84	21 64	1 31	0 73	5 00	0 140	100	0 57	21 67	168
20	28 16	24 15	1 35	0 82	5 14	0 092	100	0 80	16 67	168
21	24 52	30 98	1 46	0 76	5 13	0 085	100	0 77	15 21	252
22	23 92	17 10	1 28	0 84	5 20	0 105	70	0 65	13 96	252
23	26 53	16 18	1 26	0 76	4 92	0 076	90	0 74	15 00	154
24	23 14	18 34	1 24	0 74	5 45	0 114	80	0 68	15 42	140
25	46 68	43 98	1 38	0 81	5 40	0 078	110	0 63	16 04	126
26	34 37	41 32	1 27	0 75	5 28	0 102	120	0 86	16 88	126
27	38 22	40 88	1 50	0 82	5 14	0 073	120	0 71	15 00	168
Mean (A_1)	28 07	31 21	1 60	0 68	4 73	0 13	105 56	0 73	15 32	192 87

Contd

Table 9 Continued

1	2	3	4	5	6	7	8	9	10	11
28	31 36	39 62	1 42	0 46	4 72	0 072	90	0 74	69 60	308
29	33 14	36 14	1 84	0 54	4 66	0 143	110	0 62	67 51	434
30	36 18	34 18	1 36	0 32	4 91	0 071	110	0 74	89 31	644
31	37 20	38 01	2 07	0 19	5 03	0 072	120	0 44	107 10	756
32	32 18	36 64	2 16	0 18	4 89	0 056	100	0 47	84 18	490
33	33 37	37 32	2 14	0 34	4 96	0 073	60	0 51	106 69	602
34	41 34	34 18	2 18	0 17	4 94	0 072	70	0 74	83 56	616
35	40 70	41 04	3 12	0 16	5 07	0 072	70	0 54	89 60	630
36	38 74	31 62	2 04	0 94	4 93	0 076	80	0 59	68 14	532
37	36 16	41 78	4 10	0 87	5 26	0 080	70	0 57	77 93	588
38	32 38	38 64	2 32	0 32	5 27	0 074	90	0 61	79 60	630
39	39 84	47 86	2 74	0 80	5 24	0 076	80	0 79	82 72	350
40	30 10	42 60	0 30	0 79	4 86	0 076	90	0 71	90 43	616
41	29 46	32 16	0 86	0 84	5 14	0 046	100	0 73	141 90	392
42	28 17	30 14	0 79	0 38	5 02	0 075	80	0 71	130 65	224
43	26 39	18 38	0 94	0 47	5 28	0 089	90	0 73	88 35	308
44	25 85	18 59	1 32	0 49	5 03	0 064	110	0 62	120 86	336
45	27 16	28 34	2 48	0 61	4 77	0 091	110	0 61	129 19	308
46	26 62	26 32	2 16	0 64	4 93	0 070	80	0 61	110 44	336
47	31 36	44 92	1 58	0 68	5 16	0 067	90	0 80	105 82	182
48	29 19	42 15	1 62	0 7	15 23	0 060	100	0 91	54 18	195
49	28 33	35 60	1 64	0 72	5 09	0 074	80	0 86	31 05	266
50	27 64	32 18	1 63	0 81	5 37	0 064	70	0 99	18 55	308
51	22 80	44 38	1 38	0 89	5 20	0 061	110	0 92	37 92	504
Mean (A_2)	31 90	35 53	1 84	0 56	5 04	0 07	90	0 69	86 06	439 81
Mean (A)	29 87	33 24	1 71	0 62	4 87	0 11	98 23	0 72	48 90	309 07
						B-BLOCK				
52	41 28	31 60	2 10	0 70	5 75	0 067	100	0 91	32 51	644
53	43 30	42 20	2 48	0 32	4 94	0 063	110	0 80	177 12	560
54	35 22	41 18	2 64	0 34	5 12	0 077	100	0 58	181 08	588
55	32 18	48 00	2 56	0 29	5 24	0 066	80	0 71	117 11	602

Contd

Table 9 Continued

1	2	3	4	5	6	7	8	9	10	11
56	44 68	49 64	2 17	0 30	5 18	0 076	90	0 54	123 77	588
57	42 24	27 18	3 16	0 29	5 08	0 059	80	0 85	128 98	616
58	40 18	42 34	3 50	0 28	4 88	0 061	90	0 98	127 52	618
59	42 64	66 84	2 35	0 29	5 04	0 064	100	0 83	32 71	476
60	41 31	61 64	2 59	0 24	5 08	0 085	100	1 06	43 76	420
61	40 81	60 38	2 13	0 37	4 66	0 076	80	1 01	110 44	448
62	42 86	58 39	2 65	0 30	4 70	0 074	80	0 61	63 14	392
63	43 83	55 16	2 32	0 31	4 60	0 065	80	0 59	103 35	378
64	40 61	34 82	2 24	0 32	4 62	0 082	90	0 54	74 18	420
65	39 64	31 74	2 28	0 18	4 77	0 061	90	0 61	85 85	280
66	38 76	41 82	2 72	0 38	4 86	0 076	100	0 64	147 11	308
67	37 70	52 40	2 96	0 32	4 93	0 054	80	0 54	90 02	392
68	36 71	50 36	2 71	0 46	4 65	0 068	80	0 49	94 18	420
69	34 72	51 14	2 32	0 57	4 74	0 071	70	0 49	116 69	420
70	32 68	40 37	2 28	0 59	4 76	0 068	90	0 65	115 44	364
71	34 30	40 46	2 64	0 64	4 71	0 088	80	0 64	116 27	336
90	30 24	33 14	2 72	0 27	4 76	0 082	150	0 70	42 92	308
91	31 38	35 56	2 34	0 28	4 70	0 065	150	0 73	43 34	308
92	36 56	38 44	2 76	0 31	4 69	0 063	100	0 65	45 43	280
Mean (B_1)	38 43	44 99	2 55	0 36	4 89	0 07	94 35	0 702	96 21	442
72	33 12	32 18	2 79	0 28	4 55	0 088	60	0 64	52 72	280
73	45 06	33 50	2 54	0 21	5 10	0 079	70	0 58	44 59	196
74	41 28	36 48	1 56	0 22	4 94	0 073	70	0 58	50 01	196
75	30 68	32 50	1 60	0 31	4 96	0 088	80	0 55	43 34	196
76	35 64	31 92	1 54	0 24	4 58	0 069	80	0 64	23 13	182
77	41 04	42 80	2 06	0 27	4 98	0 091	70	0 64	27 50	196
78	36 12	34 31	0 94	0 29	4 43	0 066	80	0 57	34 17	196
79	34 19	32 15	1 24	0 34	4 69	0 077	80	0 58	29 59	196
80	39 01	32 78	1 36	0 37	4 28	0 104	80	0 58	8 75	210
81	37 54	31 64	1 57	0 32	4 53	0 083	60	0 59	9 17	210
82	36 18	33 80	1 60	0 21	4 43	0 084	70	0 59	22 50	182
83	38 16	29 80	1 42	0 26	4 51	0 083	80	0 63	24 38	182
84	40 96	22 12	1 36	0 27	4 61	0 099	80	0 67	22 71	196

Contd

Table 9 Continued

1	2	3	4	5	6	7	8	9	10	11
85	41 14	21 34	1 32	0 24	4 98	0 091	80	0 64	35 42	196
86	32 32	22 18	2 14	0 27	4 62	0 091	80	0 71	27 92	196
87	33 54	36 42	1 32	0 26	4 66	0 144	70	0 65	76 47	210
88	36 22	39 54	2 14	0 32	4 45	0 075	80	0 61	67 10	210
89	34 18	38 62	2 16	0 24	4 51	0 065	80	0 70	29 80	168
Mean (B_2)	37 02	32 45	1 70	0 27	4 66	0 08	75	0 62	34 96	199 89
Mean (B)	37 81	39 73	2 18	0 32	4 90	0 08	85 85	0 63	69 32	335 71
						C BLOCK				
93	31 17	32 24	1 75	0 33	5 16	0 016	70	0 77	8 75	280
94	32 26	31 44	1 38	0 37	4 46	0 071	100	0 74	18 55	224
95	33 54	36 42	1 28	0 46	4 61	0 069	100	0 64	7 29	238
96	31 28	31 58	1 37	0 47	4 50	0 072	110	0 63	68 14	336
97	29 64	30 16	1 24	0 44	4 27	0 107	80	0 65	72 72	364
98	28 74	33 39	2 12	0 42	4 53	0 092	90	0 65	73 76	336
99	32 71	30 18	2 14	0 45	4 48	0 079	110	0 65	61 68	322
100	32 00	43 62	1 08	0 31	4 34	0 119	130	0 66	53 13	280
101	36 10	39 08	1 74	0 21	5 06	0 178	100	0 62	44 17	280
102	34 04	38 17	1 32	0 32	5 00	0 081	110	0 72	52 93	252
103	36 64	49 66	2 37	0 38	4 96	0 126	130	0 74	57 72	252
104	38 17	26 15	2 54	0 34	5 25	0 081	90	0 66	48 34	252
105	36 81	27 58	2 62	0 32	5 02	0 136	90	0 84	41 26	266
106	32 16	26 62	2 51	0 31	5 05	0 095	100	0 74	84 60	252
107	33 87	21 38	2 41	0 37	5 14	0 085	110	0 74	96 27	224
108	29 54	23 34	2 32	0 36	5 18	0 070	110	0 78	85 22	224
109	28 62	22 18	2 62	0 38	5 17	0 071	110	0 78	85 22	280
110	21 32	25 64	2 72	0 37	5 08	0 127	130	0 89	81 68	304
111	27 18	23 32	2 78	0 32	5 32	0 084	130	0 90	86 47	322

Contd

Table 9 Continued

1	2	3	4	5	6	7	8	9	10	11
112	21 32	24 18	2 74	0 25	5 13	0 073	110	0 01	95 64	224
113	20 18	23 72	2 72	0 27	5 12	0 085	130	0 75	91 27	168
114	27 18	21 65	1 78	0 28	5 08	0 090	110	1 01	32 51	182
Mean (C)	30 66	30 07	2 07	0 35	4 91	0 09	106 82	0 753	61 24	266 45
						D-BLOCK				
115	42 00	18 28	2 44	0 41	5 17	0 086	110	1 26	29 59	84
116	44 57	21 36	2 86	0 31	5 16	0 122	100	1 17	28 13	70
117	43 62	24 15	2 72	0 36	5 13	0 089	80	1 11	29 17	84
118	42 56	19 31	2 34	0 30	5 38	0 068	80	1 20	26 88	140
119	46 82	15 34	2 12	0 29	5 28	0 090	90	1 32	43 97	168
120	48 84	8 50	2 94	0 28	5 57	0 068	90	0 98	51 26	224
121	42 18	8 16	2 74	0 26	5 41	0 084	110	0 98	66 26	210
122	41 36	8 37	2 38	0 29	5 54	0 082	80	0 70	68 14	210
123	41 36	7 32	2 62	0 28	5 41	0 082	80	0 90	68 55	168
124	32 14	9 02	2 78	0 31	5 40	0 084	80	0 77	115 44	280
125	38 37	9 31	3 14	0 32	4 92	0 116	80	1 13	120 86	420
126	36 52	8 58	3 24	0 34	4 76	0 129	80	1 17	123 36	476
127	36 50	8 48	3 23	0 34	5 16	0 083	80	1 06	121 69	420
128	32 47	8 42	3 16	0 35	4 87	0 107	70	1 09	94 60	448
129	35 33	11 91	2 90	0 29	5 20	0 071	80	0 73	72 31	420
130	31 28	9 36	2 12	0 34	5 17	0 070	80	0 80	72 93	210
131	36 14	8 37	2 71	0 39	5 23	0 068	90	1 12	89 60	196
132	47 18	10 34	2 88	0 36	5 26	0 066	90	1 26	78 35	196
133	46 24	9 67	2 57	0 31	5 42	0 065	70	1 15	95 02	196
134	41 38	9 37	2 46	0 59	5 26	0 065	80	1 04	82 31	216
135	40 98	14 46	2 12	0 60	5 18	0 092	80	1 27	90 02	238
136	42 32	14 23	3 41	0 62	5 27	0 069	80	1 20	96 27	238
137	41 37	16 28	3 47	0 63	5 07	0 087	80	1 01	102 94	252
Mean (D)	40 50	12 11	2 75	0 37	5 23	0 08	84 35	1 06	76 85	241 91

Contd

Table 9 Continued

1	2	3	4	5	6	7	8	9	10	11
						E BLOCK				
138	46 94	19 68	3 16	0 35	5 35	0 059	80	0 92	48 97	238
139	45 89	20 90	3 28	0 37	5 20	0 057	100	0 89	49 59	224
140	42 92	21 32	2 36	0 39	5 25	0 067	110	0 93	55 22	196
Mean (E)	45 25	20 63	2 93	0 37	5 27	0 06	96 67	0 91	51 26	219 33
						F BLOCK				
141	45 64	21 97	2 84	0 29	5 41	0 063	80	0 93	15 84	224
142	44 45	22 36	2 97	0 23	5 36	0 070	80	0 89	2 29	252
143	42 38	21 38	2 64	0 24	5 49	0 112	90	0 83	2 50	252
144	43 67	21 05	2 62	0 37	5 64	0 088	100	1 03	15 21	336
145	42 54	19 52	3 12	0 38	5 67	0 105	130	0 96	15 84	448
146	41 37	17 84	3 74	0 34	5 55	0 096	120	0 97	9 79	308
147	43 37	18 34	3 84	0 24	5 91	0 063	150	0 74	7 50	378
148	46 54	16 54	3 25	0 27	5 50	0 101	110	0 77	7 92	392
149	43 18	18 36	3 14	0 29	5 54	0 083	110	0 73	3 75	378
150	44 67	16 64	3 34	0 31	5 82	0 081	150	1 14	12 29	392
Mean	43 78	19 40	3 15	0 30	5 59	0 08	112	0 90	9 29	336

magnesium (r = 0 506**) and available potassium (r 0 417*) and phosphorus fixing capacity (r 0 365*) and negatively correlated with pH (r 0 443*)

Chibba and Sekhon (1985) reported that DTPA extractable manganese was within the range of 3 1 to 22 5 Bastin (1985) reported the extractable manganese content varied from 17 99 to 68 07 The work of Rajagopal *et al* (1977) confirmed the high levels of iron and manganese in soils from different regions The results obtained agree with the abovesaid findings

The highest value of zinc was obtained in F block as 3 15 followed by E and D blocks and the lowest value was 1 71 in A block Zinc was positively correlated with exchangeable hydrogen (r = 0 365*) and negatively correlated with exchangeable sodium (r = 0 436*)

The studies of Bastin (1985) revealed that DTPA extractable zinc varied from 0 70 to 4 70 in the Beypore series Similar trends also obtained for this study

Among the trace elements extracted by DTPA copper recorded the lowest values The least value obtained was 0 30 in F block and the highest in A block (0 62) Except A block all other blocks recorded almost similar values A positive significant correlation was obtained with DTPA extractable iron (r – 0 459**) and a negative correlation with exchangeable potassium (r – 0 482**) and organic carbon (r 0 397*)

Bastin (1985) reported that DTPA extractable copper vaired from traces to 1 00 for Vellayani series Chibba and Sekhon (1985) also reported a similar range of 0 33 to 1 00 ppm for DTPA extractable copper into which soils of the Banana Research Station can also be included

4 5 Soil reaction electrical conductivity and available nutrient status of the surface soil samples (Table 9)

4 5 1 Soil reaction and electrical conductivity

Mean soil pH varied from 4 87 (A block) to 5 59 (F block) All the soils were acidic in nature as expected for highly weathered and leached soils of the trop ics Heavy rainfall of Kerala has been responsible for the intense leaching of bases and consequent increase in acidity (Venugopal 1980) pH was positively correlated with Ca (r = 0 499**) cation exchange capacity (r = 0 485**) base saturation (r = 0 451*) available nitrogen (r = 0 428*) and DTPA extractable iron (r = 0 676**) and negatively correlated with organic carbon (r 0 437*) phosphorus fixing capacity (r = 0 403*) DTPA extractable manganese (r = 0 443*) and water holding capacity (r = 0 425*)

Electrical conductivity (E C) was maximum for A block (0 118 dSm^{1}) and minimum for E block (0 061 dSm^{1}) The values recorded were very low for all the soils Higher value of E C in A block may be due to the increased fertilizer addition to this intensively cultivated block However E C values in all the blocks were coming in the non harmful range

4 5 2 Available nitrogen (N) (ppm)

In the case of available N maximum value was recorded for F block (112 0) Minimum value obtained was 84 35 in D block B block had a value simi lar to that of D block The values were more or less the same for A and E blocks

Correlation studies showed a positive correlation of available N with pH (r 0 428*) and exchangeable calcium (r – 0 542**) and negatively correlated with exchangeable sodium (r 0 376*) and available phosphorus (r 0 367*)

Bastin (1985) reported that available N content was ranging from 82 01 to 135 46 in Vellayani series In soils under the present study available N status vaired within this range The high content of available N in the F block may be due to the litter addition of trees and there was no cultivation also Whereas in other blocks due to intensive cropping available N may have been depleted by the crop

4 5 3 Organic carbon (per cent)

Highest content by organic carbon was recorded in D block (1 06) followed by E and F blocks The content of organic carbon was high in all the blocks except A and B which recorded the values as 0 715 and 0 633 respectively The organic carbon showed a significant negative correlation with pH (r = 0 437) and DTPA extractable iron and copper (r 0 372* and r = 0 397* respectively)

Alexander and Durairaj (1968) observed that with an increase in the hydrogen ion concentration organic carbon content showed an increase This was in conformity with this result

4 5 4 Available phosphorus and potassium (kg ha^{1})

The mean value for available phosphorus was maximum for D block (76 85) and minimum for F block (9 29) In other blocks the values obtained were 48 90 69 32 61 24 and 51 26 for A B C and E blocks respectively All the blocks recorded higher content of available phosphorus except F block This may be due to the continuous addition of fertilizers to all blocks other than the F block where usually no cultivation is practised Nair (1973) also reported similar findings

Highest level of potassium content was obtained for F block with a value of 336 The least value was obtained in E block (219 33) High content of available potassium was observed for A B C and F blocks

Available phosphorus was negatively correlated with exchangeable calcium (r 0 416*) cation exchange capacity (r = 0 392*) and available nitrogen (r = 0 367*) whereas available potassium was positively correlated with water holding capacity (r = 0 436*) DTPA extractable manganese (r – 0 417*)

Banana requires higher amount of potassium than other nutrients In the B block continuous cultivation of banana is going on every year Higher content of potassium in the B block can be explained by the application of potassium fertilizers as well as incorporation of banana trunks to this block In the F block higher content may be due to the accumulation of litter Sawant *et al* (1983) reported that potassium availability increased with the application of compost or paddy straw in the laterite soils Prema (1992) also reported high content of available phosphorus and potassium for Banana Research Station Kannara Results of this study also agree with this

4 6 Multiple correlations

Correlations between various physico chemical characters were worked out and the results are presented in Table 10

T b 0 C rre r0 oc cients o anous ph o- m cal char rs

	pH	H	A	xchang e C	e	K	N	CEC	Ba e u a n	O g n c c bo	A ai b N	P	K	DTPA e a tab n P F C	F		Cu	Zn	S	C	
pH		0 3	0 3	0 499	0 0 0	0 02	0 3	0 465	0 5	0 437	0 428	0 029	0 3	0 403	0 6 6	0	0 26	0 302	0 355	0 292	0 2
H			0 20	0 0 5	0 0	0 0 0	0 065	0 005	0 059	0 074	0 2	0 2 9	0 0 9	0 06	0 050	0 00	0 062	0 36	0 090	0 0 6	0
A				0 454		0 65	0 06	0 4	0 8	0 094	0 3 9	0 2 0	0 099	0 03	6	0 006	0 055	0 268	0 0 0	0 00	0 0
Ca					80	0 92	0 5	0 5	0 586	0 034	0 5	0 6	0 96	0 60	0 6	0 3 6	0	0 30	0 2 5	0 0	0 25
Mg						0 46	0 03	0 46	0 16	0 48	0 272	0 056	0 208	0 03	0 0 0	0 506	0 0	0 0 8	0 069	0 3 5	0 0
K							0 032	0 0	0 89	0 041	0 0 7	0 037	0 6 5	0 008	0 36	0 2 9	0 482	0 00	0 380	0 2 6	0 3 5
Na								0 2	0	0 115	0 3 6	0 09	0 34	0 349	0 08	0 2 6	0 339	0 436	0 12	0 0	0 0 8
CEC									0 363	0 085	0 30	0 392	0 054	0 260	0 2 0	0 1 8	0 04	0 28	0 26	0	0 2 0
B s s tu t on										0 65	0 33	0 293	0 024	0 220	0 2 6	0 225	0 0 2	0 0	0 036	0 00	0 09
O gan c c b											0 043	0 200	0 14	0 232	0 2	0 000	0 39	0 06	0 273	0 053	0 226
N												0 367	0 207	0 123	0 230	0 208	0 05	0 278	0 2 0	0 053	0
P													0 0 5	0 1 8	0 06	0 099	0 48	0 4	0 2 9	0 22	0 0 6
K														0 34	0 2 4	0 7	0 320	0 00	0	0 7	0 4 6
P F C															0 26	0 65	0 300	0 02	0 153	0 066	0 288
Fe																0 352	0 459	0 192	0 59	0 592	0 5 6
Mn																	0 104	0 36	0 0 5	0 0	0
Cu																		0 353	0 34	0 083	0 336
Zn																			0 273	0 184	0 07
Sil																				0 39	0 247
Clay																					0 28
WH																					

Sign c a 5 eve 0 355
Sig i a at eve t 0 4563

5 Fertility investigation

The soil test values their classification according to soil fertility rating fertilizer recommendation (as percentage of the general recommendation) and digital fertility code number are presented in Table 11

Regarding the pH values A B and C blocks were grouped under the fertility code number 2 (low) whereas D and E under the code number 3 (medium) and F block under 4 (medium) Lime has to be applied to all the blocks as per the package of practices recommendation for each crop since all the soils are acidic in nature

Concerning the electrical conductivity of the soils all the blocks record ed low values Hence no deleterious effect upon the crop growth

In the case of organic carbon content A B and C blocks were rated under the fertility code number 3 (medium) with 97 per cent of the general recom mendation for nitrogen In E and F blocks the fertility class number was 4 (medi um) with a recommendation of 91 percentage for nitrogen D block was grouped under the code number 5 (medium) and requires only 84 per cent of the general recommendation

All the blocks except A_2 of A and F blocks rated under the fertility code number 9 (high) for phosphorus which require only 25 per cent of the general recommendation of phosphorus But the fertility code numbers of A_1 of A and F block were 4 (medium) and 2 (low) respectively Phosphorus has to be applied as 83 and 106 per cent of the general recommendation for these blocks

Table 11 Classification of soil test values

Block		pH	E C dS m 1	Organic carbon (%)	Available phosphorus kg ha 1	Available potassium kg ha 1	Fertilizer recommendation as percentage of general recommendation			Digital fertility code number
							N	P	K	
A	A_1	4 73 (2 L)	0 130 (0 L)	0 727 (3 M)	15 32 (4 M)	192 87 (4 M)	97	83	83	520/344
	A_2	5 00 (2 L)	0 074 (0 L)	0 690 (3 M)	86 06 (9 H)	439 81 (9 H)	97	25	25	520/399
B	B_1	4 89 (2 L)	0 070 (0 L)	0 702 (3 M)	96 21 (9 H)	442 00 (9 H)	97	25	25	520/399
	B_2	4 66 (2 L)	0 086 (0 L)	0 620 (3 M)	34 96 (9 H)	199 89 (5 M)	97	25	71	520/395
C		4 91 (2 L)	0 091 (0 L)	0 753 (3 M)	61 24 (9 H)	266 45 (6 M)	97	25	60	420/396
D		5 23 (3 M)	0 084 (0 L)	1 06 (5 M)	76 85 (9 H)	241 91 (6 M)	84	25	60	430/596
E		5 27 (3 M)	0 061 (0 L)	0 91 (4 M)	51 26 (9 H)	219 33 (5 M)	91	25	71	530/495
F		5 59 (4 M)	0 086 (0 L)	0 90 (4 M)	9 29 (2 L)	336 00 (8 H)	91	106	37	340/428

The numbers given in the paranthesis indicate the fertility code numbers (0 to 9)
The letters L M and H represent low medium and high levels of nutrient content

In the case of potassium A_2 of A and B_1 of B were rated under fertility code number 9 (high) Hence these blocks require only 25 per cent of the general recommendation For C and D blocks fertility code was 6 (medium) and require 60 per cent of the general recommendation E and B_2 of B block came under the fertili ty code number 5 (medium) with a recommendation of 71 per cent A_1 of A block requires 83 per cent while F block requires only 37 per cent of the general recom mendation

Digital fertility code numbers were also calculated For coding the soil test values the codes for the soil texture and other soil test values was written begin ing with the code number for texture followed by pH and electrical conductivity Then an oblique line followed by code numbers for organic carbon available phosphorus and potassium as given by Nambiar *et al* (1977)

Ramamoorthy and Velayudham (1972) have rightly pointed out that the rate of fertilizer dozes to be applied for a particular crop requires greater accuracy in fertilizer adjustments to soil test data inorder to make them as economical as possi ble Ghosh and Hassan (1976) reported that scientific as well as economic approach could imply the use of plant nutrients according to the actual need of the situation which can best be judged through soil tests

Based on the soil test values fertilizer recommendations for various crops are given in the Table 12

According to the soil test values nitrogen fertilizers can be reduced by 5 to 10 per cent Application of phosphatic fertilizers can be reduced by 75 per cent in most of the blocks In the case of potassium also two blocks need only 25 (A_2 of A

Tab e 12 Recommendauon of f rt ers acco dıng o varıou o est a es

Block	Crop	Variety	Recommendation N	P	K	Fertilizer reco e a ation o percenta e of general recommend ation	P	K	Recon ended dose	P	K	Lime	FYM
1	2	3	4	5	6		8	9	10	11	12	13	14
A_1	Coconut kg/palm/ year	Hybrids irrigated	1 00	0 50	2 00	97	83	83	0 97	0 415	1 66	Lime 1 00 April-+ ay	15 to 25 (June-July
		Rainfed	0 50	0 32	1 20				0 485	0 266	0 99o	gSO_4-0 50 (August September)	
A													
A_2	Banana (g/plant/ annum)	endran	190	115	300				184 3	28 75	75		10 kg/
		Palayankodan	100	200	400	97	25	25	97 0	50 0	100		plant at the time of planting
		Other varieties	160 200	160 200	320 400				155 2 194	40 50	80 00		
B_1	Banana g/plant/ annum	Similar to A_2				97	25	25	Similar to A_2				
	Tapioca (kg ha [1])	H 97 & H 226	75	75	75				72 75	18 75	18 75		1 kg/plant
		H 165 Sree sahya Sree visakham	100	100	100				97 0	25 0	25 0		
		M 4 & Local	50	50	50				48 50	12 50	12 50		
B_2	Coconut kg/palm/ year	Hybrids irrigated)	1 00	0 50	2 00	97	25	71	0 97	0 125	1 42		As given for A_1
		Rainfed	0 50	0 32	1 20				0 485	0 08	0 852		
	Banana g/plant/ annum	endran	190	115	300	97	25	71	184 3	28 75	213		Similar to A_2
		Palayankodan	100	200	400				97 0	50 00	284		
		Other varieties	160 200	160 200	320 400				150 194	40 50	227 2 284		
C	Banana (g/plant/ annum)	endran	190	115	300				184 3	28 75	180		
		Palayankodan	100	200	400	97	25	60	97 0	50 0	240		
		Other varieties	160 200	160 200	160 200				155 194	40 50	96 120		
	Vegetables o the general recommended dose apply 97% of nitrogen 25 of phosphorus 60% of potassium												
D	Tapioca (kg ha [1])	H 97 & H 226	75	75	75				63	18 75	45 0		As given for B_1
		H 165 Sree sahya Sree visakham	100	100	100	84	25	60	84	25 00	60 0		
		N-4 & Local	50	50	50				42	12 50	30 0		
	Banana (g/p ant/ annum)	Nendran	190	115	300				159 60	28 75	180		
		Palayankodan	100	200	400				84	50 0	240		As given for A_2
		Other varieties	160 200	160 200	320 400				134 40 168	40 50	192 240		
E	Pepper g/ i e/ years	(General recommendation	50	50	150	91	25	71	45 50	12 50	106 50		10 kg/ plant/ year
	ango 10 yeras) g plant/ year		500	360	750	91	106	37	455	381 50	277 50		25 kg/ plant

and B_1 of B) and others require 37 (F block) 60 (C and D blocks) 71 (E block) and 83 (A_1 of A block) of the general recommendation Phosphatic fertilizers are very costly By reducing it s amount we can save the cost of inputs and hence cost of cultivation can be reduced considerably Similarly large amount of potassium also can be saved, thus cost of cultivation can be reduced considerably

A tendency of decreasing the yield of banana has been reported in this area This may be due to the excess application of chemical fertilizers than the re quired level The accumulation of any nutrient in the soil can deter the uptake of other nutrients due to the antagonistic effect Phosphorus may have such a pro nounced effect upon the availability of other nutrients which can cause a decline in yield Luxurious consumption of potassium also lead to the imbalance of other nutri ents in the plant and metabolic activities may be affected A decreased resistance of plant to pests and diseases especially attacking roots is reported

The approach suggested in the interpretation of soil test data and formu lation of fertilizer recommendation will in a large measure help to achieve the de sired adjustments to soil test data as well as to evolve an economical fertilizer dosage warrented by actual needs of the situation

6 Nutrient index and soil fertility map

Nutrient indices were calculated by the method suggested by Biswas and Mukherjee (1987)

Number of soil examples falling in the category of low medium and high status were given weightages of 1 2 and 3 respectively The number of soil samples falling in the category of low medium and high were multiplied by 1 2 and

3 respectively and the sum is found out By dividing the sum by total number of samples nutrient indices were calculated for each nutrient Arbitrarily chosen an index below 1 5 is low between 1 5 and 2 5 is medium and above 2 5 is high A soil fertility map can be prepared by plotting the value of nutrient index on an outline map of the area

Nutrient indices for different blocks were calculated and presented in Table 13

Nutrient index of A_1 of A block was medium for N P and K whereas in A_2 of A block and B_1 of B block the indices were similar Index for N was medium and high for P and K B_2 of B C D and E blocks had medium indices for N and K and high for P In the case of F block indices were medium low and high for N P and K respectively

Based on the nutrient index values fertility map of Banana Research Station Kannara was drawn (Fig 5)

7 Soil classification (Table 14)

The classification of pedons under taxonomy upto the subgroup level have been attempted (Soil Survery Staff 1987)

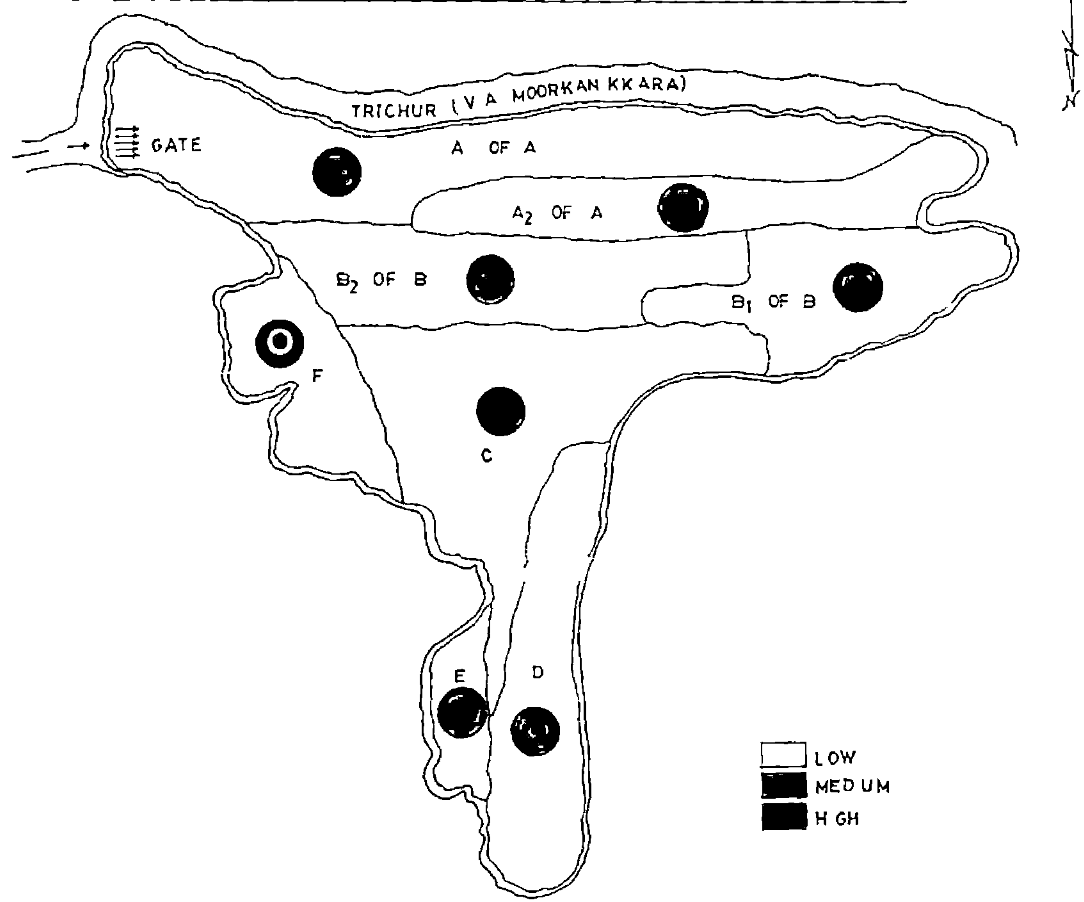
The first profile in the A block belongs to the order Entisol Entisol have little or no evidence of development of pedogenic horizons The first profile being located in the flood plain flooding and deposition of soil material occur during rainy seasons This may be the reason for the absence of diagnostic horizon The sub order is Orthents which are the Entisols on recent erosional surfaces Great group is

Table 13 Nutrient indices of the soil samples

Block		Nutrient indices		
		N	P	K
A	A_1	1 96 M	1 93 M	2 00 M
	A_2	1 92 M	2 96 H	3 21 H
B	B_1	1 91 M	3 00 H	3 00 H
	B_2	2 00 M	2 61 H	2 06 M
C		2 00 M	2 77 H	2 50 M
D		2 00 M	3 00 H	2 09 M
E		2 00 M	3 00 H	2 00 M
F		2 00 M	1 40 L	2 70 H

L M H indicates low medium and high levels respectively

Fig 5 SOIL FERTIL TY MAP OF BANANA RESEARCH STAT ON, KANNARA



Nutrient indices for available nitrogen available phosphorus and available potassium are indicated in the outer middle and interior circles respectively

Table 14 Classification of pedons according to soil taxonomy

Profile No	Order	Suborder	Great group	Subgroup
I	Entisol	Orthents	Troporthents	Typic Troporthents
II	Alfisol	Udalfs	Kandiudalfs	Rhodic Kandiudalfs
III	Alfisol	Udalfs	Kandiudalfs	Typic Kandiudalfs
IV	Alfisol	Udalfs	Kandiudalfs	Typic Kandiudalfs
V	Alfisol	Udalfs	Kandiudalfs	Typic Kandiudalfs
VI	Alfisol	Udalfs	Kandiudalfs	Typic Kandiudalfs
VII	Alfisol	Udalfs	Kandiudalfs	Plinthic Kandiudalfs
VIII	Inceptisol	Tropepts	Eutropepts	Typic Eutropepts
IX	Alfisol	Udalfs	Kandiudalfs	Typic Kandiudalfs
X	Alfisol	Udalfs	Kandiudalfs	Typic Kandiudalfs

Troporthents which are characterised by isomeric or warmer temperature regime are not dry in some or all parts of the moisture control section for as many as 90 cumulative days in most years and EC values < 2 dS m^{1} m all subhorizons The subgroup is Typic Troporthents since this profile do not have a layer in the upper 75 cm that has texture finer than loamy fine sand and a lithic contact within 50 cm of the soil surface It is usually seen on a surface that is actively erodic Soils are normally acidic and clay fraction has moderate or low activity

The profile P_2 (A block) P_3 P_4 and P_5 (B block) P_6 and P_7 (C block) P_9 (E block) and P_{10} (F block) belong to the order Alfisol suborder Udalfs great group Kandiudalfs and subgroup Typic Kandiudalfs

The particular characters that helped to classify the soil under the order Alfisol are they do not have a fragipan base saturation by sum of cations is 35 per cent or more at a depth 1 8 m below the soil surface Epipedon has a sandy or sandy skeletal particle size throughout and is >50 cm thick The suborder is Udalfs which are brownish or reddish more or less freely drained and have udic moisture regimes and warmer temperature regimes The great group is Kandiudalfs and except for P_7 subgroup is Typic Kandiudalfs which do not have an epipedon that is 50 cm to 100 cm thick if particle size class is sandy throughout and do not have mottles that have chroma of 2 or less within 75 cm of the soil surface These have an Ap horizon which has a colour value 4 or more dry or 6 or more after the soil has been crushed For P_7 the subgroup is Plinthic Kandiudalfs which have a horizon within 150 cm from the surface that has >5% plinthite by volume which is the only difference from Typic Kandiudalfs

Plate 1 P_5 of B block belonging to the order Alfisol

Plate 2 P_7 of C block belonging to the order Alfisol

Plate 3 P_8 of D block belonging to the order Inceptisol

Plate 1.

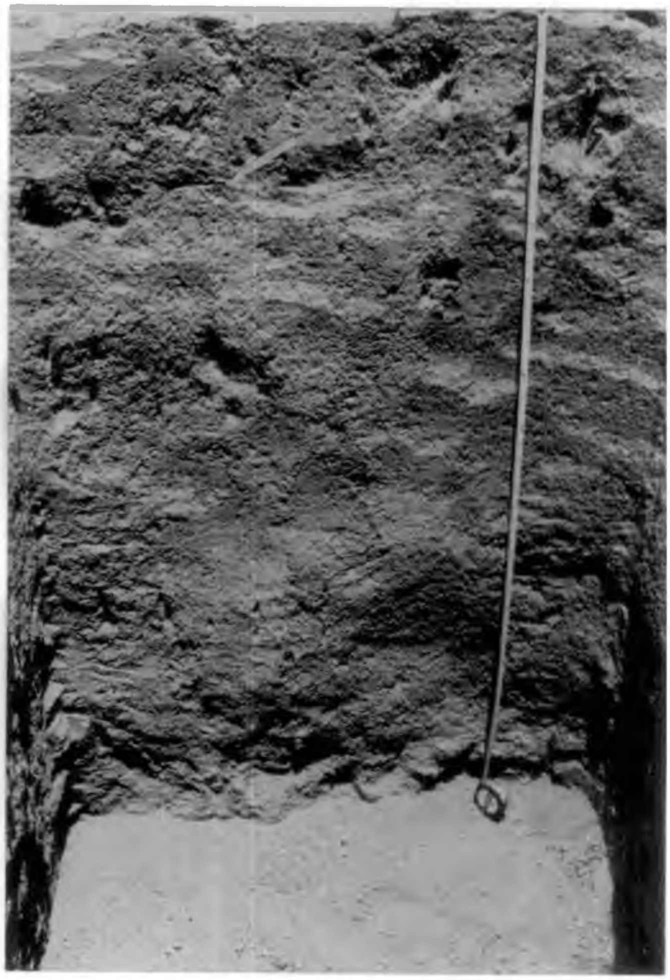


Plate 2.

Plate 3.

P_8 belongs to the order Inceptisol suborder Tropepts greatgroup Eutropepts and subgroup Typic Eutropepts Inceptisol do not have a spodic argillic natric or oxic horizon unless it is a buried horizon or is an intermittent horizon that occupies less than half the area of each pedon Do not have plinthite that forms a continuous phase within 30 cm of the soil surface have an ochric epipedon and do not have an aridic moisture regime Tropepts are brownish to reddish more or less freely drained have an isomeric or warmer temperature regime Eutropepts have 50% or more base saturation throughout all subhorizons between depths of 25 cm and 1 m have a udic moisture regime do not have a horizon containing soft powdery secondary lime within 1 5 m of the soil surface Typic Eutropepts do not have a layer in the upper 75 cm that has texture finer than loamy fine sand that is as much as 18 cm thick or has a bulk density of 0 98 cm or less in the fine earth fraction Do not have mottles that have chroma of 2 or less within 1 m of the soil surface if mottled horizon is saturated with water Have content of organic carbon that decreases regularly with depth and reaches a level of 0 2 per cent organic carbon or less within 1 25 m from the soil surface

The present study points out some of the significant informations about the taxonomy and fertility investigation of soils of Banana Research Station Kannara The fertility status of the soils of each blocks were assessed which helped to evaluate the nutrient status of this area and to recommend the amount of fertilizer needed to supplement the nutrient supply in the soil Hence it was possible to recommend the actual amount of inputs required for the maximum returns

Summary

SUMMARY

Present investigation aims at the taxonomy and fertility investigation of the soils of Banana Research Station Kannara Profiles as well as surface samples were collected and analysed

For the profile samples intensity of the colour increased with depth and texture showed variation but in general the clay content increased with depth Soil in all blocks were deep Apparent density of various blocks were found to be almost similar In profiles P_6 P_9 and P_{10} the apparent density increased with depth but there was a slight decreasing trend in other profiles Higher bulk density values were observed A decrease in the bulk density with depth was noted generally A decreasing trend was observed for maximum water holding capacity values with the depth Clay and silt fractions were associated with this property A decreasing trend of pore space with depth was observed

Soils were acidic in reaction and low in the electrical conductivity Organic carbon and total nitrogen content showed a definite decrease with the depth of the profile Total P_2O_5 content was found to be lower than total K_2O content Low reserves of total nutrients were reflective of the parent material with few weatherable minerals from which these soils were derived

Intermediate layers showed maximum accumulation of sesquioxides and the content of sesquioxide was very high for all the samples analysed Predominant cation was calcium followed by magnesium A general increase was observed with depth for cation exchange capacity as well as effective cation exchange capacity The low values of effective cation exchange capacity for the surface layer samples sug gest the adoption of proper management practices to prevent the leaching loss

The oxalate extractable iron (active iron) content was very low whereas dithionite extractable iron had a much higher value The higher proportions of Fe_d is an indication of greater silicate weathering Distribution of total iron content was quite irregular

For the surface samples wide variation in the texture was observed from block to block The texture varied from silty to sandy clay loam Significant posi tive correlation was observed for the clay content and waterholding capacity whereas silt and organic carbon failed to show any influence on moisture retention

Exchangeable aluminium showed higher content than exchangeable hydrogen for all the soils in general Among the cations calcium content was the highest followed by magnesium Cation exchange capacity showed a variation of 4 37 to 5 53 and the effective cation exchange capacity values were almost similar to these values

The phosphorus fixing capacity for all the soils analysed were found to be high DTPA extractable micronutrients were more than adequate Values record ed for copper and zinc were low compared to iron and manganese

According to the soil test values nitrogen fertilizers can be reduced by 5 to 10 per cent and phosphatic fertilizers by 75 per cent in most of the blocks In the case of potassium also two blocks need only 25 (A_2 of A and B_1 of B) and others require 37 (F block) 60 (C and D blocks) 71 (E block) 83 (A_1 of A block) per centage of the general recommendation The surface soils were acidic and low in total salt content

As estimated by the nutrient index values content of organic carbon was found to be medium Available phosphorus was high for A_2 of A B C D and E blocks For A_1 of A phosphorus content was medium but for F block the available phosphorus was low Available potassium content was high for A_2 of A B_2 of B and F blocks medium for A_1 of A B_2 of B C D and E The fertility map of the Banana Research Station was drawn

The soils of various blocks were classified and according to soil taxono my P_1 (A block) belongs to the order Entisol P_2 (A block) P_3 P_4 and P_5 (B block) P_6 and P_7 (C block) P_9 (E block) and P_{10} (F block) belong to the order Alfisol and P_8 (D block) belongs to Inceptisol

By the present study the nutrient status of each block was assessed and actual amount of input required can be recommended for maximum return

References

REFERENCES

Alexander M T , Duraıraȷ D J 1968 Influence of soıl reactıon on certaın soıl propertıes and avaılabılıty of maȷor nutrıents ın Kerala soıls *Agrıc Res J Kerala* 6 15 19

Alexander E B 1974 Extractable ıron ın relatıon to soıl age on terrace along the Truckee Rıver Nevada *Proc Soıl Scı Soc Am* 38 121 124

Arduıno E Barderıs E Carraro F and Forno M G 1984 •Estımatıng relatıve ages from ıron oxıde/total ıron ratıos of soıls ın the Western PO Valley Italy *Geoderma* 33 39 52

Azız M A Rabıe F H and Fanous N E 1987 Some physıcal propertıes of the soıls of Eastern Desert Wadıes as related to theır chemıcal and mınera logıcal characterıstıcs *Egypt J Soıl Scı* 27 181 193

Balaguru T and Mosı D 1972 Studıes on the forms and dıstrıbutıon pattern of manganese and ıron ın Tamıl Nadu soıl profiles *Madras agrıc J* 59 391 396

Bastın B 1985 Physıco chemıcal characterısatıon of red soıl ın dıfferent regıons of Kerala M Sc (Ag) thesıs Kerala Agrıcultural Unıversıty Vellanıkkara Trıchur

Bhattacharya T Gosh K S and Prakash N 1983 Chemıcal and morphologıcal characterıstıcs of amorphous materıals present ın red soıls derıved from granıte gneıss *Clay Res* 2 20-27

Bıswas T D and Mukherȷee S K 1987 *A Textbook of Soıl Scıence* Tata Mc Graw Hıll Publıshıng Company Ltd New Delhı p 193

Brar J S Chibba I M and Brar S P S 1988 Some characteristics and nutrient status of soils of S W districts of Punjab *J Res Punjab agric Univ* 25 15 23

Challa O and Gaikawad S T 1986 Soils in a catena from Dadra and Nagar Haveli their characterization and classification *J Indian Soc Soil Sci* 34 543 550

Chaudhury S K Roy H K and Sarkar A K 1990 Quantity intensity relationship of potassium in acid red loam soils (Alfisols) of Ranchi *Indian J agric Sci* 60 814 7

Chavan D P Bangar A R and Shingte A K 1980 Zn Mn B and Mo distribution in soil profiles of different agroclimatic zones of Maharashtra *J Maharashtra agric Univ* 5 183 389

Chen J H and Barber S A 1990 Effect of liming and adding phosphate on predicted phosphorus uptake by Maize on acid soils of three soil orders *Soil Sci* 150 844-849

Chibba, I M and Sekhon G S 1985 Effect of pH and organic carbon on availability of nutrients in acid soils *J Indian Soc Soil Sci* 33 409-411

Coleman N I and Thomas, G W 1967 The chemistry of soil acidity *Soil Acidity and Liming* Agronomy No 12, American Society of Agronomy Madison p 1 41

Conry M J 1972 Pedological evidence of man s role in some profile modification in Ireland *Geoderma* 8 139 146

Conventry R J and Williams W T 1983 Numerical examination of a field classification of some red yellow and grey earth profiles *Aust J Soil Res* 21 343 357

Divakar B L Bhagat K N Mehta N S and Tewari J C 1986 Fertility status of horticultural areas of plithograph soils *Progressive Horticulture* 18 222 226

*Durairaj D J 1961 Advanced studies on soil colour M Sc (Ag) thesis Madras University

Ekambaram S Kothandaraman G V and Krishnamurthy K K 1975 Studies on the distribution of different forms of potassium in red soil *Madras agric J* 62 243 247

Ghabru S K Arnaud R J S and Mermut A R 1990 Association of DCB extract able iron with minerals in coarse soil clays *Soil Sci* 149 112 119

Ghosh R C and Banerjee S K 1979 Distribution of different forms of iron in some soils of W Bengal *Indian Forester* 105 773 778

Ghosh A B Bajaj J C Hassan R and Singh D 1983 *Soil and Water Testing Methods A Laboratory Manual*, Soil Testing Laboratory I A R I New Delhi, p 25

*Ghosh A B and Hassan R 1976 Available Potassium Status of Indian Soils *Bull Indian Soc Soil Sci* 10 21 31

Ghosh A B and Hassan R 1980 Nitrogen fertility status of soils of India *Fert News* 25 19 24

Gopalaswamy V 1969 Studies on the profile morphology analytical characteristics and micromorphology of some laterites and lateritic soils of Kerala Ph D thesis Kerala University

Govindarajan S V and Rao H G G 1978 *Studies on Soils of India* Vikas Publishing House Pvt Ltd Bangalore

Guidi, G Poggio G and Petruzzelli G 1985 The porosity of soil aggregates from bulk soil and from soil adhering to roots *Pl Soil* **87** 311 314

Gupta V K Raj H and Singh K 1980 Distribution and relationship of micronutrients with soil properties of soils of South Western Haryana *Haryana agric Univ J Res* **10** 235 241

Harrison R Swift R S Campbell A S and Tonkin P J 1990 A study of two soil development sequences located in a montane area of Canterbury New Zealand I Clay mineralogy and cation exchange properties *Geoderma* **47** 261 282

Hassan M A 1977 Fertility investigation on the laterite soils of Kerala State M Sc (Ag) thesis Kerala Agricultural University Vellanikkara Trichur

Hesse P R 1971 *A Textbook of Soil Chemical Analysis* John Murray Publishers Ltd London

Iyer, M S 1979 Studies on laterite and red soil association in certain locations in Kerala M Sc (Ag) thesis Kerala Agricultural University Vellanikkara Trichur

Jackson M L 1958 *Soil Chemical Analysis* Prentice Hall Inc Eagle Wood Cliffs N J U S A Reprint by Prentice Hall of India (Pvt) Ltd New Delhi

Jadhav N S Malewar G U and Varade S B 1978 Vertical distribution of zinc and iron in some citrus growing soils of Marathwada *J Maharashtra agric Univ* **3** 85 87

Jeanroy E Rajot J L Pillon P and Herbillon A J 1991 Different dissolution of hematite and goethite in dithionite and it s implication on soil yellowing *Geoderma* **50** 79 94

Jessymol A S and Mariam K A 1993 Transformation of added potassium in later ite soils *J trop Agric* 31 29 33

Juo A S R Moorman F R and Maduakor H O 1974 Forms and distribution of extractable iron and aluminium in selected soils of Nigeria *Geoderma* 11 167 179

Katyal J C and Sharma B D 1991 DTPA extractable and total Zn Cu Mn and Fe in Indian soils and their association with some soil properties *Geoderma* 49 165 179

Kemp R A 1985 The cause of redness in some buried and non buried soils in eastern England *J Soil Sci* **36** 329 334

Koshy M M and Brittomuthunayagam A P A 1961 Fixation and availability of phosphate in soils of Kerala *Agric Res J Kerala* 1 70 78

Kothandaraman G V Krishnamurthy, K K 1978 Phosphorus fixation capacity of Tamil Nadu soils *Madras agric J* **65** 645 649

Lal F and Biswas, T D 1974 Factors affecting the distribution and availability of micronutrient elements in major soil groups of Rajasthan II Soil pro files *J Indian Soc Soil Sci* 22 333 346

Lindsay, W L and Norwell, W A 1978 Development of a DTPA soil test for zinc, copper, iron and manganese *Soil Sci Soc Am J* 42 421-428

*Maida J H A and Chilma Z W 1981 Changes in indices of soil fertility under continuous cropping *Luso* 2 15 25

Makarim A K Cassel D K and Wade M K 1988 Effects of land reclamation practices on physical properties of an acid infertile oxisol *Soil Technol ogy* 1 195 207

Mandal S C 1971 *Acid red soils of India and their management* Presidential address Agric Sci Section 58th Indian Science Congr Bangalore

Marwaha B C and Sood R 1989 Effect of partially acidulated rock phosphate in minimising the P fixing capacity of an acid Alfisol *J Indian Soc Soil Sci* 37 333 336

Mathan K K 1990 Application of soil fertility capability classification to acid soils *J Indian Soc Soil Sci* 38 469-473

Mathew R and Nair R V 1985 Moisture retention characteristics of red and forest soils of Kerala *Agric Res J Kerala* 23 17 25

Misra U K Satapathy S and Panda N 1989 Characterization of some acid soils of Orissa I Nature of soil acidity *J Indian Soc Soil Sci* 37 22 28

* Mochoge B O and Beese F 1988 The effect of cultivation on org C N and P of some Kenyan red soils IRDC Manuscript Reports 170, 296-302

Mohanty, S K and Filipovski G 1981 Fertility potential classification of rice growing soils using principal components analysis *J Indian Soc Soil Sci* 30 312 319

Nad B K Goswami N N and Leelavathy C R 1975 Some factors influencing phosphorus fixing capacity of Indian soils *J Indian Soc Soil Sci* 23 319 327

Nahson D B 1991 Self organization in chemical lateritic weathering *Geoderma* 51 5 13

Naik K C S Deb D L and Ramaiah P K 1988 Studies on P fixation and release in coffee growing Oxisols *J Nucl Agric Biol* 17 162 165

Nair K H 1973 Studies on the fertility status of the red soils of Kerala and the effect of adding nitrogen in combination with MnO_2 on the grwoth yield and composition of rice M Sc (Ag) thesis Kerala Agricultural University, Trichur Kerala

Nair T J Nambiar I P and Money N S 1966 Studies on Keen Raczkowski measurements and their relation to soil test values in cultivated soils of Kerala *Agric Res J Kerala* 4 50-54

Nambiar E P Jacob C I and Nair T J 1977 Digital expression of soil fertility a new approach to the interpretation of soil test data and formulation of fertilizer recommendation *Agric Res J Kerala* 16 201 209

Olson, K R 1988 The effects of erosion on soil pore distributions and root ramification in fine textured Illinois soils *Soil Sci* 145 365 373

Olsen R A Anderson F N Frank K D Grabouski P H Rehm G W and Shapiro C A 1987 Soil testing interpretations Sufficiency vs build up and maintenance *S S S A Special Publication* U S A 21 41 52

Paramasivam P and Gopalaswamy A 1993 Characteristics and classification of some soils of lower Bhavani Project command area Tamil Nadu *Agropedology* 3 105 107

Parsons R B and Balster C A 1966 Morphology and genesis of six Red Hill soils in Oregon Coast Range *Proc Soil Sci Soc Am* 30 90 93

Phonde D B Mehta V B and Chavan A S 1990 Phosphorus fixation capacity as influenced by properties of rice soils of Konkan *J Maharashtra agric Univ* 15 46-48

Piper C S 1942 *Soil and Plant Analysis* Asian reprint 1966 Hans Publishers Bombay

Prameela, K P and Nair R V 1985 Moisture retention characteristics of alluvial soils of Kerala *Agric Res J Kerala* 23 24-30

Praseedom R K and Koshy M M 1975 The zinc status of Kerala soils *Agric Res J Kerala* 13 1-4

Prema D 1992 Status availability and transformation of magnesium in acid soils of Kerala Ph D thesis Kerala Agricultural University Trichur

Prema D and Jose A I 1994 Magnesium status of the soils of Kerala *J trop Agric* 32 129 131

Puranik R B Joshi R P and Deshmukh, S D 1990 Studies on soil phosphorus in relation to physical properties of soil *Indian J agric Chem* 23 229 231

Radwanski S A and Ollier C D 1959 A study of an East African Catena *J Soil Sci* 10 149 168

Raguraj R 1981 Studies on the physico-chemical properties of major soil series of Madurai district M Sc (Ag) thesis, Tamil Nadu Agricultural University Coimbatore

Rajagopal C K Sherieff M M Selvakumari, G and Jabrani W 1977 Status of available micronutrient cations in the soils of Kerala *Agric Res J Kerala* 15 165 171

Ramamoorthy B and Velayudam S 1972 Soil fertility and fertilizer use in India *Indian Fmg* 22 80-85

Rao C C and Singh K D 1992 Prediction of post harvest soil test values after Maize Wheat and Maize Wheat Moong sequences based on initial soil test values *J Indian Soc Soil Sci* 40 748 752

Ratnam C Sundararajan R and Duraıraj J 1972 Soıls of Tamıl Nadu *Soıls of Indıa* The Fert Assoc of Indıa New Delhı p 249 259

Raychaudhurı S P and Reddy P S A 1963 Ratıng of some red soıls of Bangalore Dt Mysore State *J Indıan Soc Soıl Scı* 11 311 319

Reeuwıjk L P V 1992 *Procedures for Soıl Analysıs* Internatıonal Soıl Reference and Informn Centre, Netherlands p 11 13

Sahnı J S Marok A S Sodhı J S and Vınayak A K 1980 Soıl propertıes ın relatıon to avaılabılıty of mıcronutrıent catıons ın soıls of Kapurthala dıstrıct (Punjab State) *Indıan J agrıc Res* 14 103 110

Sahu, G C Panda N and Nanda, S S K 1983 Genesıs and mıneralogy of some red and laterıte soıls of Orıssa *J Indıan Soc Soıl Scı* 31 254 62

Sawant R D Kadrekar S B and Dongale J H 1981 Phosphorus and potassıum avaılabılıty as affected by organıc manure and dıfferent moısture re gımes *J Maharashtra agrıc Unıv* 6 179 182

Schulten H R Leınweber, P and Sorge C 1993 Composıtıon of organıc matter ın partıcle sıze fractıons of an agrıcultural soıl *J Soıl Scı* 44 677 691

* Schwertmann U and Taylor R N 1977 Iron oxıdes *Mınerals ın Soıl Envıron ments* (Eds) Dıxon J B and Weed S B Soıl Scıence Socıety of Amerıca Madıson p 145 180

Sharma B K Dhır R P and Joshı D C 1985 Avaılable mıcronutrıent status of some soıls of arıd zone *J Indıan Soc Soıl Scı* 33 50-55

Sharma P K Sethı A S Mısra V K and Sharma O K 1980 Effect of O M clay and sılt on some physıcal parameters and CEC ın some acıd soıls of Hımachal Pradesh *Indıan J agrıc Res* 14 241 246

Shouse P J Gerik T J Russel W B and Cassel D K 1990 Spatial distribution of soil particle size and aggregate stability index in a clay soil *Soil Sci* 149 351 360

Singh R and Brar S P S 1973 Correlation of different soil tests with maize re sponse for nitrogen and phosphorus at different fertility levels of soil *J Indian Soc Soil Sci* 21 320-324

Singh K , Minhas R C and Tomar K P 1990 Characterization and classification of some Mid Shiwalik soils m different physiographic units *J Indian Soc Soil Sci* 38 474-480

Singh R M and Tripathi B R 1970 Correlation studies on soil tests for available N and response of paddy on certain soils of U P *J Indian Soc Soil Sci* 18 313 318

Singh K Tripathi D and Tomar K P 1993 Pedogenesis and taxonomy of soils in topo-sequence of Central Himalayas *Agropedology* 3 29 38

Snedecor G W and Cochran W G 1967 *Statistical Methods* Oxford and IBH Publishing Co New Delhi

Soil Survey Staff 1987 *Keys to Soil Taxonomy* SMSS technical monograph No 6 Ithaca New York

Soil Survey Staff 1992 *Soil Survey Laboratory Methods Manual* Soil Survey Inves tigations Report No 42 Version 2 U S D A National Soil Survey Centre and Soil conservation Service Washington

Subbiah, B V and Asija G L A 1956 A rapid procedure for the estimation of available nitrogen in soils *Curr Sci* 25 259 260

Subrahmanyan K S and Kumaraswamy K 1989 Effect of continuous croping and fertilization on the PO_4 fixation capacity of soil *J Indian Soc Soil Sci* 37 682 686

Tamgadge D B Gajbhiye K S and Gaikawad S T 1986 Evaluation of crop productivity potential of soils *J Indian Soc Soil Sci* 34 551 557

Thiyagarajan T M 1978 Physico-chemical appraisal of selected soil profiles M Sc (Ag) thesis Tamil Nadu Agricultural University Coimbatore

Thulaseedharan C K and Nair R V 1984 Moisture retention characteristics of laterite soils of Kerala *Agric Res J Kerala* 22 11 16

Ushakumari K 1983 Aggregate size of distribution and it s relation to physical and chemical properties of some typical soils of Kerala M Sc (Ag) thesis Kerala Agricultural University Trichur Kerala

Ushakumari K Leela K and Sharda A 1987 Structural status in relation to physico chemical characteristics of soil *Agric Res J Kerala* 25 36 44

Venugopal, V K 1969 Cation exchange studies in Kerala soils M Sc (Ag) thesis Kerala Agricultural University Trichur Kerala

Venugopal, V K 1980 Pedologic studies on lateritic catenary sequences occurring in Kerala Ph D thesis, Kerala Agricultural University Vellanikkara Trichur

Venugopal V K and Koshy M M 1976 Cation exchange capacity in relation to the mechanical composition and organic matter status of some soil profiles of Kerala *Agric Res J Kerala* 14 58 63

Venugopal V K and Koshy M M 1976 Exchangeable cations of some important soil profiles of Kerala *Agric Res J Kerala* 14 37-42

Wang C Schuppli P A and Ross G J 1987 A comparison of hydroxylamine and ammonium oxalate solutions as extractants for Al Fe and Si from Spodosols and Spodosol like soils in Canada *Geoderma* 40 345 335

Watanabe P S and Olsen S R 1965 Test of an ascorbic acid method for determining phosphorus in water and $NaHCo_3$ extracts from soil *Proc Soil Sci Soc Am* 29 677 678

Webster R 1965 A catena of soils of Northern Rhodesian Plateau *J Soil Sci* 16 31-43

Williams J Prebble R E Williams W T and Hignett C T 1983 The influence of texture structure and clay mineralogy on the soil moisture characteristic *Aust J Soil Res* 21 15 32

Wolsten J H M and Genuchten M T V 1988 Using texture and other soil properties to predict the unsaturated soil hydraulic functions *J Soil Sci Soc Am* 52 1762 1770

* Yosef B B Kafkai U Rosenberg R and Sposito G 1988 P adsorption by kaolinite and montmorillonite I Effect of time ionic strength and pH *J Soil Sci Soc Am* 52 1580-1585

*Yuan T L 1963 Some relationship among hydrogen aluminium and pH in solutions and soil systems *Soil Sci* 95 155 163

* Originals not seen

Appendix

APPENDIX I

Description of soil profile

PROFILE I

Location	A block Banana Research Station Kannara
Topography	1 3% slope in east west direction foot slope
Drainage	Ponded run off very slow erosion impermeable drain age occassional flooding
Ground water table	2 5 metres
Land use	Coconut and banana
Remarks	Soil are very deep with little coarse fragments Fine to / coarse porosity and no cutans were visible

Horizon	Depth (cm)	Description
A_p	0-11	Dark reddish brown (5YR 3/3) clay loam medium week subangular blocky very friable sticky plastic few fine roots impermeable drainage clear smooth bound ary
A_{21}	11 20	Dark reddish brown (5YR 3/3) clay loam medium size moderate subangular blocky friable sticky plastic few fine roots impermeable drainage clear smooth boundary
A_3	20-72	Dusky red (2 5YR 3/2) silty clay medium weak subangular blocky friable sticky plastic few coarse roots gradual wavy boundary
B_1	72 106	Yellowish red (5YR 4/6) sandy clay loam medium weak subangular blocky friable slightly sticky, slightly / plastic diffuse wavy boundary

B_{21}	106 140	Yellowish red (5YR 4/6) sandy clayloam medium size moderate subangular blocky, friable slightly sticky slightly plastic diffuse wavy boundary
B_{22}	140-165+	Reddish brown (5YR 4/4) sandy clay medium weak subang ular blocky friable sticky plastic
B_3	165+	Reddish brown (5YR 4/4) sandy clay medium weak subang ular blocky friable slightly sticky slightly plastic

PROFILE II

Location	A block Banana Research Station Kannara
Topography	8 to 15% gradient 50 to 150 m length foot slope
Drainage	Medium well moderate erosion slow run off no flood ing
Ground water table	More than 10 metres
Land use	Coconut
Remarks	Soils are very deep with coarse fragments (gneissic gravel) at a depth of 90-116 cm fine to coarse porosi ty patchy thin cutans visible at lower depth

Horizon	Depth (cm)	Description
A_p	0-13	Dusky red (2 5YR 3/2) silty clay loam very fine granular very friable slightly sticky slightly plastic few coarse roots clear smooth boundary
A_1	13 13	Dark reddish brown (2 5YR 3/4) clay loam fine granular friable sticky plastic few very fine roots clear wavy boundary
A_2	31 60	Dark red (2 5YR 3/6) clayey medium weak subangular blocky friable sticky plastic few fine roots gradual wavy boundary

B_1	60-90	Dusky red (10R 3/4) clayey medium moderate subangular blocky friable sticky plastic few fine roots gradual wavy boundary
B_{12}	90 116	Dusky red (10R 3/4) clayey medium moderate subangular blocky friable sticky plastic few fine roots distinct wavy boundary
B_2	116-133+	Dark red (10R 3/6) clayey medium moderate subangular blocky firm very sticky very plastic gneissic gravel present few thin patches of cutans visible

PROFILE III

Location	B block Banana Research Station Kannara
Topography	8 15% slope in east west direction
Drainage	Very slow run off very slow erosion medium well drainage
Ground water table	More than 10 metres
Land use	Banana and tapioca
Remarks	Deep soil with fine gravel and coarse fragments at a depth of 32 79 cm Very fine common porosity No cutans visible

Horizon	Depth (cm)	Description
A_p	0 15	Dark reddish brown (5YR 3/3) silty clay medium weak subangular blocky very friable slightly sticky coarse roots common clear smooth boundary
A_{21}	15 32	Strong brown (7 5YR 4/4) silty clay moderate medium subangular blocky friable slightly hard slightly plastic few fine roots abrupt smooth boundary
B_1	32 72	Strong brown (7 5YR 5/8) silty clay moderate medium subangular blocky friable plastic very fine few roots abrupt smooth boundary

B_{21}	72 105	Strong brown (7 5YR 5/8) clay loam moderate medium subangular blocky friable plastic very fine few roots abrupt smooth boundary
B_{22}	105 120	Strong brown (7 5YR 5/8) clayey moderate medium subangular blocky friable plastic

PROFILE IV

Location	B block
Topography	Foot slope 3 8% gradient
Drainage	Medium well no flooding
Ground water table	5 10 metres
Land use	Banana
Remarks	Deep soils with little coarse fragments fine to coarse porosity cutans are visible at lower depth

Horison	Depth (cm)	Description
A_p	0-26	Dark brown (7 5YR 3/2) silty clay loam very friable weak medium subangular blocky slightly sticky slightly plastic medium common roots gradual wavy boundary
A_1	26-43	Dark brown (7 5YR 3/2) clay loam friable weak medium – subangular blocky sticky, plastic few coarse roots clear wavy boundary
B_1	43 89	Dark reddish brown (5YR 3/3) sandy clay very friable moderate medium subangular blocky sticky plastic few fine roots gradual wavy boundary
B_2	89 106	Brown (7 5YR 4/4) sandy clay very friable moderate medium subangular blocky sticky plastic gradual wavy boundary

PROFILE V

Location	B block
Topography	Foot slope
Drainage	Medium well run off also medium well occassional flooding
Ground water table	More than 10 metres
Land use	Banana
Remarks	Medium deep soils on colluvium parent material very slow erosion

Horizon	Depth (cm)	Description
A_p	0-19	Dark reddish brown (5YR 3/3) clay loam firm medium coarse moderate medium subangular blocky slightly sticky slightly plastic fine roots common clear smooth boundary
A_1	19-40	Dark reddish brown (5YR 3/4) silty clay slightly hard firm moderate medium subangular blocky sticky plastic few fine roots clear wavy boundary
B_1	40-70	Dark reddish brown (5YR 3/3) mottle colour reddish yellow (7 5YR 6/8) silty clay slightly hard very firm coarse moderate subangular blocky sticky plastic diffuse wavy boundary
B_{12}	70 100	Dark reddish brown (5YR 3/4) silty clay slightly hard extremely firm coarse moderate subangular blocky slightly plastic diffuse wavy boundary
B_{13}	100-140	Dark reddish brown (5YR 3/3) silty clay slightly hard firm fine medium porosity moderate coarse subangular blocky sticky plastic

PROFILE VI

Location	C block
Topography	Foot slope 3 8% gradient
Drainage	Medium well no flooding
Ground water table	5 10 metres
Land use	Banana
Remarks	Deep soils with little coarse fragments Fine to coarse porosity

Horizon	Depth (cm)	Description
A_p	0-32	Reddish brown (5YR 4/4) clay loam medium weak subangular blocky slightly plastic very friable fine coarse few coarse roots gradual wavy boundary
A_1	32-43	Brown (7 5YR 4/4) silty clay loam medium moderate sub angular blocky slightly plastic loose very friable abrupt wavy boundary
B_1	43 74	Dark red (2 5YR 3/6(r) silty clay loam medium strong sub-angular blocky slightly hard firm slightly plastic gradual smooth boundary gravel present
B_2	74-115	Strong brown (7 5YR 5/8(r) silty clay medium strong subangular blocky hard very firm slightly plastic fine gravel present

PROFILE VII

Location	C block
Topography	Foot slope 3 8% gradient
Drainage	Medium well no flooding very slow erosion
Ground water table	More than 10 metres
Land use	Banana vegetables

Remarks	Deep soil with coarse fragments at a lower depth plinthite and yellowish mottles at lower depth

Horizon	Depth (cm)	Description
A_p	0-28	Yellowish red (5YR5/6) silty clay loam medium weak sub angular blocky slightly hard friable sticky plastic fine coarse porosity few fine roots clear smooth boundary
B_1	28-49	Strong brown (7 5YR 5/8) clay loam medium moderate subangular blocky slightly hard firm sticky plastic gradual wavy boundary
B_2	49 67	Yellow (2 5YR 7/8) silty loam medium strong subangular blocky hard firm sticky plastic gradual wavy boundary fine gravel present
B_{22}	67 114	Red (2 5YR 4/6) silty clay loam medium strong subangular blocky hard very firm sticky plastic diffuse wavy boundary fine gravel present
B_3	114-145	Red (2 5YR 5/8) silty clay loam medium strong subangular blocky, hard very firm sticky plastic fine gravel present

PROFILE VIII

Location	D block
Topography	Foot slope less than 3% gradient
Drainage	Well drained
Ground water table	5 10 metres
Land use	Tapioca Banana
Remarks	Deep soil brown colour predominant intensive cultivation practices

Horizon	Depth (cm)	Description
A_p	0-19	Brown (7 5YR 4/4) silty clay loam medium, moderate, subangular blocky, soft friable slightly sticky slightly plastic fine roots common clear smooth boundary
A_1	19 47	Brown (7 5YR 5/4) silty clay loam, medium moderate sub angular blocky slightly hard friable slightly sticky slightly plastic very fine few roots clear smooth boundary
B_1	47 69	Brown (7 5YR 4/4) silty medium moderate subangular blocky slightly hard very friable slightly sticky slightly plastic gradual smooth boundary
B_{21}	69 90	Dark reddish brown (5YR 3/3) silty, medium weak subangular blocky slightly hard very friable slightly sticky slightly plastic gradual wavy boundary
B_{12}	90-135	Dark reddish brown (5YR 3/4) silty medium weak subangular blocky slightly hard very friable slightly sticky slightly plastic

PROFILE IX

Location	E block
Topography	Foot slope 1-4% slope
Drainage	Well drained
Ground water table	Within 5 10 metres
Land use	Pepper
Remarks	Deep soil soft not much corase fragments

Horizon	Depth (cm)	Description
A_p	0 25	Dark brown (7 5YR 3/2) silty clay loam medium weak subangular blocky loose friable slightly sticky slightly plastic medium roots common clear smooth boundary

B_1	25 56	Brown (7 5YR 4/4) silty clay loam medium moderate sub-angular blocky, soft friable slightly sticky slightly plastic gradual wavy boundary
B_{21}	56-73	Yellowish red (5YR 4/6) silty loam medium weak subangular blocky soft friable sticky slightly plastic gradual wavy boundary
B_{22}	73 109	Dark reddish brown (5YR 3/3) silty loam medium weak subangular blocky soft very friable slightly sticky slightly plastic

PROFILE X

Location	F block
Topography	Foot slope 5% gradient
Drainage	Well drained
Ground water table	Within 15 metres
Land use	Mango trees
Remarks	Laterisation is evident Not much cultural operations

Horizon	Depth (cm)	Description
A_p	0 34	Strong brown (7 5YR 5/6) silty loam medium weak subangular blocky, hard friable sticky plastic medium few roots gradual wavy boundary
B_1	34-48	Yellowish red (5YR 5/8) silty clay loam medium weak subangular blocky very hard firm sticky plastic clear wavy boundary
B_{12}	48 104	Yellowish red (5YR 4/6) red (2 5YR 4/8 (r) silty clay medium, moderate, subangular blocky very hard firm sticky plastic coarse fragments present gradual wavy boundary
B_{22}	104 118	Yellowish red (5YR 4/6) red (2 5YR 4/8(r) silty clay medium strong subangular blocky very hard very firm sticky plastic coarse fragments present

FERTILITY INVESTIGATION AND TAXONOMY OF THE SOILS OF BANANA RESEARCH STATION, KANNARA

By

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ABSTRACT OF A THESIS

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ABSTRACT

Taxonomy and fertility investigation of the soils of Banana Research Station Kannara was the main intension of the present investigation Representative surface soil samples were collected from each block of this research station namely A B C D E and F for investigating the fertility status of soil Profiles considered for the study were P_1 and P_2 in A block P_3 P_4 and P_5 in B block P_6 and P_7 in C block P_8 in D block P_9 in E block and P_{10} in F block Profiles were excavated to study the characteristics of each of the horizons in the soil profile and classify the soils of each block

After the collection and preparation of soil samples, laboratory analyses were carried out as per the standard methods

With an increase in depth profile samples showed an increasing intensity of colour of the horizons and increase in clay content whereas a decreasing trend was noticed for apparent density absolute density water holding capacity and pore space

Soils were acidic and low electrical conductivity values were observed

Organic carbon and total nitrogen decreased with depth Total P_2O_5 content was lower than total K_2O Low reserves of total nutrients were observed for other elements also

Sesquioxide content was very high and intermediate layers showed maximum accumulation

In surface as well as profile samples the predominant cation was calcium followed by magnesium

A general increase of CEC and ECEC with depth was observed

Oxalate extractable iron content was lower than the dithionite extractable iron Distribution of total iron was irregular

Surface soil showed wide variation in texture Clay content showed significant positive correlation with water holding capacity whereas silt and organic carbon failed to impart any influence upon the same Phosphorus fixing capacity was high for all the samples DTPA extractable micronutrients were more than the adequate amount

Based on the soil test values fertilizers were recommended for various blocks Nitrogeneous fertilizers can be reduced by 5 to 10 per cent Application of phosphatic fertilizers can be reduced by 75 per cent in most of the blocks Potassium fertilizers can also be reduced considerably

Nutrient indices were calculated and a soil fertility map was drawn

Classification of pedons of various blocks according to soil taxonomy has been attempted and found that P_1 of A block belongs to the order Entisol P_2 (A block) P_3 P_4 and P_5 (B block) P_6 and P_7 (C block) P_9 (E block) and P_{10} (F block) belong to the order Alfisol P_8 of D block belongs to the order Inceptisol

By this investigation, the classification of soil profiles were done and the fertility status of each block was found out. In accordance with the soil test values, fertilizer recommendations were made. Thus, by reducing the inputs, cost of cultivation could be reduced considerably.