FERTILITY INVESTIGATIONS AND TAXONOMY OF THE SOILS OF REGIONAL AGRICULTURAL RESEARCH STATION, PATTAMBI

By

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THESIS

Submitted in partial fulfilment of the requirement for the degree of

Master of Science in Agriculture

Faculty of Agriculture

KERALA AGRICULTURAL UNIVERSITY

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COLLEGE OF HORTICULTURE

VELLANIKKARA, THRISSUR

1995

DECLARATION

I hereby declare that the thesis entitled **"Fertility investigations and taxonomy of the soils of the Regional Agricultural Research Station, Pattambi"** 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 other similar title, of any other University or Society.

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ACKNOWLEDGEMENTS

I wish to place on record with utmost sincerity my deep sense of profound gratitude to Dr. N.P. Chinnamma, Professor, Department of Soil Science and Agricultural Chemistry and Chairperson of my Advisory Committee for her valuable guidance, constant encouragement and patience throughout my Masters Degree programme and I owe enormous debt to her for the immense help in the preparation of this manuscript.

I am quite indebted to Dr. A.I. Jose, Professor and Head, Department of Soil Science and Agricultural Chemistry and member of my Advisory Committee for his valuable suggestions and support during my Masters Degree Programme.

The help I received from Dr. Harikrishnan Nair, Assoc. Professor, College of Agriculture, Vellayani is thankfully acknowledged.

My sincere thankfulness are also due to Smt. K.A. Mercey, Assistant Professor, Department of Agricultural Statistics, College of Horticulture, for the timely assistance rendered to me.

I am deeply obliged to Dr. V.K. Venugopal, Associate Professor, College of Agriculture, for the generous help he has always accorded to me during the course of this study. He, inspite of a busy schedule has offered constructive suggestions for the betterment of this manuscript.

The help and support received from the staff members of the Department of Soil Science and Agricultural Chemistry, College of Horticulture, Vellanikkara is gratefully acknowledged.

I also place on record my sincere thanks to Dr. K. Anilakumar, Associate Professor, other staff members, employees and labourers of R.A.R.S., Pattambi for their valuable help during field study.

I extend my sincere gratitude to all my friends for the innumerable help and support rendered during the course of the study.

My sincere thanks are to M/s Peagles, Mannuthy for the neat and prompt typing of this manuscript.

I am forever beholden to my parents, brother and in-laws for their constant support during my course of study. I remember with gratitude the love and personal sacrifices of my husband during the course of study. I owe a lot to them for their encouragement for the completion of this effort.

Last but not the least I bow my head before The Almighty whose blessings were with me during every inch of study enabling me to undertake the venture successfully.

K.P. DEEPA

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Introduction

INTRODUCTION

The Regional Agricultural Research Station, Pattambi has entered the seventh decade of activities. The station now under the Kerala Agricultural University, was established by the erstwhile Madras Government in 1927, with the name Paddy Breeding Station, Pattambi. The name of the station was changed to Agricultural Research Station, Pattambi in 1930, so as to take up investigations on other crops like cotton, sugarcane, sesame, groundnut and pulses. With the reorganisation of states in 1956, it became the main institution for rice research in Kerala. In 1962, the rice research set up of the Kerala State was reorganised and the station was raised to the status of Central Rice Research Station of the Kerala State with regional centres at Mannuthy, Chalakudy, Vytilla, Kayamkulam, Moncompu and Karamana. When Kerala Agricultural University was formed in 1972, the station was transferred to the University. With the implementation of National Agricultural Research Project in 1981 the station was reorganised as the Regional Agricultural Research Station of the Central Zone and has lead functions on rice, pulses, horticultural crops, oil seeds, and rice based farming systems. It also functions as an Advanced Centre for Studies on Laterite Soil Management.

The station is situated within a km east of the Pattambi railway station along the Pattambi-Perinthalmanna road. The total area of the station is 63.64 ha and it includes both upland and lowland.

The upland is occupied by paddy, coconut, pepper, fruit trees and other horticultural crops. Paddy is cultivated in the lowlands and the paddy lands fall under three categories namely rainfed uplands or 'Modan', 'Palliyals' or single crop wetlands and 'Iruppu lands' or double crop wetlands. The 'Modan' lands are not level with the result water cannot be impounded in the fields. Rice varieties which can tolerate drought better are cultivated in these lands as a rainfed crop followed by other miscellaneous crops taking advantage of the North East Monsoon. 'Palliyals' or single crop wet lands are terraced lands with small plots and considerable variation in topography occur from field to field. 'Irruppu lands' or the double crop lands are wet lands where fields are larger and field to field level difference is not much.

A detailed survey of the soil in the area of the station has not been made by the Soil Survey Department and hence a taxonomic classification of the soil and fixing of the soil series as per the Soil Taxonomy has not been made. A reconnaissance survey was made according to which these soils were included under a soil association namely Karakurissi-Koonathara-Vadanamkurissi association.

Since the systematic analysis and classification of soil under taxonomy had not been done so far, the present study was formulated. The objectives of the study were to find out the morphological and physico-chemical characteristics of soil profiles of the different blocks, to analyse the surface soil samples from all the blocks for fertility parameters, to classify the soils under taxonomy and to prepare the soil fertility map of the station.

It was hoped that the data collected from the study will provide information on the fertilizer requirement of different blocks and will help to carry out soil management practices more efficiently. It will also help for better and more productive utilization of the soils in different blocks to the best advantage. The basic data obtained from the study can be used for finding out the changes in the fertility status of the soil with time. Correlation of the data obtained from this study with the previous data available will help to find out the changes in the soil properties due to continuous cultivation. Data collected from the analysis of soil profile will help to classify the soil under Soil Taxonomy.

Review of Literature

REVIEW OF LITERATURE

Morphological characteristics

Soil colour

The clay content of the soil is not correlated with the chroma of the soil colour, but is highly correlated with the reciprocal of chroma. Pore space, water holding capacity and moisture equivalent are all negatively correlated with soil colour (Durairaj, 1961).

According to Sathyanarayana and Thomas (1961) the colour of laterite soils depend on the content and form of iron hydroxides and oxides which imparted the yellow, pink, brown and red colours to the ground matrix and earthy clay.

Study on the influence of topographic site and drainage conditions on the colour variations of laterite soils revealed that the upland well drained soils are frequently reddish to reddish brown or brownish red, occasionally very bright red or purplish red. These red colours denote the presence of a non-hydrated iron oxide, haematite, in the soil. The hydrated iron oxides in these soils are mainly goethite and limonite and their presence is responsible for the change in colour from reddish brown to brown or orange brown and then to yellowish brown or even brownish yellow (Brammer, 1962).

A study on the relationship between soil colour and physical properties showed that hue of the soil is significantly correlated with moisture holding capacity, clay content and specific gravity of the soil (Savithri and Rangasamy, 1967).

The colour of laterite soils varied from red to yellow depending upon the degree of acidity and the degree of hydration of ferric oxide (Ratnam *et al.*, 1974).

Studies on the profile samples in rice growing soils of Wyanad showed that the value of colour lies between 3 and 8 and the chroma between 0 and 8. A shift in hue between the dry and moist states is observed in some profiles and this change was between 10 YR and 7.5 YR (Nair, 1977).

According to Yadev *et al.*,(1977) the topography and drainage are responsible for the colour development in red soils of U.P. It was concluded that the oxidative weathering of limonite is responsible for the red colour of soils. Laterite soils from different locations in Kerala have striking similarity in colour with red hues predominantly increasing with depth in the profile (Jacob, 1987).

The laterite soils of the upland profiles have predominantly red hues while soils from valleys have brown hues at surface followed by greyish subsurface layers with mottling (Krishnakumar, 1991).

The difference in colour of laterite soils are due to the oxides of iron in various degree of hydration and sometimes also manganese. Compounds of iron impart a grey-black colour and compounds of manganese, a velvetty black in a reducing medium (Varghese and Byju, 1993).

Physical properties

Soil texture

The amount of clay in soil influences many of the physical constants of soil. Correlations of clay with coarse and fine sand are negative (Parthasarathy, 1959). Gravel content of soil is the result of disintegration of fossilized laterite (Mohr and Van Baren, 1959).

It was observed that the mechanical composition of acid soils under paddy cultivation varied from clayey with a clay content of 59.6 per cent to loamy sand with a sand content of 75.0 per cent (Raychaudhury and Anantharaman, 1960).

According to Queiroz (1963), sand fraction in seven profiles under study decreases and clay and silt content increases with depth. Within the sand fractions, coarse sand decreases and fine sand increases down the profile. This increase of fine particles was attributed to the migration of soil particles with the gravity water.

In the studies on cultivated soils of Kerala, Janardhanan *et al.* (1966) found that the absolute specific gravity and apparent specific gravity are a function of the coarser particles of the soil while water holding capacity, pore space, volume of expansion and organic carbon are related to the finer particles of the soil both in quantity and in quality.

An increase in the coarse sand and clay fractions with depth was observed in a red soil profile at Patchallor in Kerala. Silt and fine sand contents decreased with depth (Rajagopalan, 1969).

The upland laterite soils of Kerala contain a higher percentage of coarser fractions than the soils from corresponding low land positions. The finer fractions (clay and silt) varied between 25.50 and 53.50 per cent in the dry land soils, while they varied between 29.00 and 55.00 per cent for the corresponding wet land soils. The apparent specific gravity of the profile samples ranged between 1.00 and 1.50 while the absolute specific gravity varied between 2.15 and 2.20 (Hassan, 1977).

The coarse fragments showed significant differences between the sequential profiles of the transect in all the three locations at Varkala, Poruvazhy and Kalliasserry in Kerala. A decrease in coarse fragments down slope was a general feature of all the three toposequences. The crest profile in all the three locations had the maximum gravel content which increased with depth and merged with the hard laterite land (Venugopal, 1980).

Among the different soil groups of Kerala, laterite, black cotton, red loam, riverine alluvium and coastal alluvium show downward migration of clay (Ushakumari, 1983).

It was reported that the wet land soils are quite variable in material nature but always have high clay activity unlike upland soils, which are dominated by low activity clays (Kyuma, 1985).

Based on the study conducted on the Edamalayar project area, Krishnakumar (1991) reported that coarse fragments formed a predominant part in the soils from upland which increase in content with depth. In respect of the soils of the wet lands, wide variation in the content of coarse fragment was observed. Very low content of silt with clay illuviation to lower layers was noticed to be a common feature.

Soil structure

The structure of red ferrallitic soils was observed as granular to moderate blocky by Govindarajan and Rao (1978).

A progressive diminition in structural development and horizon differentiation was observed in the lower slope members as compared to the upper slope members in the soil catenary sequence of Varkala (Venugopal, 1980).

The study on the influence of physico-chemical properties on soil structure of 5 major soil groups of Kerala viz., laterite, black, red loam, riverine alluvium and coastal alluvium inferred that properties like clay, organic matter, CEC and sesquioxide play an important role in building soil structure in most of the soil groups except riverine alluvium because of its comparatively recent origin (Ushakumari *et al.*, 1987).

It was observed that the red and laterite soil groups of Kerala have an excellent state of aggregation. The soils contain more than 70 per cent of the aggregates in the size range of diameter more than 0.25 mm (Antony and Koshy, 1988).

Good structural development was noticed in upland soils of Edamalayar command area. But wet lands show weak sub angular blocky surface structure followed by massive structure in the sub soils. Poor structural and weak horizon development were characteristic of the imperfectly drained wet lands (Krishnakumar, 1991).

Based on the studies conducted on the permanent manurial experiments at Pattambi, Padmam (1992) reported the beneficial effects of organic matter addition on bulk density, water holding capacity and aggregate stability of soil.

Moisture retention characteristics

A high positive correlation was obtained among mechanical components, physical properties and moisture constants in a heterogenous collection of soils by Kandasamy (1961) in the studies conducted of Tamil Nadu.

A beneficial effect by soil organic carbon on soil moisture retention characters was noticed irrespective of the texture and mineralogical composition of clays in some cultivated soils of India. Organic carbon and available moisture were found to be positively correlated (Ali, 1965).

Water holding capacity was inferred as a function of finer fractions of soil by Janardhanan *et al.* (1966) based on the studies on some important cultivated soils of Kerala.

Hydraulic conductivity was reported to be high in surface layer of light textured soils with rapid permeability.

Maximum water holding capacity increased from Ap horizon to B_{2t} horizon in consonance with latter's higher clay content (Ravikumar and Thiyagarajan, 1980).

Study with laterite soils of Kerala showed that the content of clay has significant positive correlation with the moisture content. Significant negative correlation was obtained between the contents of coarse fractions and moisture retention. The laterite soils were found to have an overall available water content of 3.1 per cent. Effect of organic carbon on moisture content was not significant (Thulasidharan and Nair, 1984).

Chemical properties

Total chemical composition

Total iron oxide, free iron oxide, aluminium and magnesium seemed to be increasing with depth in the red soils of Mysore (Parvathappa and Raj, 1970). It was pointed out by Chesworth (1973) that chemical weathering increases SiO_2, Al_2O_2 and Fe_2O_3 in surface soil.

In the studies on the profile samples in the rice growing soils of Wyanad, Nair (1977) found that the Fe_2O_3 content tends to increase with depth to a maximum in the lowest layer. The Fe_2O_3 content of soil profiles of Varkala toposequence was found to range between 1.60 and 10.93 per cent by Venugopal (1980).

According to Vageler (1938), in humid tropics and sub tropics the carbon-nitrogen ratio varied from 8:1 to 12:1 in surface soil. The ratio dropped to 6:1 to 10:1 in sub soil.

A high positive correlation between organic carbon and nitrogen was obtained by Mahalingam (1962) in Nilgiri soils. The amount of humus and nitrogen was reported to be progressively decreasing with depth in the profile by Czerwinski (1963).

Krishnamoorthy (1966) reported a close correlation between total N and available N whereas Ramdas (1970) obtained a high correlation between available N and organic matter in soils of Tamil Nadu.

The total nitrogen content of the wet land soils of the ribbon valleys of Kerala was observed to range from 0.08 to 0.20 per cent. In the profiles, a decrease in total nitrogen was observed with depth and this decrease paralleled the organic matter content (Hassan, 1977).

The organic carbon, nitrogen and C:N ratio registered an increase in the downslopes of the Varkala and Peruvazhy toposequence and a slight decrease in Kalliassery toposequence (Venugopal, 1980).

It was observed by Jacob (1987) that the organic carbon, nitrogen and C:N ratio of laterite soils from different parent materials in Kerala are low. Highly significant positive correlation was observed between organic carbon and nitrogen. Brady (1988) reported that the mineralisation of organic matter is very rapid in the tropies which results in its depletion.

Organic carbon content of both upland and wetland soils of Edamalayar command area recorded low values. A steady decrease in organic carbon content with depth was observed in all soils except for Konchira where the last layer showed accumulation of organic matter (Krishnakumar, 1991).

Carbon-nitrogen ratio was reported to be related to climate, increasing progressively from warm semi arid areas to the cooler and more humid areas (Das *et al.*, 1992).

The level of total phosphorus in soil profiles of Kerala was found to vary from 0.024 to 0.025 per cent. The phosphorus fixing capacity vary widely with maximum in acid soils having high sesquioxide content (Koshy and Brito-muthunayagam, 1961).

Studies conducted on the vertical distribution of total and available phosphorus in some typical soil profiles of Gujarat showed that the top soil was richer than sub soil in total and available phosphorus (Patel and Mehta, 1962).

It was reported by Varghese (1972) that acid soils of Kerala have low P_2O_5 content.

Jackson (1972) and Muthuvel and Krishnamoorthy (1980) reported that available P content of soils was affected by soil moisture regimes.

Phosphorus fixing capacity of laterite soils of India was determined to vary from 21 to 55 per cent by Nad (1975).

Analysis of soil samples from different blocks of the RARS, Pattambi (1977) has indicated that in general nutrient index graded from low to medium for N and P and medium to high for K (Anon., 1977).

Red, black, alluvial and laterite soils of Tamil Nadu were found to differ widely in their P fixing capacity, the highest values being for laterites and the lowest for alluvial soils. The P fixing capacity was found to be positively correlated with clay, total sesquioxides and total alumina (Kothandaraman and Krishnamoorthy, 1978).

minimum value was observed in laterite soil and maximum in black soil (Venugopal, 1969).

It was observed by Hassan (1977) that the calcium and magnesium status of laterite soils of Kerala are very poor. Total calcium increases with depth while magnesium decreases with depth.

A close correlation between total Ca and Mg and total Ca and exchangeable Mg^{++} were observed by Loganathan and Krishnamoorthy (1979) in soils of A.P. Similar positive correlations were obtained between exchangeable Ca^{++} and total Mg.

The total reserves of CaO, MgO, K_2O and P_2O_5 are very low in laterite soils of Kerala and is mainly a reflection of the mineralogy of the sand fraction dominated by quartz (Jacob, 1987; Krishnakumar, 1991).

The average zinc content of most of the mineral soils in India is between 10 and 300 ppm and depending on the type of extractants used, available zinc content varied from less than 1 ppm to a few ppm (Swaine, 1955).

Pisharody (1965) reported that total Mn content of rice soils of Kerala varied from 355 to 625 ppm in surface soils and from 367 to 764 ppm in sub soils of water logged profiles. Water soluble Mn ranged from 1.8 to 14.8 ppm.

According to Kanwar and Randhawa (1967) in most Indian soils, total zinc content ranges from 2 to 1600 ppm.

According to Nair (1970), total and available copper ranged from 27 to 136 ppm and from 1.68 to 5.50 ppm in Onattukara soils and from 49 to 97 ppm and 0.3 to 3.3 ppm in Kuttanad soils.

It was reported by Praseedom (1970) that total copper content of the laterite soils of Kerala ranges from 9.0 to 78.0 ppm with a mean value of 34.3 ppm.

An available Cu content of 0.7 to 4.4 ppm in alluvial soils of Kerala was reported by Varughese (1971).

According to Fatehlal and Biswas (1973) the total micronutrient content of soil is directly related to the nature of parent material and degree of weathering. The pH, organic carbon, texture, $CaCO_3$ and type of clay minerals was reported to be markedly controlling the availability of micronutrientsin the major soil groups of Rajasthan.

Soils containing less than 15 ppm of active Mn is designated as deficient, 15 to 100 ppm as critical and greater than 100 ppm as high in available Mn (Kanwar and Randhawa, 1974).

In a study of the zinc status of Kerala soils, it was reported that total zinc content of surface layer varied from 3.5 ppm in red soil to 72.0 ppm in the alluvial soil. Significant positive correlation was obtained between total and available zinc. The downward distribution of zinc did not follow any regular pattern (Praseedom and Koshy, 1975).

Total copper content of Indian soils range from a minimum of 12 ppm to a maximum of 138 ppm in paddy soils (Domigo and Kyuma, 1983).

According to Kanwar and Tripathi (1986) the distribution of total copper in soil profiles is heterogeneous and it has no direct relationship with the contiguity of area, climate and parent material. It is influenced by soil pH, calcium carbonate and clay content. The amount of DTPA extractable copper is found to be associated with pH and clay content, suggesting that most of the available copper is held as easily exchangeable form on clay particles.

A level of 0.55 ppm DTPA extractable Zn in soils was found to be critical below which response to Zn was expected, whereas in top half of plant tissues, 16.3 ppm Zn was estimated to be critical (Sharma *et al.* 1986).

Iron and iron fractions of soils

According to Pisharody (1965) total iron content of rice soil profiles of Kerala ranges from 19,200 to 1,36,000 ppm. The sub soil is richer in total and exchangeable iron than surface soils in majority of the profiles studied. Total iron increases with increase in finer fractions.

It is reported that the elements iron, aluminium and manganese are greatly affected by the process of soil profile genesis. The distribution of their pedogenic oxides and hydroxides in the soil profile therefore help in describing the type, direction and extent of pedogenic processes and can be used to define soil groups and other soil classes (Blume and Schwertmann, 1969).

Dithionate extractable iron content increases with depth in the red soils of Kerala (Iyer, 1979).

Total and free iron in rice soils of West Bengal vary within a narrow range. The free iron oxide has a strong positive correlation with organic carbon and total iron content (Mitra and Mandal, 1983).

Investigations on the red soils of Kerala reveal that the dithionate extractable Fe ranges between 1.24 and 3.56 per cent. The oxalate extractable iron show low values compared to dithionate extractable Fe and it ranges from 0.001 to 0.004 per cent (Bastin, 1985).

Laterite soils from different parent materials in Kerala show that the dithionate extractable Fe ranges from 0.85 to 10.87 per cent and oxalate extractable Fe from 0.06 to 0.84 per cent (Jacob, 1987).

Total iron content is fairly high in the case of uplands as compared to wet lands. Profile trends were erratic except in one profile where a steady increase with depth was noticed (Krishnakumar, 1991).

Cation exchange properties

The maximum cation exchange capacity is reported to be at an intermediate depth in the profile by Raychaudhuri (1943).

A negative correlation between elevation and base exchange capacity and a positive correlation between base exchange capacity and exchangeable calcium was reported by Mahalingam (1962) in Nilgiri soils.

According to Satyanarayana and Thomas (1962) the CEC (NH_4OAC) of laterite soil of Angadipuram vary from 4.5 to 5.8 me/100 g in the profile. The value for the profile from Kasargod area was 2.5 to 7.0 me/100 g.

An increasing trend of CEC was observed with depth by Hutcherson (1963) in his studies on Maury soil series of U.S.A. A marked inverse relationship between cation exchange capacity and silica sesquioxide ratio was observed by Mannion (1963) in Irish soils. For laterite soils, a base exchange capacity of 4 to 7 me/100 g soil was reported by Raychaudhuri (1963).

It was noticed by Wilding and Rutledge (1966) that in the A horizon organic matter influences cation exchange capacity whereas in the B horizon cation exchange capacity seems to be a function of clay.

Cation exchange capacity of soils of Rajasthan was found to be significantly correlated with clay, silt and organic matter content. Contribution of clay to CEC value is dominant (Lavti *et al.*, 1969). Cation exchange capacity greatly depends on organic matter than on mineral fractions in acid soils (Sanchez, 1969).

Cation exchange capacity of the soils of Kerala ranges from 1.62 me/100 g for laterite to 49.56 me/100 g for black soils. In laterite profiles, calcium seems to be the predominant exchangeable base followed by magnesium (Venugopal and Koshy, 1976).

The CEC of midland laterite soils of Kerala from various horizons varied between 5.0 to 8.5 me/100 g (Hassan, 1977).

According to Ross *et al.* (1985) acidification lowers the soil pH and greatly decreases the permanent charges of CEC and ratios of exchangeable Ca^{++}/Mg^{++}, Ca^{++}/K^{+}, Mg^{++}/K^{+} and $Ca^{++}+Mg^{++}/K^{+}$. The proportional losses of exchangeable bases follow the order: $Ca^{++}>Mg^{++}>K^{+}$.

Exchangeable bases in laterite soils of Kerala occur in the order Ca>Mg>K>Na (Jacob, 1987).

The cation exchange capacity of soils in the command area of Edamalayar irrigation project calculated by NH_4OAC method was low. Profile trends were erratic except for Ikkanadu series which showed a decreasing trend with depth. Among the exchangeable bases, Ca and Mg formed the predominant cations. The exchangeable bases of the soils were in the order Ca>Mg>K>Na in most of the profiles. The percentage base saturation value for all soils were low (Krishnakumar, 1991).

Soil reaction

The presence of free sesquioxide and free silica has considerable influence on the buffer capacities of the red soils of India (Raychaudhuri, 1941).

Joachim and Kandiah (1947) studying on Ceylon soils reported that the ultimate pH of the soil is related to the nature of clay as characterised by the silica sesquioxide ratio.

The surface soils in the uplands of the entire mid lateritic belt of Kerala have a pH ranging between 4.0 and 6.3. The pH values of soils from corresponding positions in the ribbon valleys adjacent to the sites of sampling for dry land soils recorded a pH value ranging from 4.2 to 5.2 (Hassan, 1977).

Soil acidity tends to increase down the slope in all the catenary sequence studied in Kerala (Venugopal, 1980). According to Raguraj (1981) the pH of profiles ranged from 6.0 to 10.1 in red soils and from 3.4 to 6.3 in lateritic soils of Madurai district. The low pH in the lateritic soils was attributed to the high organic matter content and also to the leaching of bases. The pH of surface soil is high compared to the sub surface layer.

It was reported that exchangeable Al and per cent Al saturation are negatively correlated with pH of soils in water and 1N Kcl solution respectively. Different forms of Fe and Al are positively correlated with organic matter and clay fractions. With decrease in soil pH, release of Fe and Al increases (Adhikari and Si, 1991).

Nature of acidity in some acid soils of West Bengal was studied by Das *et al.* (1992) and reported that organic carbon and exchangeable Al are significantly correlated with hydrolytic acidity of soils whereas exchange acidity is highly significantly correlated with exchangeable Al only. Besides various soil factors, available P, organic carbon, exchangeable Al and exchangeable acidity show significant correlation with pH of the soils.

Electrical conductivity

According to Sampath (1987) EC remains low without any change in depth in red and lateritic soils of Tamil Nadu.

Classification

Taxonomy

In earlier classification system of many countries most oxisols were called latosols. This term was coined to designate zonal soils having their dominant characteristics with low silica sesquioxide ratio, low base exchange capacity, low activity of clay and low content of weatherable minerals (Kellog, 1949).

It was indicated by Maignien (1966) and Sye (1968) that the laterite soils come under either oxisols, alfisols, ultisols or inceptisols of comprehensive system of classification.

Important rice growing soils of tropical regions are wet alfisols. They are mainly located in areas with dry climate. Most of them have an aquic or an athraquic moisture regime (Somasiri, 1985).

Laterite soils from different parts of Kerala were classified under oxisol by Jacob (1987).

Materials and Methods

MATERIALS AND METHODS

The investigation was carried out at the Regional Agricultural Research Station, Pattambi, Kerala, comprising a total area of 63.64 ha divided into 22 blocks.

1. Field studies

Profile pits were dug in the typical areas identified and the morphological features observed were recorded as per Soil Survey Staff (1967). The particulars of the profile samples collected are presented in Table 1. The profiles selected for the study are indicated in Fig.1. The salient features of the areas in respect of location, physiography, drainage, vegetation and land use were also recorded. The morphological descriptions of the profiles are presented in Appendix I.

After morphological examination of the profiles, soil samples representing the different horizons in each profile were collected for laboratory examination.

The surface soil samples from 0-15 cm depth were collected from all the 22 blocks for estimating the available nutrient status. The particulars of the surface samples collected are presented in Table 2.

Table 1. Details of profile samples collected

Sl. No.	Block No.	Sample No.	Horizon	Depth (cm)
1	2	3	4	5
1	B (West) (Lowland Paddy)	1	Ap	0-10
		2	C1	10-15
		3	C2	15-30
		4	C3	30-60
		5	C4	60-125
2.	C (Coconut)	1	Ap	0-10
		2	A1	10-35
		3	B1	35-55
		4	C1	55-100
		5	C2	100-150
3.	F (Upland)	1	Ap	0-10
		2	B1	10-35
		3	B21	35-45
		4	B22	45-75
		5	B3	75-120
4.	L (Palliyal)	1	Ap	0-14
		2	A3	14-40
		3	B1	40-80
		4	B21	80-110
		5	B3	110-160

Contd.

Table 1 (Contd.)

1	2	3	4	5
5.	I (Lowland paddy)	1	Ap	0-20
		2	C1	20-60
		3	C2	60-100
6.	V (Lowland paddy)	1	Ap1	0-10
		2	Ap2	10-30
		3	C1	30-45
		4	C2	45-70
		5	C3	70-125
7.	VIII (Upland)	1	Ap	0-7
		2	A1	7-17
		3	A3	17-41
		4	B1	41-110
		5	B2	110-150
8.	IX (Mango orchard)	1	Ap	0-10
		2	A3	10-25
		3	B1	25-45
		4	B21	45-71
		5	B22	71-110
		6	B3	110-140
9.	X (Coconut)	1	Ap	0-10
		2	A3	10-35
		3	B1	35-75
		4	B2	75-100

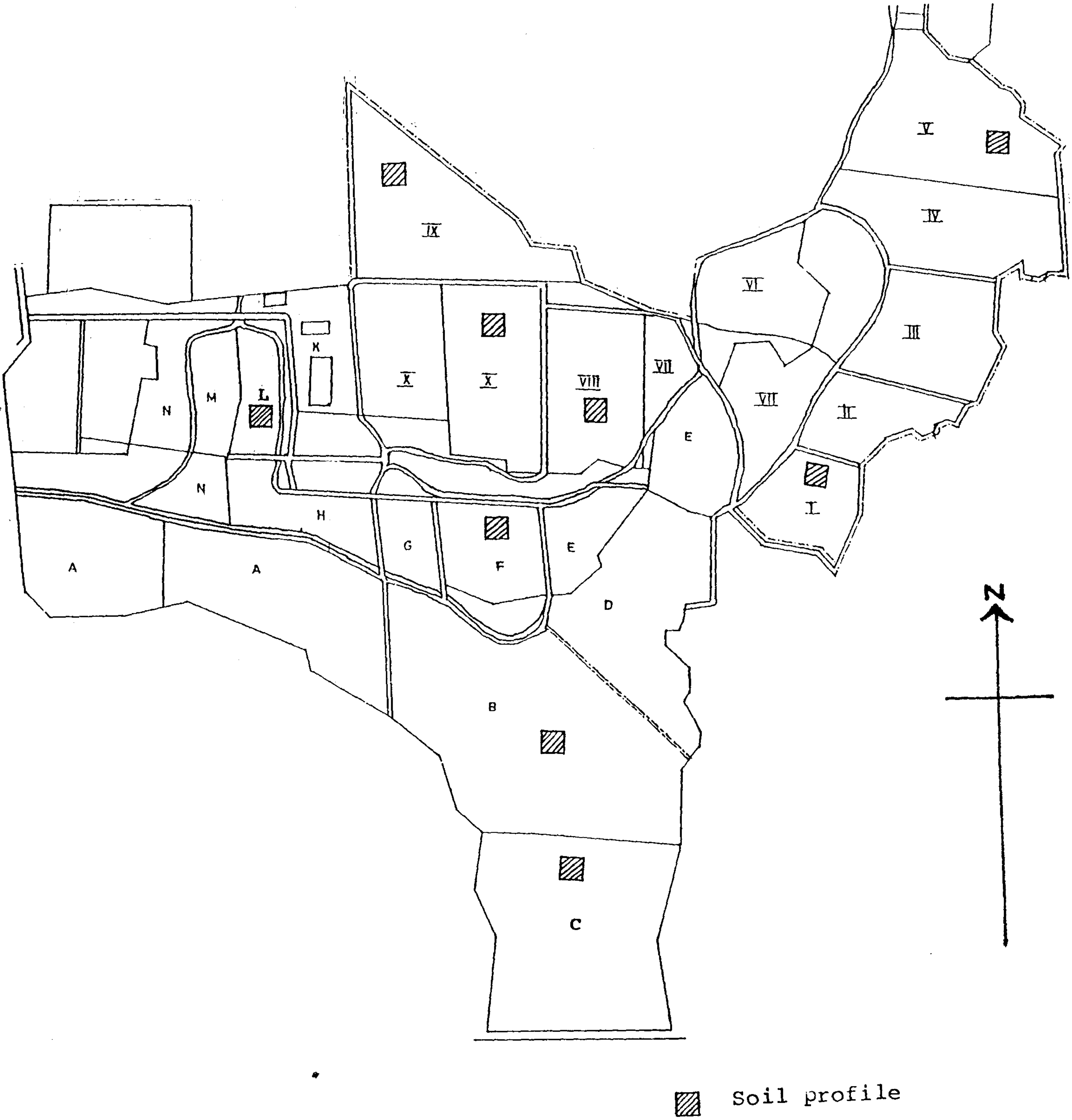

FIG.1 LOCATION OF SOIL PROFILES IN THE STATION

Table 2. Details of surface samples collected

Sl. No.	Block No.	Upland/Lowland	Area	No. of samples
1.	A	Lowland	9.60	12
2.	B	Lowland	8.82	10
3.	C	Upland	4.59	11
4.	D	Lowland	4.78	10
5.	E	Lowland	2.98	7
6.	F	Upland	4.19	10
7.	G	Upland	1.49	8
8.	H	Upland	2.04	10
9.	K	Upland	2.21	8
10.	L	Upland	2.42	15
11.	M	Upland	2.33	6
12.	N	Upland	3.35	12
13.	I	Lowland	3.48	7
14.	II	Lowland	3.89	10
15.	III	Lowland	5.52	10
16.	IV	Lowland	5.64	8
17.	V	Lowland	7.38	13
18.	VI	Lowland	6.24	14
19.	VII	Lowland	4.95	10
20.	VIII	Upland	6.86	12
21.	IX	Upland	6.66	10
22.	X	Upland	1.02	9

2. Laboratory studies

2.1 Preparation of samples

The collected soil samples were air dried, powdered gently and passed through a 2 mm sieve. The samples thus prepared were utilized for further studies analysis.

2.2 Physical properties

The particle size distribution of the soil samples was determined by the International Pipette Method (Piper, 1942). Other physical constants like bulk density, particle density, porosity and water holding capacity were determined using Keen and Raczowski box by the method outlined by Sankaram (1966).

3. Chemical properties

The chemical properties of the samples were determined by standard analytical procedures.

3.1 Analysis of profile samples

Soil reaction was determined in a 1:2.5 soil water suspension using a Systronics pH meter. Electrical conductivity was read in the same suspension using an Elico conductivity meter. Organic carbon was determined by Walkley and Black method and total nitrogen by semi micro kjeldahl method (Soil Survey Staff, 1967).

Total P_2O_5, K_2O, NaO, CaO, MgO, Fe_2O_3 and SiO_2 were determined in the perchloric-nitric acid (1:2) extract (Hesse, 1971). Total P_2O_5 was estimated by Vanadophosphoric yellow colour method (Jackson, 1958). Total potassium and sodium were determined by flame photometry using EEL flame photometer. Total calcium and magnesium were estimated in the diacid extract using atomic absorption spectro-photometer. Total iron was determined by O-phenanthroline method (Hesse, 1971) and total SiO_2 was determined gravimetrically.

Cation exchange capacity w s estimated by distillation procedure. Exchangeable calcium and magnesium were determined in neutral 1N NH_4OAc extract by EDTA titration method as outlined by Hesse (1971). Exchangeable potassium and sodium were read using EEL flame photometer (Jackson, 1958). Exchange acidity, exchangeable aluminium and hydrogen were estimated in the 1N KCl extract (Soil Survey Staff, 1967).

Free iron oxide was extracted using dithionate-citrate-bicarbonate method (Mehra and Jackson, 1960) and determined colorimetrically by the O-phenanthroline method. Amorphous iron oxide was extracted using ammonium oxalate(McKeague and Day, 1966) and determined by the O-phenanthroline method (Hesse, 1971).

3.2 Analysis of surface samples

Soil reaction, conductivity, organic carbon, cation exchange capacity and excangeable cations were determined using the same proceedure as that of profile samples.

Available nitrogen was determined by the alkaline permanganate method (Subbiah and Asija, 1956). Available phosphorus was extracted using Bray I extractant (0.03N NH_4F in 0.025 N HCl) and determined by molybdophosphoric acid method as described by Jackson (1958). Available potassium was extracted using 1 N NH_4OAc and determined using an EEL flame photometer (Jackson, 1958).

Phosphorus fixing capacity was determined by the method outlined by Hesse (1971). The micronutrients iron, manganese, copper and zinc were extracted using DTPA (Lindsay and Norwell, 1978). The contents were estimated using an atomic absorption spectrophotometer.

4. Preparation of soil fertility map

Based on the content of organic, carbon available P and K, nutrient indices for N, P and K in all the blocks were calculated and the soil fertility map was prepared as outlined by Biswas and Mukherjee (1987).

Results and Discussion

RESULTS AND DISCUSSION

1. Environmental factors affecting the area under study

1.1 Climate

The area enjoys a humid tropical climate with hot summers. It is placed in the central zone of agro-climatic region. Annual rainfall averages about 250 mm spread over an average of 110 rainy days and temperature ranges from 19 to 35°C.

The relative humidity remains high throughout the year and goes upto 94 per cent. High wind velocity is observed during January-February.

1.2 Soil type

Laterite soil is the major type occupying the area under study.

1.3 Present land use

The Regional Agricultural Research Station, Pattambi is comprised of a total area of 63.64 ha.

Area cultivated	:	52.22 ha
Area occupied by roads and buildings	:	11.42 ha
Area under garden land	:	21.17 ha
Area under wet land	:	31.05 ha

Out of the 31.05 ha of wet land, only 19.88 ha is double cropped, the rest 11.17 ha being single cropped.

Paddy is the most extensively raised crop on low lands followed by coconut in garden lands. Other crops in dry lands include pepper, fruit trees etc.

2. Profile morphology

Considering the physiographical positions, nine soil profiles were excavated. These profiles were located in well drained uplands and in low lands. The profiles from blocks I, V and B were located in paddy lands and the remaining six profiles were representing garden lands. The morphological descriptions of the profiles are given in Appendix I.

2.1 Colour

The upland soils have surface colour ranging from yellowish red to strong brown, dark and weak red with a predominant hue of 7.5 YR. The hue of subsurface horizons vary from 5 YR to 10 YR. In lower layers, colour varied from yellowish red to yellowish brown.

In lowlands, the colour of soils vary from a hue of 7.5 YR to 10 YR with varying value and chroma.

The colour of the soils are typical of the tropical and intensely weathered regions. The colour ranging from yellow to red is due to strong pigmenting effect of haematite which is a dominant mineral in the soil. These soils have a fairly high free iron oxide content (Table 13) which has also contributed to its colour.

2.2 Structure

All profiles have weak to medium sub-angular blocky structure in surface layer. The structure graded from medium to moderate sub angular blocky in the sub surface layer in all profiles except in profile V. The structural development was more pronounced in the lower horizons. The high sesquioxide content of these soils, and the conducive drainage conditions may be responsible for the good structural development observed in these soils. Krishnakumar (1991) has also obtained results which are in agreement with the above findings in his study on the soils of Edamalayar command area.

In the case of ill drained paddy soils represented by the profile of block V weak sub angular blocky structure was observed in the surface layer with massive structure in the lower horizons. Puddling of the soil for paddy cultivation, relatively high water table and consequent poor drainage condition may be the factors responsible for the weak structure and poor horizon development observed in this block.

2.3 Coarse fragments

The results are presented in Tables 3 and 4. Profiles from block F, L and IX show high gravel content of 51.26, 55.09 and 57.33 per cent mean values respectively. The blocks F and IX showed uniform high content of gravel throughout the profile irrespective of depth whereas in L block it was maximum in the lowest layer. All these blocks are uplands. In the other three blocks coming under the upland namely C, VIII and X, gravel content was comparatively low in all the layers in C block whereas in VIII block it was high in the surface and in lowest layers with low content in the middle layer. In block X, the gravel content decreased with depth. The lowest gravel content was in block C.

In the case of wet lands namely B, I and V blocks, they have fairly low gravel content compared to the blocks F, L, VIII and IX which are uplands. In blocks B and V, the middle layer has the least value whereas in block I the last layer has the lowest gravel content. However profiles from blocks C (upland) and I (wet land) showed least gravel content ranging from 22.00 to 44.18 per cent and 27.37 to 39.88 per cent respectively.

There was no clear difference between uplands and low lands with respect to the gravel content. All the soils contained a large volume of coarse fragments. The presence of such a large volume of coarse fragments will have a great influence on soil properties like pore size distribution, penetrability to roots, water retention and transmission characteristics. The gravel according to Mohr and Van Baren (1959) is mainly the disintegration product of fossilized laterite. All these soils may be developed from the same type of parent material. There is not much difference in the elevation between the uplands and wet lands. These may be the reasons for the insignificant difference in the gravel content between the uplands and wet lands.

2.4 Texture

Texture of the soils of profiles are presented in Table 3. The texture ranged from sand to loamy sand, sandy loam, loam, sandy clay loam, clay loam and sandy clay. In the case of texture also no significant difference was noticed between uplands and low lands.

2.5 Drainage

In general, the soils of the area under study are well drained. All the profiles except that of block V has rapid to moderate permeability. The high gravel content of soils has a dominant role in deciding the permeability of soils. The paddy soils of the V block is imperfectly drained mainly because of its physiographic position. The presence of greyish coloured lower layer with mottlings is indicative of the impeded drainage conditions.

2.6 Particle size distribution

The particle size distribution of soils, range and mean values for profiles are presented in Tables 3 and 4. The depth wise distribution of the particle size fraction in the soil profiles is illustrated in Fig.2.

In general, the soils of the area under study represented by the profiles are dominated by the sand fraction. Among the sand fractions, coarse sand fraction formed the predominant fraction in all the blocks. Coarse sand showed maximum variation in block I ranging from 18.62 to 63.68 per cent. The coarse sand fraction showed a decreasing trend with depth in all the blocks except in block I, although some variations were also noticed. All the soils in the area are developed from acid igneous rock with quartz predominating the light mineral suite. The acid igneous rock on weathering produce quartz rich in fertile soils. The higher sand fraction owes its origin to parent material from which the soils were formed.

The fine sand fraction however showed no uniform trend of variability with depth. The fine sand fraction of the lowest layer was higher compared to the surface layer in blocks B, C, V, VIII and X and in all other blocks a reverse trend was noticed. Here also no difference in the pattern of distribution of fine sand was noticed between upland and wet land soils. The fine sand fraction of wet lands varied from 9.24 per cent in block B to 27.71 per cent in block V and that of uplands varied from 6.11 per cent in block IX to 42.78 per cent in block X.

For wet lands, the silt fraction ranged from 6.42 per cent in block I to 29.50 per cent in block V. The silt formed the highest per cent of 49.90 in block IX while the lowest content of 3.75 per cent was recorded in block C for uplands. An increase in the silt content with depth was noticed in the profile of block IX but in all other profiles it showed no definite trend with depth.

In the case of clay content, it varied from a lowest content of 15.0 to 44.0 per cent in block I for wet lands. For uplands it recorded the lowest value of 4.62 per cent in F block and the highest value of 48.04 per cent in C block.

For paddy fields, increased clay content was noticed in the sub surface layer compared to the surface layer. In the case of uplands also increased clay content in sub surface layer was noticed in blocks C, F, L and X. In blocks VIII and IX comparatively high content was noticed in the surface layer compared to the sub surface layer.

The highest clay content was noticed in block C and the lowest content was noticed in F block both coming under garden land. As in the case of sand and silt no clear difference was noticed between garden and wet lands in the clay content also. Compared to fine sand and silt fraction, clay content was higher in all the blocks except in blocks F VIII, IX and X. The intense weathering conditions of the profiles may be responsible for the complete transformation of the feldspar to clay with insignificant proportion of silt in most of the profiles.

The coarse sand to fine sand ratio varied from 0.71 to 7.63 per cent in uplands. In wet lands, it ranged from 0.94 to 5.31 per cent. The silt to clay ratio varied from 0.08 per cent in C block to 6.2 per cent in block X, both are uplands.

Among the textural ratios, silt to clay ratio was taken as an index of weathering of the soil. Van Wambeke (1962) reported that silt to clay ratio less than 0.15 and weatherable minerals less than 3 per cent as indicative of highly weathered conditions. All the profiles except the profile in block IX registered values above the limits stipulated by Van Wambeke indicating less mature nature of soils. The silt to clay ratio of both the upland and wet land soils fall within the same range indicating similarities in their maturity.

Table 3. Particle size distribution of soils

Soil profile and depth (cm)	Coarse fragments >2mm, (%)	Size, class and particle diameter in mm (%)				Textural class	Coarse sand / Fine sand	Silt/ clay
		Coarse sand 2-0.2	Fine sand 0.2-0.02	Silt 0.02-0.002	Clay <.002			
1	2	3	4	5	6	7	8	9
B Block								
0-10	47.05	56.75	11.33	10.35	21.57	Sandy loam	5.01	0.47
10-15	45.68	44.57	9.24	10.30	35.89	Sandy clay loam	4.82	0.28
15-30	26.92	50.54	9.52	13.94	26.00	Sandy loam	5.31	0.54
30-60	46.98	48.64	13.93	10.10	27.33	Sandy loam	3.49	0.36
60-125	32.85	49.04	15.93	12.10	22.92	Sandy loam	2.07	0.52
C Block								
0-10	32.50	53.29	11.50	22.00	13.21	Sandy loam	4.63	1.66
10-35	34.48	42.63	9.56	18.91	28.19	Sandy clay loam	4.46	0.65
35-55	44.18	37.45	13.80	3.75	45.00	Sandy clay loam	2.71	0.08
55-100	23.94	34.55	13.82	5.60	37.33	Sandy clay loam	2.50	0.15
100-150	22.00	23.69	17.07	11.20	48.04	Sandy loam	1.38	0.23

Contd.

Table 3 (Contd.)

1	2	3	4	5	6	7	8	9
F Block								
0-10	56.65	55.86	28.92	10.60	4.62	Sand	1.93	2.29
10-35	46.31	50.07	14.97	12.34	22.62	Sandy loam	3.34	0.55
35-45	48.38	23.27	20.07	26.08	30.58	Sandy clay loam	1.15	0.85
45-75	45.45	20.08	28.68	28.17	23.09	Sandy clay loam	0.71	1.22
75-120	59.49	36.04	18.32	24.64	21.00	Sandy clay loam	1.96	1.17
L Block								
0-14	51.94	36.40	15.31	19.00	29.29	Sandy clay loam	2.38	0.65
14-40	49.09	34.67	14.71	8.57	42.00	Sandy clay	2.35	0.20
40-80	48.91	36.70	13.42	6.88	43.00	Sandy clay	2.73	0.16
80-110	56.84	32.73	14.65	14.62	38.00	Sandy clay loam	2.23	0.38
110-160	68.67	31.98	14.85	16.17	37.00	Sandy loam	2.15	0.43
I Block								
0-20	39.88	50.83	21.41	12.76	15.00	Sandy loam	2.37	0.85
20-60	34.33	18.62	11.04	26.34	44.00	Clay loam	1.69	0.59
60-100	27.37	63.68	14.90	6.42	15.00	Loam sand	4.27	0.43

Contd.

Table 3 (Contd.)

1	2	3	4	5	6	7	8	9
V Block								
0-10	45.58	34.50	16.66	20.10	28.74	Sandy clay loam	2.07	0.69
10-30	48.19	30.66	19.77	15.53	34.04	Sandy clay loam	1.55	0.45
30-45	33.75	26.35	19.84	29.50	24.31	Sandy clay loam	1.33	1.21
45-70	41.66	26.06	27.71	26.23	20.00	Sandy loam	0.94	1.31
70-125	41.77	30.37	24.16	23.47	22.00	Sandy clay loam	1.25	1.06
VIII Block								
0-7	52.17	40.94	26.10	8.46	24.50	Sandy clay loam	1.56	0.34
7-17	51.80	39.40	24.97	21.10	14.53	Sandy loam	1.58	1.45
17-41	25.24	34.00	28.46	17.80	19.74	Sandy loam	1.19	0.90
41-110	35.93	36.19	24.81	27.11	11.89	Sandy loam	1.45	2.28
110-150	52.17	37.98	27.37	16.98	17.67	Sandy loam	1.38	0.96
IX Block								
0-10	55.55	46.23	12.72	5.05	36.00	Sandy loam	3.63	0.14
10-25	59.46	34.40	16.20	26.10	23.30	Sandy clay loam	2.12	1.12
25-45	56.45	31.16	6.11	39.80	22.93	Loam	5.09	1.73
45-71	57.45	18.93	11.45	43.22	26.40	Loam	1.65	1.63
71-110	59.52	24.06	28.80	43.10	4.04	Silty clay loam	0.83	1.06
110-140	55.55	29.19	10.30	49.90	10.61	Loam	2.83	4.70

Contd.

Table 3 (Contd.)

1	2	3	4	5	6	7	8	9
X Block								
0-10	46.39	55.24	16.74	18.10	9.92	Loamy sandy	3.29	1.82
10-35	39.56	55.02	7.21	15.20	22.57	Sandy clay loam	7.63	0.67
35-75	36.48	46.36	8.83	38.60	6.22	Sandy loam	5.25	6.21
75-100	33.33	39.36	42.78	8.16	9.70	Sand	0.92	0.84

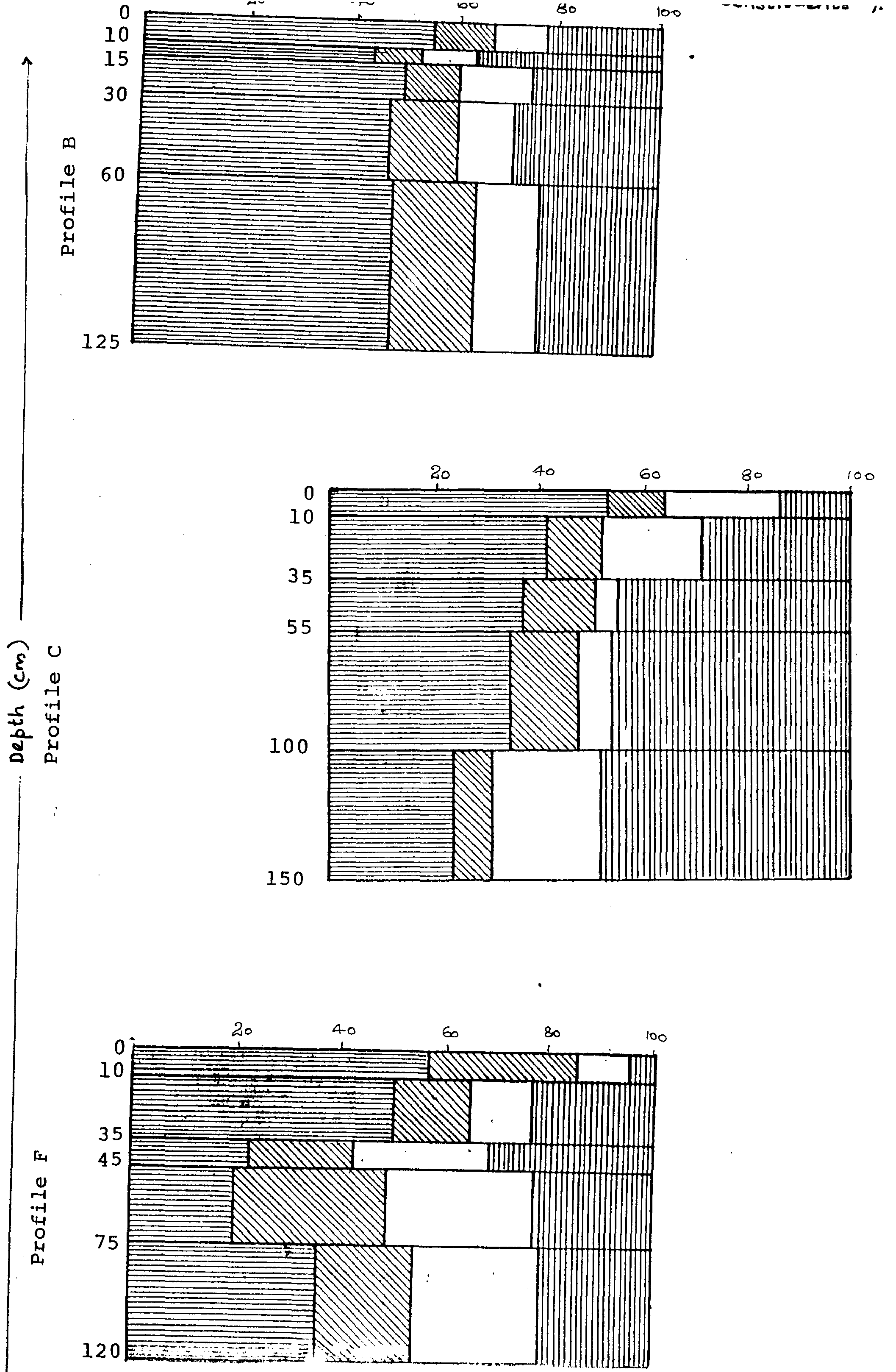

FIG.2 PARTICLE SIZE DISTRIBUTION WITH DEPTH IN SOIL PROFILES

Fig.2 (Contd.)

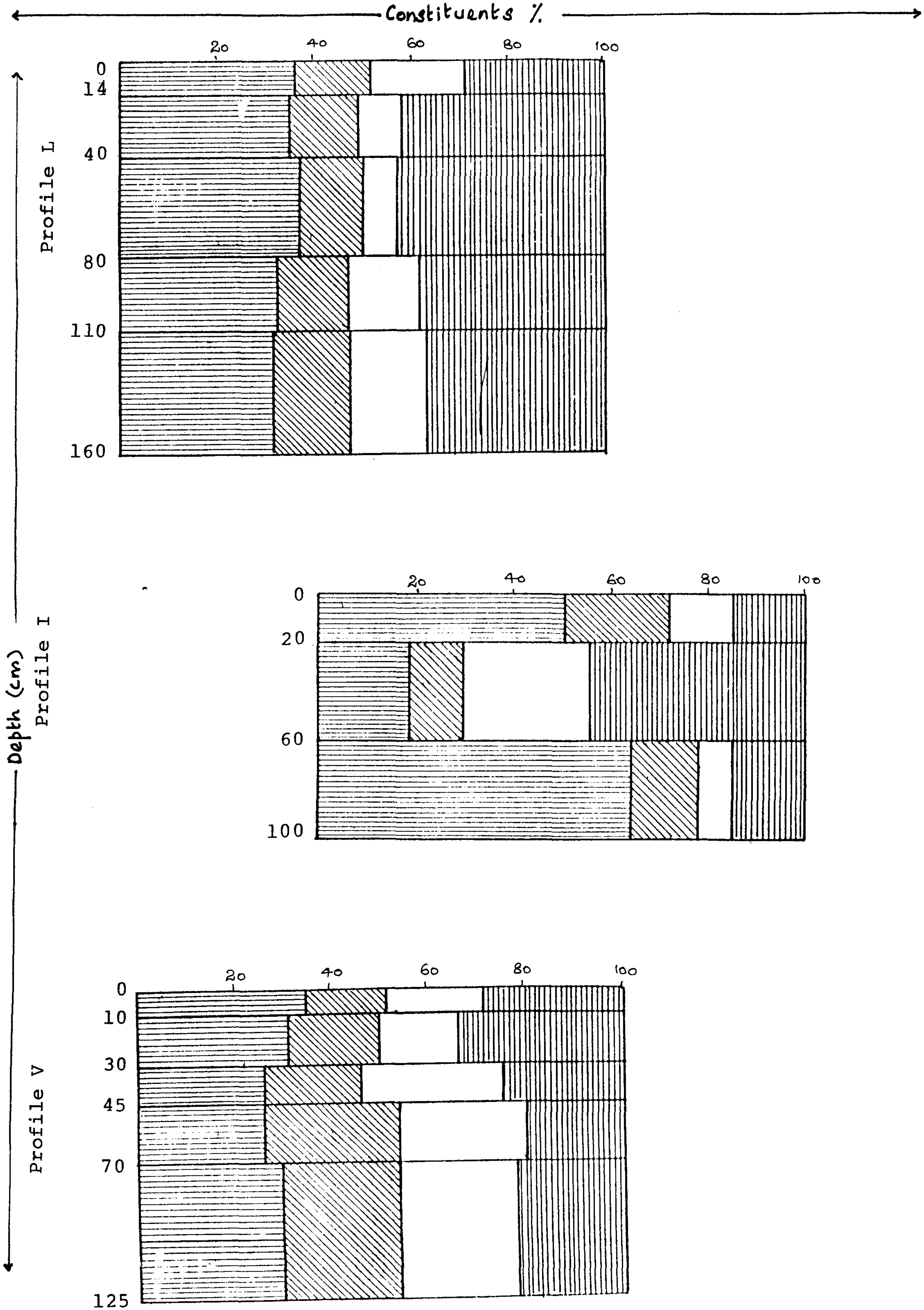
Constituents %
Depth (cm)
Profile L
20
40
60
80
100
0
14
40
80
110
160
Profile I
20
40
60
80
100
0
20
60
100
Profile V
20
40
60
80
100
0
10
30
45
70
125

Fig.2 (Contd.)

20
40
60
80
100
0
7
17
41
110
150
Profile VIII
0
10
25
45
71
110
140
Profile IX
Depth (cm)
0
10
25
75
100
Profile X
COARSE SAND
FINE SAND
SILT
CLAY

Table 4. Particle size distribution - range and mean values for profiles

Soil profile	Constituents (%)					Coarse sand/ Fine sand	Silt/clay
	Coarse fragments >2 mm	Coarse sand 2-0.2 mm	Fine sand 0.2-0.02 mm	Silt 0.02-0.002 mm	Clay <.002 mm		
B	26.92-47.05 (39.89)	44.57-56.75 (49.91)	9.24-15.94 (11.99)	10.10-13.94 (11.36)	21.57-35.89 (26.74)	3.07-5.31 (4.34)	0.28-0.54 (0.43)
C	22.0-44.18 (31.42)	23.69-53.29 (38.32)	9.56-17.07 (13.15)	3.75-22.00 (12.29)	13.21-48.04 (34.49)	1.38-4.63 (3.14)	0.08-1.66 (0.55)
F	45.45-59.49 (51.26)	20.08-55.86 (37.06)	14.97-28.92 (22.19)	10.60-28.17 (20.36)	4.62-30.58 (20.33)	0.71-3.34 (1.83)	0.55-2.29 (1.22)
L	48.91-68.67 (55.09)	31.98-36.70 (34.49)	13.42-15.31 (14.58)	6.88-19.0 (13.04)	29.29-43.00 (37.86)	2.15-2.73 (2.37)	0.16-0.65 (0.36)
I	27.37-39.88 (33.59)	18.62-63.68 (44.38)	11.04-21.41 (15.78)	6.42-26.34 (15.17)	15.00-44.00 (24.67)	1.69-4.27 (2.78)	0.43-0.85 (0.62)
V	33.75-48.19 (42.19)	26.06-34.50 (29.58)	16.66-27.11 (21.63)	15.23-29.50 (22.96)	20.00-34.04- (25.82)	0.94-2.07 (1.43)	0.45-1.31 (0.94)
VIII	25.24-52.17 (43.46)	34.0-40.94 (37.70)	24.81-28.46 (26.34)	8.46-27.11 (18.29)	11.89-24.5 (17.67)	1.19-1.53 (1.43)	0.34-2.28 (1.18)
IX	55.55-59.52 (57.33)	18.93-46.23 (30.66)	6.11-28.80 (25.07)	5.05-49.9 (34.53)	10.6-40.4 (26.61)	1.65-5.09 (2.69)	0.14-4.70 (1.73)
X	33.33-46.39 (38.94)	39.36-55.24 (48.99)	7.21-42.78 (18.88)	8.16-38.6 (20.02)	6.22-22.57 (12.10)	0.92-7.63 (4.27)	0.67-6.20 (2.39)

2.7 Physical constants

Physical constants of soils, its range and mean values for profiles are presented in Tables 5 and 6.

The apparent density did not reveal appreciable difference between soil profiles. It varied from 1.14 to 1.46 Mg m^{-3} in low lands, whereas the variation is from 1.05 to 1.46 Mg m^{-3} in uplands. Profile wise it is seen that apparent density increases with depth in profiles B and V, decreases with depth in C, L, IX and X, remains without much change in F, decrease initially with depth and later increase in block I, increase with depth and then decrease in block VIII. These results indicate that the general trend for wet lands was to increase with depth whereas for uplands no such trend was noticed. This indicates that the system of crop and soil management employed was likely to influence its bulk density. Brady (1988) reported that there is distinct tendency for the bulk density to increase with depth. This apparently results from a lower content of organic matter, less aggregation and root penetration and a compaction caused by the weight of the overlying layers. But in the present study such a trend was noticed in the profiles from wet lands only. Lack of such a trend in uplands may be due to the reason that the penetration to a deeper level which result in addition of organic matter and soil aggregation to a more deeper level in uplands than in wet lands.

The absolute specific gravity ranged from 1.97 to 2.30 Mg m^{-3} in low lands and in uplands it varied from 1.77 to 2.37 Mg m^{-3}. This property showed no uniform variability with depth. The profile of block B showed almost uniform value for absolute specific gravity irrespective of depth. However, there was no wide variation between upland and low land soils. Brady (1988) reported that mineral surface soils which always have high organic matter content than the sub soils, usually possess lower particle densities than do subsoils. But in the present study, such a trend was not noticed in most of the profiles. This may be because of the migration of organic matter to lower layers which is mainly the result of high rainfall.

The absolute specific gravities are not above 2.70 and this indicates that the observed variations could only be due to difference in organic matter content. The profile values varied from 1.77 to 2.37. The narrow range in the property is indicative of the more or less similar primary mineral assemblage of these soils.

Maximum water holding capacity varied from 27.78 to 44.59 per cent in low lands and from 26.37 to 50.83 per cent in uplands. Different patterns are observed with regard to

Table 5. Physical constants of soils

Soil profile and depth (mm)	Apparent density ($Mg\ m^{-3}$)	Absolute specific gravity ($Mg\ m^{-3}$)	Maximum water holdiing capacity (%)	Pore space (%)
1	2	3	4	5
B Block				
0-10	1.28	2.27	38.49	50.64
10-15	1.37	2.22	31.46	43.68
15-30	1.37	2.30	32.69	45.79
30-60	1.41	2.23	30.66	44.31
60-125	1.46	2.27	27.78	41.11
C Block				
0-10	1.46	2.24	31.64	43.84
10-35	1.15	1.85	45.32	53.12
35-55	1.13	2.07	45.46	52.07
55-100	1.21	2.04	41.45	45.28
100-150	1.15	1.78	42.25	40.95
F Block				
0-10	1.22	1.85	40.11	35.78
10-35	1.22	1.91	40.05	37.16
35-45	1.23	1.99	39.92	42.40
45-75	1.25	2.00	39.28	39.54
75-120	1.21	1.94	40.16	38.02

Contd.

Table 5 (Contd.)

1	2	3	4	5
L Block				
0-14	1.21	1.94	40.27	38.15
14-40	1.18	2.04	41.13	44.80
40-80	1.14	1.88	42.79	43.45
80-110	1.15	1.93	43.99	41.99
110-160	1.12	1.87	45.49	41.76
I Block				
0-20	1.36	2.18	32.24	39.59
20-60	1.14	2.01	44.59	45.95
60-100	1.33	2.21	30.01	40.91
V Block				
0-10	1.29	1.97	32.19	39.16
10-30	1.25	2.22	34.52	50.31
30-45	1.25	2.17	35.78	46.79
45-70	1.39	2.27	31.22	47.49
70-125	1.35	2.23	32.59	45.56
VIII Block				
0-7	1.17	2.05	42.16	48.74
7-17	1.19	2.03	43.91	45.01
17-41	1.46	2.37	27.62	41.36
41-110	1.12	1.79	48.27	52.74
110-150	1.07	1.79	49.47	41.13

Contd.

Table 5 (Contd.)

1	2	3	4	5
IX Block				
0-10	1.20	2.14	39.06	51.38
10-25	1.09	2.18	48.21	49.82
25-45	1.06	1.82	50.85	40.23
45-71	1.06	1.78	49.39	39.81
71-110	1.11	1.90	47.57	41.50
110-140	1.05	1.77	50.83	41.02
X Block				
0-10	1.43	2.10	27.67	35.46
10-35	1.36	2.14	32.11	42.29
35-75	1.28	2.10	26.37	43.46
75-100	1.23	2.07	35.34	45.94

Table 6. Physical constants - range and mean values for profiles

Soil profile	Apparent density ($Mg\ m^{-3}$)	Absolute specific gravity ($Mg\ m^{-3}$)	Maximum water holding capacity (%)	Pore space (%)
B	1.27-1.46 (1.37)	2.22-2.27 (2.25)	27.78-38.49 (32.22)	41.11-50.64 (45.10)
C	1.13-1.46 (1.22)	1.78-2.24 (1.99)	31.64-45.46 (41.22)	40.95-53.12 (47.05)
F	1.21-1.25 (1.22)	1.85-2.00 (1.93)	39.28-40.16 (39.90)	35.78-42.40 (38.58)
L	1.12-1.21 (1.16)	1.87-2.04 (1.93)	40.27-45.49 (42.73)	38.15-44.80 (42.08)
I	1.14-1.36 (1.27)	2.01-2.21 (2.13)	30.01-44.59 (35.61)	39.59-45.95 (42.15)
V	1.25-1.38 (1.30)	1.97-2.27 (2.17)	31.22-35.78 (33.26)	39.16-50.31 (45.86)
VIII	1.07-1.46 (1.20)	1.61-2.37 (1.98)	27.62-49.47 (42.28)	41.13-52.94 (45.83)
IX	1.05-1.20 (1.09)	1.77-2.18 (1.93)	39.06-50.83 (47.65)	39.81-51.38 (43.96)
X	1.23-2.06 (1.50)	2.07-2.14 (2.10)	26.37-35.34 (30.37)	35.46-45.94 (41.78)

the variation in the maximum water holding capacity in the profiles. The maximum water holding capacity remains fairly steady in F block, decreases with depth in B block, increases initially with depth and then decreases in blocks C, I and V, increases with depth in blocks L and IX increases initially then decreases and again increases in VIIIth and Xth blocks.

The percentage pore space is found to be the highest in the middle layer in most of the profiles i.e., C, F, L, I, V and VIII, whereas it decreases with depth in B and IX and increases with depth in X. With regard to pore space also no definite pattern of variation could be observed in different profiles. This is evidently due to changes in the factors influencing these values brought about by frequent disturbances caused by intensive land use.

2.8 Chemical characteristics

2.8.1 Soil reaction, electrical conductivity and organic carbon content of soil

The soil reaction, electrical conductivity, C content, C to N ratio, its range and mean values for profiles are given in Tables 7 and 8 respectively.

Soils were in general acidic with pH in 1:2.5 soil water varying from 4.8 in C block to 6.9 in block X in the case of uplands and 5.0 to 6.7 in the case of low lands. The acidic nature of parent rock, intense weathering condition and leaching of bases under high rainfall are the factors contributing to acidity. No distinct variation was noticed between upland and wet land soils in pH. The pH showed an increasing trend with depth in blocks C and I whereas the reverse was true for block F. Other profiles showed no definite variation with depth.

Out of the three wet land profiles B, I and V, surface soil recorded low values for blocks B and I whereas in block V which is an ill drained area surface soil recorded the highest value. In upland soils, out of the six blocks C, L and X recorded low values in the surface soil whereas in F, VIII and IX a comparatively high value was read in the surface layer. Frequent disturbances of the soil caused by intensive land use may be one of the reasons for the lack of any definite trend in the pH value of the soils within the profile or between upland and wet lands.

The electrical conductivity values were very low and showed little variation within the profile and between soils from different profiles. The electrical conductivity of wet land soils ranged from 0.035 dS m^{-1} in B block to 0.354 dS cm^{-1} in Vth block whereas for uplands it ranged from 0.017 to 0.116 dS m^{-1} in C and X block respectively.

The exchange acidity was maximum for blocks V and VIII with a value of 0.70 cmol(+) kg^{-1} and all other blocks recorded values lower than this. The exchange acidity showed a decreasing trend with depth for profiles B, F and L while it remained without change in the block I and increased with depth in block X. In all other blocks, it showed no regular trend with depth.

The organic carbon content of soils was low and it is characteristic of tropical soils. Organic matter mineralisation under tropical condition is very rapid causing its depletion (Brady, 1988). The organic carbon content of soils varied from 0.44 per cent in Vth block to 1.96 per cent in B block in the case of wet lands. For uplands, it ranged from 0.55 to 1.36 per cent. Organic carbon content was high in the surface layer compared to the lower layers in blocks B and VIII. In blocks C, F, L, I, V and IX it showed a tendency to increase with depth where as in block X it remained without much variation in different layers.

The results of the present study disagrees with the results reported by other workers. Hassan (1977) reported that the organic matter content of the surface soils are generally higher as most of the organic residues in both cultivated and in virgin soils are incorporated in or deposited on the surface. But in this study, only in six out of nine profiles selected, organic carbon content was found to increase with depth. One of the possible explanations for the increased organic carbon content in the lower layers is that it may be due to the translocation and deposition of humus from the surface layers under conditions of high rainfall. Texture of the soil in most of the area is sandy loam or sandy clay loam and this may accelerate easy leaching of the humus. However, the increase in carbon content in the lower layers in the profile in blocks L and V is much more than what could be anticipated by such a process. Biswas and Mukherjee (1987) have also reported that coarse textured soils show accumulation of organic matter in the lower layers having been leached out from the surface as soil organic matter is composed of molecules which can move downwards through soil pores if not too fine.

No significant difference was noticed between the upland and low land soils in organic carbon content. Under waterlogged anaerobic situation prevailing in the paddy field, the rate of degradation of organic matter is reported to be markedly low compared to upland aerobic situation. But in this study, such difference is not noticed between uplands and low lands. It has to be noted that after every two cropping seasons in a year, the fields pass through a summer fallow when the soils are totally dry and during this period, it is possible that the accumulated humus gets oxidised.

Table 7. Soil reaction, electrical conductivity and C/N ratio of profile samples

Soil profile and depth (cm)	Soil reaction (1:2.5)	Electrical conductivity (1:2.5) dS m^{-1}	Exchange acidity cmol(+) kg^{-1}	C (%)	C/N
1	2	3	4	5	6
B Block					
0-10	5.1	0.046	0.3	1.96	7.84
10-15	6.4	0.035	0.2	1.44	7.20
15-30	6.1	0.037	0.1	1.38	9.85
30-60	5.9	0.040	0.1	1.35	9.64
60-125	6.0	0.036	0.1	1.45	8.05
C Block					
0-10	4.8	0.046	0.4	1.11	9.25
10-35	5.0	0.044	0.6	1.09	7.26
35-55	5.0	0.028	0.5	1.17	7.31
55-100	5.2	0.020	0.5	1.21	9.30
100-150	5.3	0.017	0.1	1.35	9.00
F Block					
0-10	6.5	0.088	0.3	0.85	6.07
10-35	6.1	0.051	0.2	0.90	5.00
35-45	6.0	0.052	0.1	1.24	8.26
45-75	6.0	0.043	0.1	1.30	9.97
75-120	6.0	0.043	0.1	1.23	8.20

Contd.

Table 7 (Contd.)

1	2	3	4	5	6
L Block					
0-14	5.1	0.046	0.3	0.55	4.23
14-40	6.4	0.035	0.2	0.60	3.33
40-80	6.1	0.037	0.1	1.26	8.40
80-110	5.9	0.040	0.1	1.14	7.60
110-160	6.0	0.036	0.1	1.36	7.55
I Block					
0-20	5.3	0.057	0.2	1.01	5.61
20-60	5.5	0.039	0.2	1.14	7.60
60-100	6.1	0.074	0.2	1.35	9.00
V Block					
0-10	6.7	0.207	0.4	0.44	7.33
10-30	6.3	0.354	0.4	0.48	8.00
30-45	5.0	0.067	0.7	0.65	7.22
45-70	5.8	0.042	0.2	1.25	8.92
70-125	6.0	0.042	0.2	1.34	9.57
VIII Block					
0-7	6.2	0.046	0.5	1.55	9.68
7-17	5.8	0.075	0.7	1.12	9.33
17-41	5.1	0.048	0.2	1.36	9.71
41-110	5.8	0.040	0.5	1.29	8.06
110-150	5.6	0.043	0.4	1.36	9.71

Contd.

Table 7 (Contd.)

1	2	3	4	5	6
IX Block					
0-10	5.6	0.020	0.2	1.00	8.33
10-25	6.0	0.064	0.4	1.00	9.09
25-45	5.2	0.045	0.4	1.22	8.71
45-71	5.5	0.047	0.2	1.28	8.53
71-110	5.6	0.036	0.1	1.20	8.00
110-140	5.5	0.026	0.1	1.29	9.21
X Block					
0-10	5.4	0.034	0.1	1.24	9.53
10-35	6.9	0.116	0.1	1.23	8.78
35-75	6.1	0.037	0.2	1.25	8.33
75-100	5.7	0.028	0.2	1.21	9.30

Table 8. Soil reaction, electrical conductivity and C:N ratio of soil profiles - range and mean values

Soil profile	Soil reaction (1:2.5)	Electrical conductivity (1:2.5) dS m^{-1}	Exchange acidity cmol(+) kg^{-1}	C (%)	C/N
1	2	3	4	5	6
B	5.1-6.4 (5.90)	0.036-0.046 (0.039)	0.1-0.3 (0.16)	1.35-1.96 (1.52)	7.20-9.85 (8.52)
C	4.8-5.3 (5.06)	0.017-0.046 (0.031)	0.1-0.6 (0.42)	1.09-1.35 (1.18)	7.26-9.45 (8.42)
F	6.0-6.5 (6.12)	0.043-0.088 (0.055)	0.1-0.3 (0.16)	0.85-1.31 (1.11)	5.00-9.97 (7.50)
L	5.1-6.4 (5.90)	0.035-0.046 (0.038)	0.1-0.3 (0.16)	0.55-1.36 (0.98)	3.33-8.40 (6.22)
I	5.1-5.5 (5.13)	0.039-0.074 (0.056)	0.2-0.3 (0.25)	1.01-1.35 (1.16)	5.61-9.00 (7.40)
V	5.0-6.7 (5.96)	0.042-0.354 (0.149)	0.2-0.7 (0.38)	0.44-1.34 (0.83)	7.22-9.57 (8.21)
VIII	5.1-6.2 (5.70)	0.040-0.075 (0.050)	0.2-0.7 (0.46)	0.55-1.36 (1.14)	8.06-9.71 (9.29)
IX	5.2-6.0 (5.56)	0.020-0.064 (0.049)	0.1-0.4 (0.23)	0.9-1.29 (1.09)	8.00-9.21 (8.65)
X	5.4-6.9 (6.02)	0.028-0.116 (0.059)	0.1-0.2 (0.15)	0.84-1.31 (1.15)	8.33-9.53 (8.98)

The C to N ratio ranged from 3.33 in L block to 9.97 in F block. Brady (1988) reported that in general the C to N ratio is narrower for sub soils than for the corresponding surface layers. In the present study no such trend was noticed. In the case of wet land soils the ratio was higher in most of the lower layers compared to the surface layer of soil, in all the three blocks. No regular trend was noticed with depth in the upland soils. It is generally stated that the C to N ratio of soil will be usually within the range of 10:1 to 12:1 whereas the result of the present investigation gave mean values less than 10:1. The lower C to N ratio obtained in the study may be due to the greater degree of oxidation of organic matter thereby decreasing the ratio between carbon and nitrogen. The increase in the nitrogen content of the soil due to regular application of manures and fertilizers as the area is belongs to a research station may be another reason for the lowering of the C to N ratio of the soil. Low C to N ratios less than 10:1 have been reported by many workers in tropical soils. In Kerala soils similar results have been reported by many workers (Padmam, 1992; Venugopal, 1980).

2.8.2 Total nutrient content of soils

The total nutrient content of soils are presented in Table 9 and range and mean values in Table 10.

The total nitrogen content ranged from 0.06 to 0.25 per cent in the case of wet lands and 0.11 to 0.18 per cent for uplands. Among the profiles from wetlands namely B, I and V, nitrogen content was very low in block V compared to the other two blocks in the surface soil upto 45 cm depth. Organic carbon content was also low in this profile upto 45 cm depth.

No regular variation was observed depth-wise in the profiles or between profiles. The heavy monsoon rains leading to leaching of organic matter to lower layers may be one of the reasons responsible for the lack of a regular trend in the distribution of N in the profile.

Total P_2O_5 content varied from 0.039 to 0.169 per cent for wet lands and from 0.047 to 0.195 per cent for uplands. The values are in accordance with the findings of Hassan (1977) in respect of the laterite soils of Kerala. An irregular pattern of distribution of P_2O_5 with depth was a feature showed by all profiles.

The content of total K_2O varied from 0.028 to 0.152 per cent for wet lands whereas for uplands it ranged from 0.025 to 0.206 per cent. As in the case of P_2O_5, K_2O content also showed an irregular distribution with depth. Similar results have been reported by Venugopal (1980) in most of the profiles of the laterite soils of Kerala. The total K_2O

content of the soil was rather low which is in agreement with the findings of Venugopal (1969) in respect of the laterite and red soils of Kerala.

In the case of total calcium, its content ranged from 0.13 to 1.20 per cent for wet lands and from 0.05 to 1.17 per cent for dry lands.

Total MgO content ranged from 0.08 to 0.43 per cent for wet lands and 0.07 to 1.18 per cent for uplands. Both CaO and MgO showed no regular pattern of distribution with depth. The level of total magnesium was more or less the same as that of total calcium in these soils. The results obtained in the present study agree with the findings of Venugopal (1969). No significant difference was noticed between the uplands and wetlands in the content of total CaO and MgO. Contrary to this, Hassan (1977) in a study of the ribbon valley laterite of Kerala observed an increase in the contents of CaO and MgO in the wetland soils as compared to uplands.

Total Na_2O content for wet lands varied from 0.005 to 0.015 per cent and for uplands it varied from 0.006 to 0.026 per cent.

The total reserves of P_2O_5, K_2O, CaO, MgO and Na_2O were low as is expected of a humid tropical soil where intense

Table 9. Total nutrient content of soils (per cent on whole soil basis)

Soil horizon and depth (cm)	N	P_2O_5	K_2O	CaO	MgO	Na_2O	Sesqui oxides (R_2O_3)
1	2	3	4	5	6	7	8
B Block							
0-10	0.25	0.134	0.065	0.55	0.20	0.011	10.04
10-15	0.20	0.064	0.054	1.20	0.08	0.012	9.95
15-30	0.14	0.064	0.047	0.13	0.13	0.005	10.42
30-60	0.14	0.049	0.066	0.35	0.20	0.011	10.88
60-125	0.18	0.039	0.049	0.15	0.10	0.006	10.01
C Block							
0-10	0.12	0.070	0.092	0.13	0.20	0.112	10.21
10-35	0.15	0.075	0.152	0.08	0.35	0.017	21.06
35-55	0.16	0.068	0.162	0.25	0.38	0.016	21.59
55-100	0.13	0.058	0.220	0.85	0.38	0.020	20.74
100-150	0.15	0.047	0.228	1.17	0.85	0.019	10.90
F Block							
0-10	0.14	0.063	0.152	0.65	0.43	0.026	11.32
10-35	0.18	0.053	0.132	0.27	0.35	0.017	11.75
35-45	0.15	0.055	0.182	0.30	0.33	0.020	10.60
45-75	0.13	0.062	0.168	0.50	0.27	0.020	11.30
75-120	0.15	0.068	0.192	0.55	0.35	0.020	11.51

Contd.

Table 9 (Contd.)

1	2	3	4	5	6	7	8
L Block							
0-14	0.13	0.195	0.146	0.43	0.35	0.023	11.21
14-40	0.18	0.181	0.172	0.10	0.25	0.019	10.76
40-80	0.15	0.136	0.190	0.23	0.40	0.022	11.32
80-110	0.15	0.110	0.180	0.45	0.43	0.016	11.58
110-160	0.18	0.127	0.206	0.40	0.35	0.021	11.28
I Block							
0-20	0.18	0.075	0.028	0.78	0.33	0.006	11.40
20-60	0.15	0.169	0.152	0.25	0.28	0.010	11.12
60-100	0.15	0.077	0.054	0.25	0.18	0.007	11.14
V Block							
0-10	0.06	0.112	0.076	0.63	0.20	0.009	10.92
10-30	0.06	0.117	0.078	0.40	0.18	0.010	10.05
30-45	0.09	0.098	0.058	0.43	0.15	0.006	10.50
45-70	0.14	0.108	0.074	0.78	0.43	0.015	10.50
70-125	0.14	0.119	0.070	0.38	0.25	0.009	11.18
VIII Block							
0-7	0.16	0.178	0.172	0.10	0.35	0.012	10.50
7-17	0.12	0.145	0.164	0.35	0.28	0.013	10.51
17-41	0.14	0.047	0.028	0.05	0.08	0.006	11.22
41-110	0.16	0.138	0.027	0.25	0.48	0.022	10.79
110-150	0.14	0.151	0.025	0.10	0.37	0.023	11.17

Contd.

Table 9 (Contd.)

1	2	3	4	5	6	7	8
IX Block							
0-10	0.12	0.148	0.098	0.25	1.18	0.020	11.50
10-25	0.11	0.117	0.136	0.20	0.10	0.022	11.31
25-45	0.14	0.091	0.110	0.18	0.07	0.015	12.35
45-71	0.14	0.094	0.164	0.23	0.10	0.023	12.05
71-110	0.15	0.082	0.152	0.23	0.15	0.023	11.30
110-140	0.14	0.087	0.190	0.28	0.25	0.026	11.32
X Block							
0-10	0.13	0.119	0.082	0.13	0.13	0.014	12.31
10-35	0.14	0.152	0.110	0.25	0.25	0.018	6.16
35-75	0.15	0.169	0.158	0.10	0.15	0.020	4.98
75-100	0.13	0.143	0.180	0.05	0.28	0.020	6.44

Table 10. Total nutrient content of soils - range and mean values for profiles (per cent on whole soil basis)

Soil profile	N	P_2O_5	K_2O	CaO	MgO	Na_2O	Sesqui oxides
B	0.14-0.25 (0.18)	0.039-0.134 (0.07)	0.047-0.066 (0.055)	0.13-1.20 (0.47)	0.08-0.20 (0.14)	0.005-0.012 (0.009)	9.95-10.88 (10.26)
C	0.12-0.16 (0.14)	0.047-0.075 (0.064)	0.092-0.228 (0.171)	0.08-1.17 (0.49)	0.20-0.55 (0.38)	0.016-0.112 (0.037)	10.21-21.59 (16.90)
F	0.13-0.18 (0.15)	0.053-0.068 (0.060)	0.132-0.192 (0.165)	0.27-0.65 (0.45)	0.27-0.43 (0.35)	0.017-0.026 (0.021)	10.60-11.75 (11.29)
L	0.13-0.18 (0.16)	0.110-0.195 (0.149)	0.146-0.206 (0.178)	0.10-1.45 (0.52)	0.25-0.43 (0.36)	0.006-0.010 (0.020)	10.76-11.58 (11.23)
I	0.15-0.18 (0.16)	0.075-0.169 (0.107)	0.028-0.158 (0.078)	0.25-1.78 (0.76)	0.18-0.33 (0.26)	0.006-0.010 (0.008)	11.12-11.40 (11.22)
V	0.06-0.14 (0.09)	0.098-0.119 (0.111)	0.058-0.078 (0.071)	0.38-0.78 (0.52)	0.15-0.43 (0.24)	0.006-0.015 (0.009)	10.05-11.18 (10.63)
VIII	0.12-0.16 (0.14)	0.047-0.178 (0.132)	0.025-0.172 (0.083)	0.05-0.35 (0.17)	0.08-0.48 (0.31)	0.006-0.023 (0.015)	10.50-11.22 (10.83)
IX	0.11-0.15 (0.13)	0.082-0.148 (0.103)	0.098-0.190 (0.142)	0.18-0.28 (0.23)	0.07-1.18 (0.11)	0.015-0.026 (0.022)	11.30-12.35 (11.63)
X	0.13-0.15 (0.14)	0.119-0.169 (0.146)	0.082-0.180 (0.133)	0.05-0.25 (0.13)	0.13-0.28 (0.20)	0.014-0.020 (0.018)	4.98-12.31 (7.47)

weathering conditions leave very little of primary minerals except quartz.

Total sesquioxide content varied from 9.95 to 11.40 per cent for wet lands whereas for uplands it varied from 4.98 to 21.59 per cent. There was not much difference in the sesquioxide content within the profile, in blocks B, F, L, I, V, VIII and IX whereas in the C block the content was higher in the middle layers and in block X it decreased with depth. Contrary to the above, no definite pattern with depth was reported in the Fe_2O_3 and Al_2O_3 contents by Venugopal (1980). In the present study no significant difference was noticed between uplands and low lands in the contents of sesquioxides. This is not in agreement with the results reported by Venugopal (1980) who noticed a marked decrease in the Fe_2O_3 and Al_2O_3 contents of the soil down the slope in the three roposequences studied in Kerala. The sesquioxide content was comparatively high in all the profiles and it was characteristic of laterite soils because of the progressive enrichment of Fe and Al in the upper horizons of the profiles during the process of laterisation.

2.8.3 Cation exchange properties

Cation exchange properties, exchangeable cations and their range and mean values are presented in Table 11 and 12 respectively.

2.8.3.1 Cation exchange capacity

The ammonium acetate extractable CEC varied from 3.0 to 9.6 cmol(+) kg^{-1} for wet lands and 5.6 to 12.8 cmol(+) kg^{-1} for uplands. Although a general trend of increase in CEC with depth was there, for upland soils, a gradual decrease with depth was noticed for blocks B and V which are wet lands. In the case of organic carbon also there was an increase with depth in all the profiles except in the profiles from B and VIIIth blocks. The increased organic matter content of the lower layers may be the reason for the higher CEC of soils in the lower layers.

Besides organic matter another important factor that influences the CEC of the soil is the clay content. The clay content in block B was found to be higher in lower layers while the cation exchange capacity showed a reverse trend. This indicates that CEC is dependent not only on the quantity of clay but also on its lattice structure and electrochemical nature. The laterite soils are known to contain kaolinite as the dominant clay mineral in addition to varying amounts of hydrous oxides of iron and aluminium.

The CEC of the soils under investigation are generally low and it can be attributed to the predominance of Kaolinite. Sathyanarayana and Thomas (1961) and Venugopal (1980), while working on laterite soils of Kerala, have obtained similar results.

2.8.3.2 Exchangeable cations

Among the exchangeable cations, calcium formed the predominant one in all the soils observed. The content of exchangeable Ca varied from 0.88 to 3.25 cmol(+) kg^{-1} for wet lands whereas for uplands it varied from 0.38 to 3.75 cmol(+) kg^{-1}. An increase in Ca content in the lower layers was noticed in the profiles of C, F, L, I, VIII and IX blocks whereas Ca content showed a tendency to decrease in the lower layers of the profiles of B, V and X blocks. The variations in CEC with depth also showed almost the same trend in blocks B and V as the CEC decreased with depth. There was no distinct difference between wet lands and uplands in the exchangeable Ca content.

The second major exchangeable cation is magnesium and it ranged from 0.42 to 3.33 cmol(+) kg^{-1} for wet lands and from 0.25 to 4.58 cmol(+) kg^{-1} for uplands. Magnesium content showed a trend to increase in the lower layers in the profiles B, C, L, I and IX whereas in the profiles V and VIII it showed a trend to decrease in the lower layers. In blocks F and X, Mg content first increased and then decreased in the lower layers.

Exchangeable potassium content varied from 0.03 to 0.12 cmol(+) kg^{-1} for wet lands and from 0.09 to 0.56 cmol(+) kg^{-1} for uplands. Its content showed a trend to increase with depth in profiles L, I, V, VIII and X but it showed no definite trend with depth in the case of other profiles. Exchangeable potassium content was found to be comparatively low in wet lands compared to uplands.

The exchangeable sodium content varied from 0.07 cmol(+) kg^{-1} in IXth block to 0.26 cmol(+) kg^{-1} in blocks F and VIII in dry lands and from 0.08 cmol(+) kg^{-1} in Ist block to 0.52 cmol(+) kg^{-1} in Vth block for wet lands. Exchangeable sodium content showed a tendency to decrease with depth in all the profiles from wet lands whereas no such trend was noticed in uplands.

Sum of exchangeable bases recorded the highest value of 8.39 cmol(+) kg^{-1} for block IX and the lowest value of 1.17 cmol(+) kg^{-1} for block C. The values showed a uniform increase with depth only for C block . For blocks F, L, I and IX also increased content of exchangeable bases was noticed in the lower layers compared to the surface soil whereas for other blocks no definite trend was noticed with depth. Percentage base saturation varied from 15.80 in block C to 98.71 in block IX.

Table 11. Cation exchange properties of soils

Soil profile and depth (mm)	Exchangeable cations cmol (+) kg^{-1}				Sum of bases cmol(+) kg^{-1}	CEC cmol(+) kg^{-1}	Base saturation (%)
	Ca	Mg	K	Na			
1	2	3	4	5	6	7	8
B Block							
0-10	1.62	0.63	0.12	0.19	2.56	5.6	45.71
10-15	1.75	0.75	0.06	0.17	2.73	3.4	80.29
15-30	1.38	1.25	0.06	0.14	2.83	3.2	88.43
30-60	1.50	1.12	0.07	0.12	2.81	4.0	70.25
60-125	1.25	0.88	0.07	0.09	2.29	3.0	76.33
C Block							
0-10	0.38	0.38	0.28	0.13	1.17	7.4	15.80
10-35	1.25	0.25	0.26	0.12	1.88	8.1	23.21
35-55	2.13	0.63	0.40	0.09	3.25	9.1	35.71
55-100	2.50	1.50	0.22	0.15	4.37	11.3	38.67
100-150	2.63	1.63	0.09	0.10	4.45	11.6	38.36
F Block							
0-10	1.88	1.10	0.32	0.15	3.45	6.3	54.76
10-35	2.88	1.20	0.33	0.13	4.54	6.6	68.78
35-45	2.88	2.90	0.14	0.26	6.18	6.3	98.09
45-75	3.25	1.60	0.36	0.17	5.38	7.1	75.77
75-120	3.75	1.90	0.17	0.15	5.97	7.3	81.78

Contd.

Table 11 (Contd.)

1	2	3	4	5	6	7	8
L Block							
0-14	1.75	1.00	0.19	0.15	3.09	7.0	44.14
14-40	2.25	1.38	0.25	0.15	5.03	7.7	65.32
40-80	2.50	1.25	0.20	0.15	4.10	7.6	53.95
80-110	3.38	1.25	0.24	0.16	5.03	7.6	66.18
110-160	3.50	1.63	0.24	0.16	5.53	8.2	67.44
I Block							
0-20	0.88	0.63	0.03	0.12	1.66	3.4	48.82
20-60	3.25	1.50	0.06	0.18	4.99	9.6	51.98
60-100	1.38	2.00	0.07	0.08	3.53	4.2	84.05
V Block							
0-10	2.13	3.33	0.05	0.52	5.56	6.0	92.66
10-30	2.25	1.45	0.11	0.24	4.05	4.5	90.00
30-45	1.25	0.42	0.06	0.11	1.84	5.5	33.45
45-70	1.88	1.87	0.11	0.11	3.97	6.4	62.03
70-125	1.75	2.08	0.11	0.12	4.06	5.0	81.20
VIII Block							
0-7	1.25	2.28	0.38	0.13	4.04	6.4	63.13
7-17	1.25	1.87	0.39	0.17	3.68	7.3	50.41
17-41	2.13	1.45	0.16	0.26	4.00	8.0	50.00
41-110	1.88	2.91	0.45	0.23	5.47	12.8	42.73
110-150	1.50	1.25	0.45	0.24	3.44	12.6	27.30

Contd.

Table 11 (Contd.)

1	2	3	4	5	6	7	8
IX Block							
0-10	2.88	2.49	0.29	0.07	5.73	8.1	70.74
10-25	2.12	1.87	0.56	0.09	4.64	8.0	58.00
25-45	3.75	2.70	0.55	0.07	7.07	7.9	89.49
45-71	2.12	1.04	0.18	0.11	3.45	10.0	34.50
71-110	3.62	4.58	0.11	0.08	8.39	8.5	98.71
110-140	3.12	4.36	0.11	0.09	7.68	8.6	89.30
X Block							
0-10	2.75	2.12	0.32	0.09	5.28	5.6	94.28
10-35	2.50	2.70	0.36	0.11	5.67	6.4	88.59
35-75	2.25	3.74	0.19	0.09	6.27	6.8	92.21
75-100	2.38	1.25	0.36	0.10	4.09	8.4	48.69

Table 12. Cation exchange properties of - soils range and mean values for profiles

Soil profile	Exchangeable cations cmol (+) kg^{-1}				Sum of bases cmol(+) kg^{-1}	CEC cmol(+) kg^{-1}	Base saturation %
	Ca	Mg	K	Na			
1	2	3	4	5	6	7	8
B	1.25-1.75 (1.50)	0.63-1.25 (0.93)	0.06-0.12 (0.07)	0.09-0.19 (0.1)	2.29-2.83 (2.64)	3.0-5.6 (3.84)	45.71-88.43 (72.20)
C	0.38-2.63 (1.78)	0.25-1.63 (0.88)	0.09-0.40 (1.25)	0.09-0.15 (0.12)	1.17-4.45 (3.02)	7.4-11.6 (9.50)	15.80-38.67 (30.35)
F	1.88-3.75 (2.93)	1.10-2.90 (1.74)	0.14-0.36 (0.26)	0.13-0.26 (0.17)	3.45-6.18 (5.10)	6.3-7.3 (6.70)	54.76-98.09 (75.84)
L	1.75-3.50 (2.68)	1.00-2.38 (1.30)	0.19-0.25 (0.22)	0.15-0.16 (0.15)	3.09-5.53 (4.56)	7.0-8.2 (7.62)	44.14-67.44 (59.41)
I	0.88-3.25 (1.84)	0.63-2.00 (1.38)	0.03-0.07 (0.05)	0.08-0.18 (0.13)	1.66-4.99 (3.39)	3.4-9.6 (5.73)	48.82-84.05 (61.60)
V	1.25-2.25 (1.85)	0.42-3.33 (1.83)	0.05-0.11 (0.09)	0.11-0.52 (0.22)	1.84-5.56 (0.89)	4.5-6.4 (5.48)	33.45-92.66 (71.87)
VIII	1.25-2.13 (1.60)	1.25-2.91 (1.95)	0.16-0.45 (0.37)	0.13-0.26 (0.21)	3.44-5.47 (4.13)	6.4-12.8 (9.42)	27.30-63.13 (46.71)
IX	2.12-3.75 (2.94)	1.04-4.58 (2.84)	0.11-0.56 (0.30)	0.07-0.11 (0.09)	3.45-8.39 (6.16)	7.9-10.0 (8.52)	34.50-98.71 (73.46)
X	2.25-2.75 (2.47)	1.25-3.74 (2.45)	0.19-0.36 (0.31)	0.09-0.11 (0.09)	4.09-6.27 (5.33)	5.6-8.4 (6.80)	48.69-94.28 (80.94)

The mean percentage base saturation in all the profiles was below 80 which is characteristic of acid soils. Of the different cations studied, exchangeable sodium was the lowest in most of the horizons in blocks C, F, L, VIII, IX and X whereas in blocks B, I and V which are wetlands, sodium content was found to be higher compared to potassium in all the layers. Generally, the requirement of K for paddy is high compared to other decotyledonous plants grown in uplands and that may be the reason for low content of K and high content of Na in wetlands.

Exchangeable Ca, Mg, K and Na have recorded low values characteristic of lateritic soils formed under conditions of high rainfall, temperature and intense leaching. The predominant exchangeable cation was calcium followed by Mg, K and Na in uplands and Mg, Na and K in wetlands. Low values of exchangeable cations have been reported by Venugopal and Koshy (1976), Venugopal (1980) in laterite soils of Kerala.

2.8.4 Extractable iron and active iron ratio

The total Fe_2O_3, dithionate-citrate extractable iron (Fe_d), oxalate extractable iron (Fe_o) and active iron ratio are presented in Table 13.

Total iron content varied from 2.12 in B block to 8.55 per cent in block V for wet lands and for uplands it varied from 5.14 per cent in block VIII to 10.55 per cent in F block. Only a narrow range of variation in total iron content was observed between blocks. No uniform trend of variation was noticed with depth. In profiles from blocks B and C the least accumulation of total iron content was noticed in lower most layer.

The Fe_d ranges from 1.18 per cent in block B to 6.94 per cent in block V. The Fe_d showed maximum accumulation in the lower most layer for profiles in L and X blocks, whereas in the profile from block B, the lowest content was recorded in the lowest horizon.

The Fe_d formed the major portion of total iron in all the soils under investigation. The accumulation of Fe_d in sub surface layer was observed in all the profiles except in profiles from L and Xth blocks. The accumulation in the sub surface layers is suggestive of passive movement of these oxides along with the finer fractions (Blume and Schwertmann, 1969). The Fe_d is often taken as an indication of the age of soils (Alexander, 1974). Profile means showed not much variation indicating the more or less same rating of the soils in the maturity scale.

Fe_d expressed as percentage of total iron is often referred to as the "degree of freeness of iron oxide". This

Table 13. Total iron and iron fractions in profile samples (per cent on whole soil basis)

Soil profile and depth (cm)	Total	Fe_d	Fe_o	Fe_o/Fe_d	$\frac{Fe_d \times 100}{Fe_t}$
1	2	3	4	5	6
B Block					
0-10	5.98	3.17	0.464	0.140	53.01
10-15	6.44	4.96	0.424	0.080	77.01
15-30	3.76	2.74	0.204	0.070	72.87
30-60	4.30	3.15	0.203	0.060	73.25
60-125	2.12	1.18	0.207	0.170	55.66
C Block					
0-10	7.66	5.06	0.888	0.017	66.05
10-35	9.75	6.38	0.145	0.022	65.45
35-55	8.08	5.66	0.146	0.025	70.04
55-100	7.52	4.38	0.135	0.030	58.24
100-150	6.10	4.36	0.662	0.151	71.40
F Block					
0-10	6.84	3.82	0.070	0.018	55.84
10-35	8.70	4.35	0.111	0.025	50.00
35-45	10.55	5.24	0.093	0.017	49.66
45-75	10.25	5.68	0.167	0.029	55.41
75-120	9.35	5.60	0.154	0.027	59.89

Contd.

Table 13 (Contd.)

1	2	3	4	5	6
L Block					
0-14	8.70	5.16	0.454	0.087	59.31
14-40	10.05	4.10	0.636	0.155	40.79
40-80	7.32	5.06	0.169	0.033	69.12
80-110	7.44	4.96	0.820	0.165	66.66
110-160	8.65	5.64	0.652	0.115	65.20
I Block					
0-20	2.68	1.59	0.224	0.140	59.32
20-60	7.22	4.68	0.430	0.091	64.88
60-100	3.12	2.25	0.530	0.235	72.11
V Block					
0-10	4.76	3.24	0.54	0.158	68.06
10-30	4.78	4.08	0.388	0.095	85.35
30-45	3.44	2.72	0.118	0.043	79.06
45-70	8.55	6.94	0.682	0.093	81.16
70-125	6.66	4.56	0.630	0.138	68.46
VIII Block					
0-7	7.54	5.06	0.155	0.030	67.10
7-17	7.48	5.44	0.144	0.026	72.72
17-41	5.14	3.20	0.130	0.040	62.25
41-110	6.52	5.08	0.414	0.081	77.91
110-150	7.20	5.02	0.147	0.029	69.72

Contd.

Table 13 (Contd.)

1	2	3	4	5	6
IX Block					
0-10	10.25	2.78	0.147	0.052	27.12
10-25	9.60	4.38	0.117	0.026	48.39
25-45	9.05	2.75	0.119	0.043	20.38
45-71	8.55	4.88	0.180	0.036	57.07
71-110	8.30	2.69	0.249	0.092	22.41
110-140	8.80	2.92	0.138	0.047	33.18
X Block					
0-10	5.28	2.23	0.086	0.038	42.23
10-35	5.30	1.62	0.120	0.074	29.45
35-75	6.14	2.73	0.220	0.080	44.46
75-100	6.10	2.81	0.055	0.019	46.06

Table 14. Total iron and iron fractions in soil, its range and mean values for profile (per cent on whole soil basis)

Soil profile	Total	Fe_d	Fe_o	Fe_o/Fe_d	$\frac{Fe_d x100}{Fe_t}$
1	2	3	4	5	6
B	2.12-6.44 (4.52)	1.18-4.96 (3.04)	0.203-0.464 (0.299)	0.06-0.17 (0.10)	53.01-77.01 (66.36)
C	6.10-9.75 (7.82)	4.36-6.38 (5.16)	0.088-0.662 (0.219)	0.017-0.151 (0.049)	58.24-71.40 (66.24)
F	6.84-10.55 (9.14)	3.82-5.68 (4.94)	0.070-0.167 (0.119)	0.017-0.027 (0.023)	49.66-59.89 (54.16)
L	7.32-10.05 (8.43)	4.10-5.64 (4.98)	0.169-0.820 (0.546)	0.033-0.165 (0.111)	40.79-69.12 (60.22)
I	2.68-7.22 (4.34)	1.59-4.68 (2.84)	0.224-0.530 (0.394)	0.091-0.235 (0.155)	59.32-72.11 (65.43)
V	3.44-8.55 (5.63)	2.72-6.94 (4.31)	0.118-0.682 (0.472)	0.043-0.158 (0.106)	68.06-85.35 (76.42)
VIII	5.14-7.54 (6.77)	3.20-5.44 (4.76)	0.130-0.414 (0.198)	0.026-0.081 (0.041)	62.25-77.91 (69.94)
IX	8.30-10.25 (9.09)	2.69-4.88 (3.40)	0.117-0.249 (0.158)	0.026-0.092 (0.049)	20.38-57.07 (26.91)
X	5.28-6.14 (5.71)	1.62-2.81 (2.35)	0.055-0.220 (0.120)	0.019-0.080 (0.053)	29.45-46.06 (40.55)

was found to be maximum in Vth block (68.06 to 85.35 per cent) and minimum for block IX (20.38 to 57.07 per cent).

The oxalate extractable iron recorded low values compared to Fe_d and ranged from 0.05 per cent in X block to 0.82 per cent in L block. Juo *et al.* (1974) had reported low values of Fe_d in soils derived from acidic rocks. The soils under investigation being products of weathering of acidic rocks explains the low values of Fe_o observed in the study.

Ratio of Fe_o to Fe_d termed as active iron ratio also recorded low values ranging from 0.017 per cent in blocks C and F to 0.230 per cent in Ist block. Alexander (1974) had observed that oxalate extracted iron is less than dithionate-citrate extracted iron in mineral soils and that active iron ratio approached zero in old tropical soils. The strinkingly low values of iron ratio in the present study lend support to the assumption that the soils are developed from laterite terraces. Both the oxalate extractable iron and active iron ratio do not show any uniform trend of variation within the profile.

2.9 Taxonomy

The details of classification of soils under Soil Taxonomy is given in Table 15.

Table 15. Classification of pedons under Soil Taxonomy

Profile No.	Order	Sub order	Great group	Sub group	Diagnostic Horizon	
					Epipedon	Endopedon
B Block	Entisol	Fluvent	Tropofluvent	Typic Tropofluvent	Ochric	-
C Block	Entisol	Orthent	Troporthent	Typic Troporthent	Ochric	-
F Block	Inceptisol	Ochrepts	Eutrochrepts	Oxyaquic Eutrochrepts	Ochric	Cambic
L Block	Inceptisol	Ochrepts	Eutrochrepts	Oxyaquic Eutrochrepts	Ochric	Cambic
I Block	Entisol	Fluvents	Tropofluvents	Typic Tropofluvents	Ochric	-
V Block	Inceptisol	Ochrepts	Eutrochrepts	Oxyaguic Eutrochrepts	Ochric	Cambic
VIII Block	Entisol	Psamment	Tropopsamment	Typic Tropopsamment	Ochric	-
IX Block	Entisol	Orthent	Troporthent	Typic Troporthent	Ochric	-
X Block	Entisol	Orthent	Troporthent	Typic Troporthent	Ochric	-

Plate 1. Profile B - Typic Tropofluvent

Plate 2. Profile V - Oxyaquic Eutrochrepts

Plate 3. Profile L - Oxyaquic Eutrochrepts

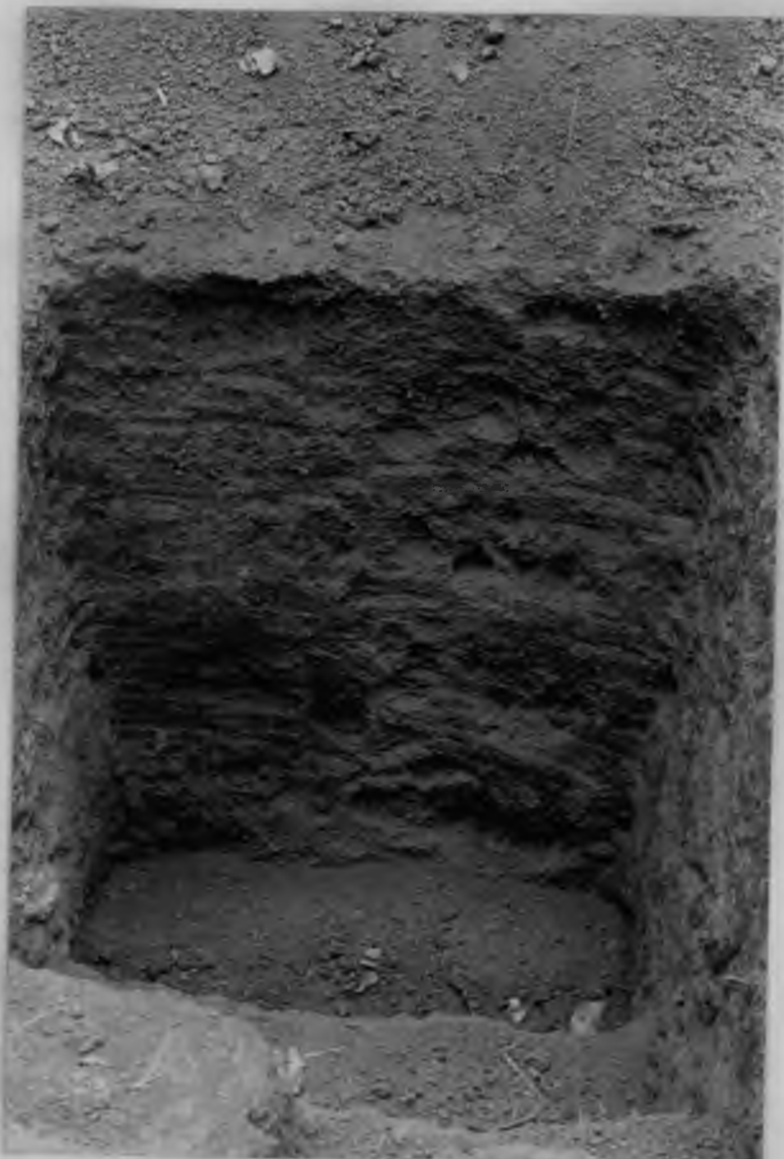

Plate 4. Profile IX - Typic Troporthent

Classification of soils under Soil Taxonomy was attempted upto the subgroup level. Out of the 9 profiles studies, 3 of them i.e., the profiles in blocks F, L and V comes under the order Inceptisols and the remaining 6 i.e., B, C, I, VIII, IX and X came under Entisols. No difference was observed between uplands and wet lands.

3. Analysis of surface samples

3.1 Mechanical composition

Particle size distribution of the surface soil samples are given in Table 16.

Out of the 22 blocks, 10 blocks A, B, D, I, II, III, IV, V, VI and VII are low land paddy fields and the remaining 12 blocks C, E, F, G, H, K, L, M, N, VIII, IX and X come under uplands.

The predominant texture in the farm is sandy loam, 10 blocks out of 22 are having this texture. The other textural classes are loamy sand, sandy clay loam, clay loam, loam and sand.

Sand formed the predominant fraction in all the samples and the content varied from 43.77 to 92.00 per cent. Silt was the lowest fraction in 16 blocks and clay formed the lowest fraction in the remaining 6 blocks. Silt content

Table 16. Particle size distribution of soils (surface samples), per cent

Block No.	Course fragments >2 mm	Size, class and particle diameter (mm)			Textural class
		Sand 2.0-0.2	Silt 0.02-0.002	Clay <0.002	
1	2	3	4	5	6
A	12.44	88.00	4.00	8.00	Loamy sand
B	26.92	62.57	10.10	27.33	Sandy loam
C	35.30	64.00	6.00	30.00	Clay loam
D	22.00	92.00	4.00	4.00	Loamy sand
E	32.48	64.79	22.00	13.21	Sandy clay loam
F	27.63	75.96	11.20	12.84	Sandy loam
G	59.50	55.39	24.51	20.10	Sandy loam
H	32.85	78.10	10.00	12.00	Loamy sand
K	46.58	62.50	10.17	27.33	Sandy loam
L	31.21	51.60	19.10	29.29	Sandy clay loam
M	42.30	43.77	26.23	20.00	Sandy loam
N	35.30	72.24	12.76	15.00	Sandy loam
I	35.00	72.00	13.00	15.00	Sandy loam
II	36.63	64.37	21.90	13.73	Sandy loam
III	14.50	88.00	4.00	8.00	Loamy sand
IV	15.00	80.00	4.00	16.00	Loam
V	35.69	46.19	25.07	28.74	Sandy clay loam

Contd.

Table 16 (Contd.)

1	2	3	4	5	6
VI	41.66	53.77	26.23	20.00	Sandy loam
VII	17.69	82.14	8.16	9.70	Sand
VIII	35.30	64.37	21.10	14.53	Sandy loam
IX	37.50	75.00	5.00	20.00	Loam
X	22.67	78.10	10.00	12.00	Loamy sand

varied from 4.00 to 26.23 per cent and clay content varied from 4.00 to 30.00 per cent. As noticed in the profile studies, no significant variation was noticed between upland and wet land soils in mechanical composition. The fairly uniform nature of the texture of soils of all the blocks indicate uniform maturity of soils.

3.2 Physical constants

Physical constants of surface soil samples are presented in Table 17.

The mean apparent density values varied from 1.16 to 1.47 Mg m^{-3} for uplands and from 1.21 to 1.50 Mg m^{-3} for wet lands. The mean values for absolute specific gravity ranged from 1.93 to 2.73 Mg m^{-3} in garden lands and from 2.05 to 2.59 Mg m^{-3} in wet lands. Mean water holding capacity varied from 28.14 to 42.17 per cent in garden lands and from 31.78 to 39.99 per cent in wet lands. In the case of pore space, the mean values varied from 42.19 to 48.79 per cent in wet lands and from 39.67 to 52.72 per cent in dry land. The data indicated that there is no marked difference in the values of physical constants due to cultivation practices, crops grown, topography of the land etc.

One of the important factors that influences the bulk density, water holding capacity and pore space is the content

Table 17. Physical constants - range and mean values for surface samples

Block No.	Apparent density ($Mg\ m^{-3}$)	Absolute specific gravity ($Mg\ m^{-3}$)	Maximum water holding capacity (%)	Pore space (%)
1	2	3	4	5
A	1.24-1.28 (1.26)	2.01-2.31 (2.19)	34.10-40.41 (36.52)	46.92-50.66 (42.57)
B	1.20-1.25 (1.22)	2.11-2.22 (2.16)	38.32-41.90 (39.99)	46.94-50.44 (48.48)
C	1.27-1.60 (1.47)	2.16-3.14 (2.70)	25.26-34.68 (30.71)	38.82-54.62 (47.86)
D	1.26-1.33 (1.29)	2.21-2.23 (2.22)	34.69-37.77 (36.38)	45.45-47.52 (46.47)
E	1.15-1.40 (1.25)	2.06-2.54 (2.31)	31.06-41.98 (36.44)	45.50-51.58 (46.47)
F	1.13.1.21 (1.18)	2.07-2.15 (2.10)	36.23-40.34 (38.41)	46.78-51.14 (49.33)
G	1.19-1.33 (1.29)	2.04-2.25 (2.16)	31.04-37.25 (33.41)	43.51-47.22 (45.42)
H	1.23-1.35 (1.27)	2.07-2.24 (2.12)	32.21-36.02 (34.93)	43.35-44.83 (44.07)
K	1.25-1.39 (1.31)	2.18-2.31 (2.24)	29.22-37.84 (34.30)	42.06-47.67 (45.38)
L	1.12-1.21 (1.16)	1.87-2.04 (1.93)	40.26-45.49 (42.17)	38.15-44.80 (42.03)
M	1.22-1.52 (1.38)	2.21-3.16 (2.73)	31.52-40.09 (36.65)	45.41-58.08 (52.72)
N	1.17-1.28 (1.23)	2.10-2.17 (2.13)	33.11-42.14 (36.53)	45.16-51.07 (47.84)

Contd.

Table 17 (Contd.)

1	2	3	4	5
I	1.29-1.38 (1.34)	2.15-2.21 (2.19)	29.36-33.70 (31.78)	40.77-43.63 (42.19)
II	1.16-1.26 (1.21)	2.01-2.16 (2.05)	35.92-37.14 (36.53)	45.17-47.75 (46.54)
III	1.21-2.44 (1.50)	2.12-3.02 (2.59)	28.08-39.70 (32.19)	42.12-50.93 (47.27)
IV	1.32-1.37 (1.33)	2.12-2.20 (2.16)	29.81-33.37 (31.78)	41.59-43.59 (42.60)
V	1.25-1.42 (1.32)	2.11-2.52 (2.23)	28.28-33.77 (31.39)	39.78-51.01 (43.77)
VI	1.21-1.27 (1.24)	2.08-2.21 (2.14)	31.00-38.36 (35.57)	44.81-48.52 (46.50)
VII	1.23-1.30 (1.25)	2.17-2.22 (2.19)	33.53-40.78 (36.59)	45.28-50.78 (48.79)
VIII	1.14-1.25 (1.19)	1.99-2.14 (2.07)	36.46-39.23 (37.62)	45.53-47.53 (46.85)
IX	1.25-1.32 (1.27)	2.19-2.21 (2.20)	32.46-36.68 (34.57)	43.54-46.48 (45.01)
X	1.35-1.37 (1.36)	2.19-2.22 (2.20)	27.13-29.28 (28.14)	38.46-41.01 (39.67)

of organic matter. The results of the study indicated that there is not much variation in the organic carbon content of the soil between uplands and wetlands and that may be the reason for the non significant difference in the physical constants between uplands and wet lands.

3.3 Soil reaction, electrical conductivity and organic carbon content of soil

The soil reaction and electrical conductivity of surface samples are given in Table 18.

Soils in general are acidic with pH values ranging from 4.71 in L block to 5.56 in block IX. For wet lands the values varied from 4.75 to 5.23 and for uplands it varied from 4.71 to 5.56. The soil reaction showed no marked difference between uplands and wet lands. Contrary to this Hassan (1977) by comparing the soil samples from two topographical positions of high land and low land in laterite soils of Kerala reported that the low land soils always have a higher pH than the upland soils. But Padmam (1992) based on the studies conducted in the permanent manurial experiments in rice at the RARS Pattambi, reported that no significant variation was noticed in the soil reaction due to wide variation in the quantity of manures and fertilizers applied for a long period. The results of this previous study lends support to our finding.

Table 18. Soil reaction and electrical conductivity - their range and mean values for surface samples

Block name	Soil reaction (1:2.5)	Electrical conductivity dS m^{-1}
1	2	3
A	4.87-5.37 (5.19)	0.042-0.093 (0.064)
B	4.71-5.04 (4.86)	0.049-0.113 (0.079)
C	4.85-5.73 (5.22)	0.023-0.047 (0.035)
D	5.0-5.50 (5.23)	0.030-0.037 (0.034)
E	4.55-4.97 (4.80)	0.039-0.116 (0.055)
F	4.48-5.31 (4.82)	0.032-0.097 (0.054)
G	4.64-5.92 (5.16)	0.042-0.101 (0.066)
H	4.57-5.28 (4.80)	0.034-0.175 (0.068)
K	5.10-5.30 (5.23)	0.037-0.048 (0.042)
L	4.39-4.96 (4.71)	0.037-0.142 (0.065)
M	4.75-4.94 (4.85)	0.038-0.088 (0.058)
N	4.51-5.39 (5.00)	0.029-0.067 (0.041)

Contd.

Table 18 (Contd.)

1	2	3
I	4.77-5.50 (5.20)	0.047-0.081 (0.060)
II	4.73-5.17 (5.05)	0.037-0.094 (0.064)
III	4.89-5.38 (4.75)	0.044-0.089 (0.064)
IV	4.65-5.11 (4.82)	0.068-0.126 (0.094)
V	4.54-5.58 (4.94)	0.052-0.125 (0.021)
VI	4.02-6.18 (4.96)	0.037-0.108 (0.069)
VII	4.93-5.86 (4.96)	0.042-0.080 (0.069)
VIII	4.81-6.38 (5.21)	0.041-6.088 (0.059)
IX	5.00-6.10 (5.56)	0.036-0.051 (0.043)
X	4.79-6.22 (5.51)	0.031-0.065 (0.049)

The mean electrical conductivity values varied from 0.021 dS m^{-1} in block V to 0.094 dS m^{-1} in block IV. This property also showed not much difference between wet and dry lands or due to differences in crops grown. The values obtained are low as expected in regions of high rainfall.

3.3.1 Organic Carbon

The organic carbon content varied from an average of 0.43 per cent in block IX to 1.2 per cent in C block (Table 19). No significant variation was noticed between uplands and wet lands in the organic carbon content of soils. The values are generally low as is characteristic of tropical soils. The high temperature of the area may be responsible for the rapid decomposition and depletion of organic matter as discussed earlier in the case of profile samples.

3.4 Available nutrient contents

3.4.1 Nitrogen

The available nutrients nitrogen, phosphorus and potassium contents for the surface samples, their range and mean values are given in Table 19.

The available nitrogen content varied from 141.1 kg ha^{-1} to 423.4 kg ha^{-1}. The nutrient index values calculated based on organic carbon content, indicated that out of the total 22 blocks, only one block i.e., block C recorded high level, 2 blocks i.e., I and IX recorded low level and the rest 19 blocks recorded medium level of N. Preliminary studies conducted earlier in the station, have indicated that out of the 22 blocks, nitrogen content was high in block III, medium in B blocks B, D, G, II, IV, V, VIII and IX and low in the rest 13 blocks A, C, E, F, H, K, L, M, N, I, VI, VIII and X. The results thus indicate that the N status of soil showed an increase in the available N content due to the continuous application of fertilizers and manures at the present dose of application.

3.4.2 Phosphorus

Available phosphorus content recorded the maximum value of 77.9 kg ha^{-1} in block X and a minimum value of 10.0 kg ha^{-1} in block VI. The nutrient index for phosphorus was high in 10 blocks, and medium in all remaining blocks E, K, M I, II, III, IV, V, VI, VII, IX and X.

In general the availability of P is low in laterite soils due to fixation by Fe and Al. Studies conducted earlier in the station have indicated that P was low in 9 blocks i.e., in B, C, E, G, K, II, V, VIII and IX and medium in remaining 13 blcoks. The results obtained in the present study indicated that the available P content increased during the last few years in almost all the blocks. The increase in the available P content may be due to the reasons that the soils are high in sesquioxide and kaolinite clays having high P adsorption capacities. They rapidly adsorb added soluble phosphates since the soil is acidic in nature, and they slowly become available during the course of time. Other reasons may be the low requirement of P by the crops compared to N and almost no phosphorus is lost by leaching. The present study indicates that available P is high in 14 blocks and medium in all other blocks. So the effect of skipping the application of P fertilizer can be considered. When excess P is retained in soil, further addition of fertilizer P can cause problems such as zinc deficiency especially in crops sensitive to Zn deficiency. The results of the present study also indicates that phosphatic fertilizers at a rate less than the recommended dose are only needed in blocks having high levels of available P. The higher availability of P noticed in the study may partly be due to the regular application of manures and fertilizers continuously for several years.

3.4.3 Potassium

Available potassium content ranged from 40.3 kg ha^{-1} in blocks III and IX to 219.5 kg ha^{-1} in blocks C, L, M, II and X. The soils of blocks A, B, D, I, II, III, IV, V, VI and IX rated average low available K and others medium. Earlier studies conducted indicated that the available K content of

Table 19. Available nutrient content nutrient indices and rating of soils - their range and mean values for surface samples,

Block Name	Organic carbon (%)	N kg ha^{-1}	Index	P kg ha^{-1}	Index	K kg ha^{-1}	Index
1	2	3	4	5	6	7	8
A	0.40-0.99 (0.60)	172.5-423.4 (295.3)	1.6 (M)	19.8-41.1 (26.05)	2.6 (H)	62.7-170.2 (107.52)	1.4 (L)
B	0.40-1.06 (0.84)	141.1-313.6 (209.4)	1.9 (M)	13.7-20.0 (33.10)	2.7 (H)	71.6-170.2 (104.80)	1.2 (L)
C	0.72-2.0 (1.20)	141.1-235.2 (200.7)	2.6 (H)	14.2-68.7 (26.80)	2.5 (H)	80.6-219.5 (142.90)	1.6 (M)
D	0.46-0.78 (0.68)	172.4-266.5 (224.2)	1.9 (M)	14.2-41.05 (32.1)	5.4 (H)	62.7-170.2 (107.5)	1.3 (L)
E	0.66-1.11 (0.88)	141.1-235.2 (192.6)	2.0 (M)	14.2-59.18 (20.6)	2.6 (H)	89.6-174.72 (134.4)	1.6 (M)
F	0.58-1.1 (0.73)	203.8-297.9 (248.6)	2.0 (M)	14.2-59.2 (24.2)	2.6 (H)	67.2-210.5 (138.8)	1.9 (M)
G	0.69-1.02 (0.81)	172.4-282.4 (210.8)	2.0 (M)	14.3-46.4 (27.7)	2.7 (H)	103.0-170.2 (126.9)	1.7 (M)
H	0.30-0.79 (0.64)	156.8-313.6 (225.7)	1.9 (M)	20.8-60.6 (34.3)	2.7 (H)	85.1-210.5 (158.7)	1.9 (M)
K	0.45-0.63 (0.62)	141.1-266.5 (192.0)	1.6 (M)	13.7-37.3 (29.9)	2.6 (H)	67.2-170.2 (126.9)	1.6 (M)
L	0.54-0.91 (0.66)	188.1-313.6 (245.6)	2.0 (M)	15.4-50.6 (31.6)	2.7 (H)	107.5-219.5 (163.1)	2.0 (M)

Contd.

Table 19 (Contd.)

1	2	3	4	5	6	7	8
M	0.54-0.82 (0.65)	141.1-266.5 (219.5)	2.0 (M)	17.2-45.0 (36.0)	1.6 (M)	152.3-219.5 (179.2)	2.0 (M)
N	0.45-0.87 (0.58)	156.8-250.8 (190.7)	1.6 (M)	13.1-70.2 (42.8)	2.8 (H)	129.9-201.6 (156.1)	2.0 (M)
I	0.4-0.00 (0.47)	235.2 -329.2 (277.7)	1.1 (L)	18.3-40.6 (26.8)	2.4 (M)	44.8-107.5 (72.3)	1.0 (L)
II	0.46-0.67 (0.60)	141.2-266.5 (196.0)	1.8 (M)	17.0-28.1 (21.0)	2.1 (M)	44.8-219.5 (87.1)	1.2 (L)
III	0.40-0.81 (0.66)	141.1-266.5 (213.2)	1.8 (M)	15.8-29.5 (19.0)	2.1 (M)	40.3-94.0 (53.7)	1.0 (L)
IV	0.69-1.0 (0.86)	188.1-297.9 (227.3)	2.0 (M)	13.0-57.9 (35.1)	2.6 (H)	44.8-76.1 (57.6)	1.0 (L)
V	0.40-1.5 (0.67)	141.1-392.0 (241.1)	1.9 (M)	11.8-37.3 (22.7)	2.3 (M)	44.8-170.2 (75.2)	1.0 (L)
VI	0.4-1.1 (0.60)	156.8-297.9 (232.7)	1.8 (M)	10.0-22.2 (14.8)	2.0 (M)	49.2-179.2 (99.7)	1.3 (L)
VII	0.57-1.08 (0.60)	172.4-266.5 (235.2)	2.0 (M)	11.8-35.8 (22.1)	2.6 (H)	89.6-210.5 (131.91)	1.6 (M)
VIII	0.57-0.99 (0.84)	203.8-329.2 (204.2)	2.0 (M)	13.9-69.4 (34.3)	2.6 (H)	44.8-170.2 (75.2)	1.7 (M)
IX	0.33-0.55 (0.43)	188.1-266.5 (230.4)	1.1 (L)	15.8-29.5 (19.0)	1.6 (M)	40.3-76.1 (57.6)	1.0 (L)
X	0.39-0.63 (0.55)	203.8-266.5 (204.4)	1.5 (M)	10.8-77.9 (25.1)	1.6 (M)	76.1-219.5 (169.2)	1.7 (M)

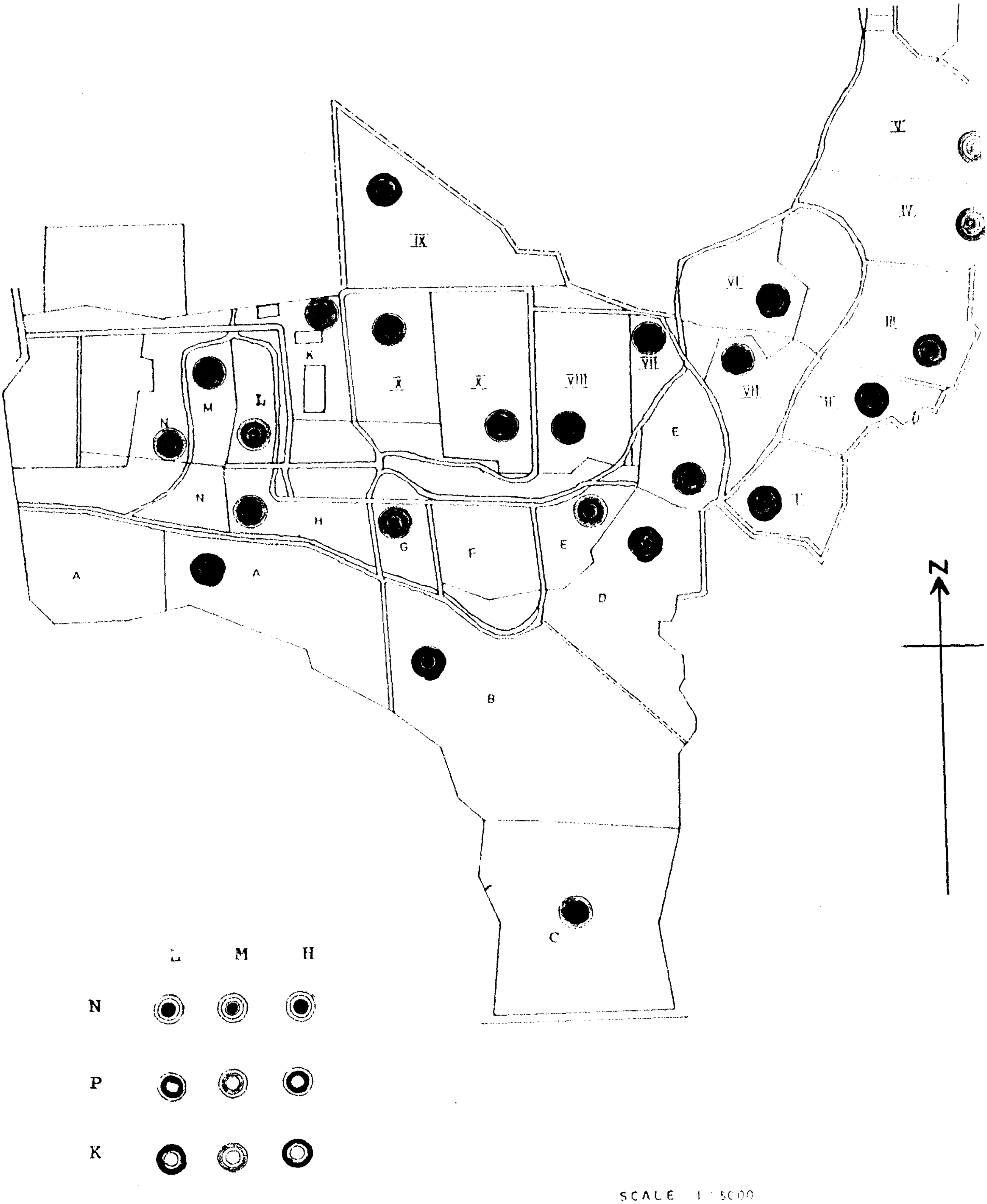

FIG.3 SOIL FERTILITY MAP OF THE STATION

soil was high in 2 blocks D and III and medium in 19 blocks. Low content was recorded only in block N. The present study indicated that the available K content decreased and 10 blocks recorded low values compared to one in the previous study. The low to medium level of available K in the soil irrespective of the application of recommended dose of K under a well managed condition for a number of years may be due to intensive leaching as the major type of clay mineral in the soil is 1:1 having low capacity for fixation of K.

Low level of available K in laterite soils had been reported by many workers (Nair, 1973; Krishnakumar, 1991). The results obtained in this study agree with their reports.

The results of the study indicate that application of recommended dose of fertilizers and manures for a longer period has not increased the N and K level of soils whereas the P content increased substantially. The results also indicated that the differences in the nutrient content due to differences in cultivation practices are insignificant as there was no sigificant difference in the nutrient content of uplands and low lands which were subjected to different fertilizer and management practices.

3.5 Cation exchange properties

Cation exchange properties exchangeable cations, their range and mean values are presented in Table 20.

Mean values for NH_4OAc CEC varied from 5.1 cmol(+) kg^{-1} in A block to 9.2 cmol(+) kg^{-1} in F block. The low values recorded are characteristic of laterite soils. The result is in accordance with the result obtained by Krishnakumar (1991) in laterite soils. No significant variation was noticed between wet lands and uplands in the CEC of the soils. There was no considerable difference in the organic matter content and clay content of these two types of soils and it is the reason for the non sugnificant difference in the CEC of the soils also.

3.5.1 Exchangeable cations

As in the case of profile samples, Ca was the predominating exchangeable cation in the surface samples also. It varied from an average of 1.20 cmol(+) kg^{-1} in C block to 4.34 cmol(+) kg^{-1} in VIIIth block.

The second major exchangeable cation was Mg and it varied from an average of 0.25 cmol(+) kg^{-1} in IXth block to 2.29 cmol(+) kg^{-1} in M block. The results indicated that there was no significant variation in the exchangeable Ca and Mg contents of soil due to variations in the crops grown and cultivation practices followed. The results of the present investigation do not agree with the findings of Hassan (1977) and Venugopal (1980) who had observed an increase in the

Table 20. Cation exchange properties - range and mean values for surface samples

Block No.	Exchangeable cations cmol(+) kg^{-1}				CEC cmol(+) kg^{-1} soil
	Ca	Mg	K	Na	
1	2	3	4	5	6
A	1.37-2.25 (1.84)	0.12-0.87 (0.68)	0.01-0.07 (0.03)	0.11-0.41 (0.34)	4.5-6.0 (5.1)
B	1.25-2.25 (1.87)	0.25-1.30 (0.61)	0.07-0.14 (0.10)	0.13-0.39 (0.34)	5.1-6.6 (5.8)
C	0.75-2.50 (1.20)	0.37-2.25 (1.23)	0.09-0.24 (0.14)	0.18-0.23 (0.20)	5.0-7.3 (5.9)
D	1.25-3.37 (2.10)	0.25-0.62 (0.48)	0.06-0.15 (0.10)	0.14-0.28 (0.17)	5.1-6.6 (5.5)
E	0.75-1.87 (1.73)	0.50-1.25 (0.82)	0.07-0.19 (0.16)	0.11-0.19 (0.14)	6.3-8.0 (6.9)
F	1.25-4.75 (2.48)	0.25-1.80 (0.81)	0.15-0.25 (0.20)	0.08-0.14 (0.10)	8.5-10.1 (9.2)
G	2.50-3.50 (2.84)	0.5-2.75 (1.25)	0.13-0.23 (0.17)	0.10-0.13 (0.11)	6.2-6.8 (6.4)
H	1.37-2.87 (2.08)	0.25-1.12 (0.83)	0.14-0.25 (0.18)	2.10-0.14 (0.12)	7.1-8.0 (7.4)
K	0.75-1.80 (1.50)	0.5-1.25 (0.85)	0.19-0.21 (0.15)	0.13-0.25 (0.14)	5.0-6.3 (5.5)
L	1.00-3.12 (2.07)	0.25-2.12 (1.18)	0.16-0.29 (0.24)	0.17-0.26 (0.18)	6.1-9.2 (6.6)
M	2.0-3.75 (2.70)	1.27-2.75 (2.29)	0.20-0.25 (0.23)	0.15-0.26 (0.19)	5.4-6.8 (6.1)
N	2.62-4.62 (3.57)	0.25-1.75 (0.68)	0.17-0.28 (0.23)	0.13-0.19 (0.15)	5.5-7.5 (6.4)

Contd.

Table 20 (Contd.)

1	2	3	4	5	6
I	1.87-4.37 (2.78)	0.37-2.50 (1.00)	0.06-0.14 (0.09)	0.10-0.18 (0.14)	5.5-7.0 (6.5)
II	1.25-3.00 (2.16)	0.25-0.50 (0.31)	0.05-0.10 (0.07)	0.13-0.19 (0.16)	5.5-7.2 (6.3)
III	1.00-2.25 (1.62)	0.12-0.50 (0.32)	0.04-0.10 (0.07)	0.13-0.21 (0.15)	5.5-7.5 (6.4)
IV	1.12-1.87 (1.64)	0.12-0.37 (0.28)	0.04-0.10 (0.07)	0.13-0.26 (0.16)	5.5-7.2 (6.5)
V	0.62-3.25 (1.40)	0.12-0.62 (0.41)	0.04-0.13 (0.06)	0.10-0.17 (0.13)	5.4-6.5 (6.1)
VI	1.37-2.87 (2.28)	0.50-1.87 (0.87)	0.10-0.30 (0.23)	0.13-0.21 (0.14)	4.8-7.1 (5.6)
VII	1.50-6.75 (2.78)	0.25-1.37 (0.76)	0.08-0.17 (0.13)	0.10-0.17 (0.14)	4.5-7.0 (5.4)
VIII	2.50-7.62 (4.34)	0.12-2.37 (1.50)	0.09-0.24 (0.14)	0.10-0.19 (0.11)	5.0-7.3 (5.9)
IX	1.12-1.75 (1.51)	0.12-0.31 (0.25)	0.06-0.12 (0.08)	0.10-0.18 (0.14)	5.5-7.0 (6.5)
X	1.62-5.50 (3.30)	0.12-1.75 (0.75)	0.04-0.10 (0.07)	0.13-0.21 (0.14)	5.5-7.5 (6.4)

contents of exchangeable Ca and Mg in the wet land soils as compared to nearby uplands.

Exchangeable K varies from 0.03 cmol(+) kg^{-1} in block A to 0.24 cmol(+) kg^{-1} in L block and exchangeable Na varies from 0.10 cmol(+) kg^{-1} in F block to 0.34 cmol(+) kg^{-1} in B block.

Exchangeable Ca, Mg, K and Na had recorded low values as in the case of profile samples. The mean values indicated that the predominant exchangeable cation was Ca in all the blocks except in block C where Mg was higher. Exchangeable Na recorded high values than exchangeable K in blocks A, B, C, D, I, II, III, IV, V, VII, IX and X. It was interesting to note that all the blocks where rice was cultivated, recorded a high content of Na than K. Similar results were obtained in all the layers of profile samples taken from paddy fields. The reason may be the higher requirement of K for rice compared to other crops as discussed earlier.

3.6 Available micronutrient content of soils

The DTPA extractable micronutrient contents of surface samples their range and mean values are given in Table 21.

The values for available Fe content varied from an average of 155 to 433 ppm. The lowest value was recorded in the K block whereas the highest value was recorded in the B block. No significant difference was observed between upland and wet land soils in the available content. These values are found to be very high characteristic of laterite soils. This is in confirmity with the result obtained by Padmam (1992). She had also reported that the long term application of manures and fertilizers had not influenced the available Fe content in soil. That may be the reason for the lack of any definite trend between the iron content of the soil in different blocks which are under different management practices and under different crops.

The available Mn content in soil varied from 1.9 to 61.1 ppm. The mean maximum and minimum values were recorded in the blocks N and VI respectively. The available Mn content was found to be high as the values obtained were well above the critical level of 1 ppm as reported by Randhawa and Katyal (1982). The values reported by Padmam (1992) based on the studies conducted on the permanent manurial trials at Pattambi also comes under this range.

The data revealed that the values recorded for Cu were high as the critical level of Cu in rice soil is reported to be 0.2 ppm. The values were found to be in the range of 4.0 to 26.0 ppm in K and VIIIth blocks respectively.

Table 21. Available micronutrient content - range and mean values for surface samples (ppm)

Block name	Fe	Mn	Cu	Zn
1	2	3	4	5
A	263-468 (348)	5.0-17.0 (9.0)	11.0-13.0 (12.0)	9.0-15.0 (11.0)
B	338-701 (433)	2.0-29.0 (8.0)	14.0-22.0 (16.0)	11.0-19.0 (13.0)
C	206-452 (258)	4.8-8.3 (6.0)	7.0-13.0 (9.0)	12.0-16.0 (13.0)
D	288-596 (405)	4.0-40.0 (20.0)	13.0-22.0 (17.0)	10.0-17.0 (12.0)
E	232-550 (396)	3.9-12.8 (7.4)	15.0-22.0 (17.0)	13.0-18.0 (16.0)
F	178-546 (287)	4.6-29.7 (16.6)	7.0-22.0 (15.0)	9.0-13.0 (15.0)
G	108-590 (367)	1.6-6.7 (4.2)	5.0-13.0 (10.0)	7.0-14.0 (10.0)
H	193-351 (278)	1.3-24.8 (8.7)	10.0-14.0 (11.0)	9.0-17.0 (11.0)
K	105-357 (230)	5.0-15.2 (7.6)	4.0-13.0 (7.0)	8.0-11.0 (9.0)
L	225-456 (356)	20.0-36.0 (25.0)	9.0-15.0 (12.0)	7.0-14.0 (9.0)
M	204-325 (255)	4.0-21.0 (7.0)	11.0-14.0 (12.0)	7.0-14.0 (6.0)
N	150-468 (289)	2.5-4.7 (3.0)	7.0-16.0 (11.0)	9.0-16.0 (13.0)

Contd.

Table 21 (Contd.)

1	2	3	4	5
I	254-334 (285)	12.0-24.0 (15.0)	9.0-14.0 (11.0)	8.0-11.0 (9.0)
II	111-397 (267)	6.0-26.0 (17.0)	10.0-19.0 (13.0)	7.0-16.0 (9.0)
III	211-313 (265)	14.0-45.0 (21.0)	10.0-18.0 (12.0)	9.0-12.0 (10.0)
IV	300-480 (373)	10.0-50.0 (20.0)	11.0-12.0 (11.0)	8.0-9.0 (8.0)
V	225-418 (308)	10.0-60.0 (30.0)	9.0-12.0 (11.0)	7.0-14.0 (9.0)
VI	219-523 (317)	12.0-61.1 (40.0)	10.0-16.0 (12.0)	10.0-13.0 (11.0)
VII	228-303 (288)	2.0-10.1 (5.2)	10.0-18.0 (13.0)	8.0-11.0 (9.0)
VIII	212-529 (329)	2.0-30.8 (24.9)	13.0-26.0 (17.0)	10.0-27.0 (15.0)
IX	126-173 (155)	11.0-14.2 (12.7)	4.0-7.0 (5.0)	9.0-15.0 (10.0)
X	180-341 (245)	12.0-29.0 (18.5)	10.0-12.0 (10.0)	11.0-15.0 (11.0)

The maximum content of available zinc was noticed in VIII block which recorded a value of 27.0 ppm and minimum in G, L, M, IInd and Vth blocks which recorded a value of 7.0 ppm. The values obtained for this nutrient was also high as the critical value for Zn in rice soils was reported to be 1.5 ppm (Swaine, 1955).

The values for all the exchangeable micronutrients studied were high in all the blocks of the station and that may be due to the high availability of these cations under acidic conditions.

3.7 Phosphorus fixing capacity of soils

The phosphorus fixing capacity of a few soil samples selected from each block are given in Table 22.

The mean value of P fixing capacity of soils varied from 58.03 per cent in block C to 94.10 mg/100g in block M. The values varied from 58.36 to 94.10 mg/100g in wet land soils and from 58.03 to 93.36 mg/100g in upland soils. No significant variation can be observed between uplands and low lands. High P fixing values observed are in accordance with the findings of Krishnakumar (1991) who also recorded high values of P fixation in laterite soils. The possible causes for high P fixing capacity are high content of sesquioxides, low organic matter and a preponderance of 1:1 type clay minerals which have a high P fixing capacity.

Table 22. Phosphorus fixing capacity of surface soil samples, on whole soil basis, mg/100g

Block name	Sample No.	P fixing capacity	Mean value
1	2	3	4
A	1	95.15	
	2	92.98	92.46
	3	89.26	
B	1	87.59	
	2	90.16	90.57
	3	93.98	
C	1	31.00	
	2	62.80	58.03
	3	80.30	
D	1	79.50	
	2	81.30	78.82
	3	75.68	
E	1	93.42	
	2	89.70	93.36
	3	96.98	
F	1	90.15	
	2	89.20	89.28
	3	88.50	
G	1	77.18	
	2	80.13	79.14
	3	80.11	
H	1	87.19	
	2	90.16	88.55
	3	88.31	
K	1	92.98	
	2	89.26	91.78
	3	93.11	
L	1	85.60	
	2	92.52	90.70
	3	93.98	

Contd.

Table 22 (Contd.)

1	2	3	4
M	1	97.30	
	2	91.90	94.10
	3	93.12	
N	1	86.28	
	2	83.37	85.90
	3	88.07	
I	1	62.80	
	2	80.30	74.40
	3	80.11	
II	1	85.60	
	2	97.30	91.80
	3	92.52	
III	1	93.42	
	2	89.20	90.37
	3	88.50	
IV	1	87.70	
	2	88.10	87.13
	3	85.60	
V	1	87.59	
	2	93.98	90.57
	3	90.16	
VI	1	89.00	
	2	83.38	84.99
	3	82.60	
VII	1	86.28	
	2	89.70	87.42
	3	86.28	
VIII	1	32.00	
	2	62.80	58.36
	3	80.30	
IX	1	6[illegible]	
	2	71.[illegible]	68.76
	3	72.30	
X	1	66.23	
	2	65.11	67.28
	3	70.50	

Summary

SUMMARY

In the present investigation attempt has been made to evaluate the morphological, physical and chemical characteristics of the soils of the Regional Agricultural Research Station, Pattambi. The physico-chemical characteristics of profile soil samples were investigated for interpreting the relationship of various properties and to arrive at the genesis of the soil. Surface samples collected from different blocks were analysed for available nutrients and other fertility parameters. The salient findings are summarised below.

1. The soils had predominantly red hues which are typical of tropical and intensely weathered regions. Ill drained lands exhibit greyish colour and mottling.

2. Good structural development was noticed except in ill drained areas which had weak subangular blocky surface structures followed by massive structure in sub soils.

3. Coarse fragments formed a predominant part in the soil samples collected. Not much difference was observed between uplands and wet lands.

4. Sand formed the predominant size fraction for all the soils from both uplands and wetlands. Silt to clay ratio

registered low values indicating less mature nature of soils.

5. The apparent density and absolute specific gravity did not reveal appreciable differences between soils from uplands and wet lands.

6. In general all the soils were acidic lacking any definite trend in the pH value of soils between uplands and wet lands.

7. Organic carbon content of all soils from both upland and wet land soils were low. A decrease with depth was noticed only in block B whereas in all other blocks it showed a tendency to increase with depth.

8. The total nitrogen content of all soils were low and no regular trend with depth was noticed.

9. No regular pattern of distribution with depth was obtained for total reserves of P_2O_5, K_2O, CaO, MgO and Na_2O which were low reflecting the dominance of the sand fraction.

10. The cation exchange capacity calculated by NH_4OAc method was low for all soils. Although a general trend of

increase in CEC with depth was there, a gradual decrease with depth was noticed for Blocks B and V.

11. Among the exchangeable bases, Ca formed the predominant cation. The exchangeable bases of the soils were in the order Ca>Mg>K>Na in uplands but in paddy fields the order was Ca>Mg>Na>K.

12. Fe_2O_3 content of soils were fairly high. Profile trends were erratic.

13. The Fe_d (dithionate fraction of iron) formed the predominant fraction. The Fe_o (oxalate extractable iron) and active iron oxide ratio (Fe_o/Fe_d) recorded low values for all soils.

14. The soils classified under Soil Taxonomy fall under two orders - Entisols and Inceptisols - indicating the less mature nature of soils.

15. Analysis of surface soils samples for available nutrients showed N in terms of organic carbon was medium in 19 out of 22 blocks, low in 2 blocks and high only in one block.

16. Available phosphorus content was high in 10 blocks and medium in the remaining 8 blocks.

17. Available potassium content was medium in 12 blocks and low in the remaining 10 blocks.

18. Based on the availability of major nutrients, the fertility map of the station has been prepared.

19. The P fixing capacity of all soils were high characteristic of laterite soils.

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* Originals not seen

Appendices

Appendix I

Description of soil profiles

Profile B

Location	:	Regional Agricultural Research Station, Pattambi Low land paddy field
Topography	:	1-3% slope, nearly level land
Drainage	:	Well drained, medium runoff, moderate permeability
Ground water	:	Less than 2 m
Land use	:	Paddy
Remarks	:	Soils are deep and have high content of coarse fragments. Have distinct horizon differentiation.

Horizon	Depth (cm)	Description
Ap	0-10	Brownish yellow 10 YR 6/6 (dry) and 10 YR 4/4 (moist). Sandy loam, granular sub angular blocky, slightly hard, friable slightly sticky, fine roots plenty.
C1	10-15	Yellowish brown 10 YR 5/8 (dry) and 10 YR 5/6 (moist) sandy clay loam, granular sub angular blocky, slightly hard, firm, non-sticky, few roots.
C2	15-30	Strong brown 7.5 YR 5/6 (dry), 7.5 YR 4/4 (moist), sandy loam, granular sub angular blocky, hard, firm, non-sticky.
C3	30-60	Dark reddish brown 5 YR 3/4 sandy loam and granular sub angular blocky, hard, firm, non-sticky.
C4	60-125	Dark reddish brown 5 YR 3/4 granular sub angular blocky, sandy loam, hard, slightly plastic, firm, non-sticky.

Profile C

Topography : 1-3% slope, undulating land

Drainage : Well drained, very slow erosion, medium runoff, no flooding.

Ground water table: More than 10 m

Land use : Coconut

Remarks : Soils are deep, with high content of gravel, no rock out crops.

Horizon	Depth (cm)	Description
Ap	0-10	Yellowish red 5 YR 4/6 (dry) and dark reddish brown 5 YR 3/4 (moist), sandy clay loam, medium, weak granular, loose, friable, non-sticky
Al	10-35	Yellowish red 5 YR 5/6 (dry) and dark reddish brown 5 YR 3/3 (moist), sandy clay loam medium, weak sub angular blocky loose, very firm, non-sticky
Bl	35-55	Reddish brown 5 YR 5/4 (dry) and dark reddish brown 5 YR 3/3 (moist), sandy clay medium weak sub angular blocky, very firm, non sticky, slightly plastic
Cl	55-100	Yellowish red 5 YR 4/6 (dry), dark reddish brown 5 YR 3/3 (moist), sandy clay loam, medium, weak sub angular blocky, firm, non sticky
C2	100-150	Yellowish red 5 YR 5/6 (dry) and dark reddish brown 5 YR 3/3 (moist), clay loam medium weak sub angular blocky, firm, non sticky, slightly plastic

Profile F

Topography	:	1-3% slope, terraced nearly level land
Drainage	:	Well drained, medium runoff, moderate permeability
Ground water table	:	More than 10 m
Land use	:	Paddy
Remarks	:	Deep gravelly soil

Horizon	Depth (cm)	Description
Ap	0-10	Strong brown 7.5 YR 5/6 (dry), dark brown 7.5 YR 4/4 (moist), clear smooth boundary, loamy, medium moderate granular, slightly hard, firm, non-sticky, non-plastic
B1	10-35	Reddish yellow 7.5 YR 6/6 (dry), dark reddish brown 5 YR 3/4 (moist), sandy loam medium moderate granular, slightly hard, firm, non-sticky, non-plastic, clean smooth boundary
B21	35-45	Reddish yellow 7.5 YR 6/6 (dry), dark reddish brown 5 YR 3/3 (moist), sandy clay loam, gradual wavy boundary, hard, firm, non sticky, non plastic
B22	45-75	Yellowish red 5 YR 4/6 (dry), dark reddish brown 5 YR 3/3 (moist), gradual wavy boundary, sandy clay loam, hard, firm, non sticky, non-plastic
B3	75-120	Reddish brown 5 YR 4/3 (dry), dark reddish brown, 5 YR 3/3 (moist), sandy clay loam hard, firm, non-sticky

Profile L

Topography : 1-3% slope, foot slope, undulating topography

Drainage : Well drained, very slow erosion, medium runoff, moderate flooding.

Ground water table: More than 10 m

Land use : Paddy

Remarks : Deep soils, no rock out crops, gravelly

Horizon	Depth (cm)	Description
Ap	0-14	Dark brown 7.5 YR 4/4 (moist) and yellowish brown 10 YR 5/6 (dry) clear smooth boundary, sandy clay loam, medium, weak, granular, loose, friable, slightly sticky, fine common pores fine roots common
A3	14-40	Yellowish brown 10 YR 5/8 (dry), yellowish brown 10 YR 5/6 (moist), clear wavy boundary, sandy clay, medium moderate sub angular blocky, slightly hard, firm, non-sticky, slightly plastic, fine pores, fine roots common
B1	40-80	Yellowish red 5 YR 5/6 (dry), dark reddish brown 2.5 YR 3/4 (moist), sandy clay, gradual wavy boundary, medium moderate sub angular blocky, slightly hard, firm, slightly sticky, slightly plastic
B21	80-110	Yellowish red 5 YR 4/6 (dry), yellowish red 5 YR 5/6 moist, gradual way boundary, sandy clay loam, medium moderate sub angular blocky, slightly hard
B3	110-160	Yellowish red 5 YR 4/6 (dry), red 2.5 YR 4/6 (moist), sandy clay loam

Profile I

Topography : Less than 1% slope, level land

Drainage : Well drained, slow erosion, medium runoff

Ground water table: More than 10 m

Land use : Paddy field

Remarks : Moderately deep soil, comparatively low gravel content

Horizon	Depth (cm)	Description
Ap	0-20	Dark brown 10 YR 3/3 (dry), dark yellowish brown 10 YR 4/4 (moist), clear smooth boundary, sandy loam, fine weak sub angular blocky loose, friable, slightly sticky, many fine roots
C1	20-60	Strong brown 7.5 YR 5/6 (dry), dark brown 7.5 YR 4/4 (moist), clear smooth boundary, clay loam, fine weak sub angular blocky loose friable sticky, fine roots many
C2	60-100	Yellowish red 5 YR 5/6 (dry), dark reddish grey 5 YR 4/2 (moist), loamy sand, weak sub angular blokcy, loose friable, sticky with no roots

Profile V

Topography : Less than 1% slope, nearly level land

Drainage : Ill drained soil, slow erosion, ponded soil, moderate flooding

Ground water table: 1.0-2.0 m

Land use : Paddy

Remarks : Soils are very deep, no rock out crop

Horizon	Depth (cm)	Description
Ap1	0-10	Weak red 7.5 YR 4/4, clear boundary, sandy clay loam texture, weak sub angular blocky, non sticky, plastic, fine roots common
Ap2	10-30	Weak red 7.5 YR 4/2 clear boundary, sandy clay loam texture weak sub angular blocky, slightly sticky, slightly plastic. This horizon is characterised by grey mottlings
C1	30-45	Dusky red 7.5 YR 3/2, clear smooth boundary, sandy clay loam texture, structureless, slightly plastic, slightly sticky
C2	45-70	Red 7.5 YR 5/6, clear smooth boundary, sandy loam texture, structureless, plastic, slightly sticky
C3	70-125	Weak red 7.5 YR 4/4, clear smooth boundary, sandy clay loam, structureless, slightly plastic, slightly sticky

Profile VIII

Topography : 1-3% slope, nearly level land

Drainage : Well drained, slow erosion, medium runoff, no flooding.

Ground water table: More than 10 m

Land use : Tapioca

Remarks : Deep soil, with high gravel content

Horizon	Depth (cm)	Description
Ap	0-7	Weak red 7.5 YR 5/4 (dry), dusky red 5 YR 3/4 (moist), gradual wavy boundary, sandy clay loam, medium, moderate angular blocky structure, slightly hard, slightly plastic, non-sticky, coarse roots many
A1	7-17	Weak red 7.5 YR 5/4 (dry), dusky red 5 YR 3/4 (moist), gradual diffuse boundary, sandy loam, moderate angular blocky structure, slightly hard, non-sticky, slightly plastic, coarse roots present
A3	17-41	Weak red 7.5 YR 5/4 (dry), dusky red 5 YR 3/3 (moist), diffused boundary, sandy loam texture, moderate angular blocky structure, slightly hard, non-sticky, non plastic
B1	41-110	Weak red 7.5 YR 5/4 (dry), dusky red 5 YR 3/4 (moist), sandy loam texture, moderate sub angular blocky structure, slightly hard, non plastic, non sticky
B2	110-150	Weak red 7.5 YR 5/4 (dry), dusky red 5 YR 3/4 (moist), sandy loam, sub angular blocky, hard, non plastic, non sticky

Profile IX

Topography : 3.8% slope, flat land (crest)

Drainage : Well drained, medium runoff, no flooding

Ground water table: More than 10 m

Land use : Coconut

Remarks : Deep soil, no rock outgrowths

Horizon	Depth (cm)	Description
Ap	0-10	Red 5 YR 4/6 (dry), dark red 7.5 YR 3/6 (moist), clear smooth boundary, sandy loam texture, medium, weak, granular, slightly hard, firm, coarse pores, coarse roots present
A3	10-25	Red 7.5 YR 4/6 (dry), dark red 7.5 YR 3/6 (moist), gradual wavy boundary, sandy clay loam, medium weak sub angular blocky, slightly hard, firm
B1	25-45	Red 7.5 YR 4/6, gradual wavy boundary, loamy texture, medium, moderate sub angular blocky structure, slightly hard
B21	45-71	Red 7.5 YR 4/6, diffused wavy boundary, loamy texture, medium moderate sub angular blocky, slightly hard, firm. Presence of argillic horizon below 60 cm
B22	71-110	Red 10 YR 4/6, diffused wavy boundary, silty clay loam, coarse moderate sub angular blocky structure, hard, firm
B3	110-140	Light red 10 YR 6/6, loamy texture, coarse moderate sub angular blocky, hard, firm, non plastic non sticky

Profile X

Topography : 1-3% slope, flat land

Drainage : Well drained, medium runoff, very slow erosion, no flooding.

Ground water table: More than 10 m

Land use : Mango orchard

Remarks : Moderately deep soil, highly content of gravel

Horizon	Depth (cm)	Description
Ap	0-10	Weak red 7.5 YR 4/4 (dry), dusky red 5 YR 3/3 (moist), clear smooth boundary, loamy sand, medium, moderate granular, hard, firm, few roots
A3	10-35	Weak red 7.5 YR 4/4 (dry), dusky red 5 YR 3/3 (moist), gradual wavy boundary, sandy clay loam, weak sub angular blocky, hard, non sticky, non plastic
B1	35-75	Weak red 7.5 YR 4/4, clear smooth boundary, sandy loam, moderate sub angular blocky, non sticky, non plastic
B2	75-100	Weak red 7.5 YR 4/4, sand, weak sub angular blocky, non sticky, non plastic

Appendix II

Ratings of soils for available nutrients

Class No.	Rating	Organic carbon (%) sandy soils	Organic carbon (%) loamy & clayey soils	Percentage recommendation of N
0	Low	0.00-0.10	0.00-0.16	128
1	Low	0.11-0.20	0.17-0.33	117
2	Low	0.21-0.30	0.34-0.50	106
3	Medium	0.31-0.45	0.51-0.75	97
4	Medium	0.46-0.60	0.76-1.00	91
5	Medium	0.61-0.75	1.01-1.25	84
6	Medium	0.76-0.90	1.26-1.50	78
7	High	0.91-1.10	1.51-1.83	71
8	High	1.11-1.30	1.84-2.16	63
9	High	1.31-1.50	2.17-2.50	54

Rating for P and K

Class No.	Rating	Class value for P $kg\ ha^{-1}$	Class value for K $kg\ ha^{-1}$	Percentage recommendation of P&K
0	Low	0.00-3.0	0-35	128
1	Low	3.1-6.5	36-75	117
2	Low	6.6-10.0	76-115	106
3	Medium	10.1-13.5	116-155	94
4	Medium	13.6-17.0	156-195	83
5	Medium	17.1-20.5	196-235	71
6	Medium	20.6-24.0	236-275	60
7	High	24.1-27.5	276-315	48
8	High	27.6-31.0	316-355	37
9	High	31.1-34.5	356-395	25

Appendix III

Classification of soil test values

Block	pH	EC dSm^{-1}	Organic carbon %	Available P $kg\ ha^{-1}$	Available K $kg\ ha^{-1}$	Fertility recommendation as percentage of general recommendation			Digital fertility Code No.
						N	P	K	
A	5.19 (3,M)	0.064 (0,L)	0.60 (4,M)	26.5 (7,H)	107.5 (2,L)	91	48	106	230/472
B	4.86 (2,L)	0.079 (0,L)	0.84 (6,M)	33.1 (9,H)	104.8 (2,L)	78	25	106	320/692
C	5.22 (3,M)	0.035 (0,L)	1.20 (8,H)	26.8 (7,H)	142.9 (3,M)	63	48	94	630/873
D	5.23 (3,M)	0.034 (0,L)	0.68 (5,M)	32.1 (9,H)	107.5 (2,L)	84	25	106	230/592
E	4.80 (2,L)	0.055 (0,L)	0.88 (6,M)	20.6 (6,M)	134.4 (3,M)	78	60	94	320/663
F	4.82 (2,L)	0.054 (0,L)	0.73 (5,M)	24.2 (7,H)	138.8 (3,M)	84	48	94	320/573
G	5.16 (3,M)	0.066 (0,L)	0.81 (6,M)	27.7 (8,H)	126.9 (3,M)	78	37	94	330/683
H	4.80 (2,L)	0.068 (0,L)	0.64 (5,M)	34.3 (9,H)	158.7 (4,M)	84	25	83	220/594
K	5.23 (3,M)	0.042 (0,L)	0.62 (5,M)	29.9 (8,H)	126.9 (3,M)	84	37	94	330/583
L	4.71 (2,L)	0.065 (0,L)	0.66 (5,M)	31.6 (9,H)	163.1 (4,M)	84	25	83	320/594

M	4.85 (2,L)	0.058 (0,L)	0.65 (5,M)	36.0 (9,H)	179.2 (4,M)	84	25	83	320/594
N	5.00 (2,L)	0.041 (0,L)	0.58 (4,M)	42.8 (9,H)	156.1 (4,M)	91	25	83	320/494
I	5.20 (3,M)	0.060 (0,L)	0.47 (4,M)	26.8 (7,H)	72.3 (1,L)	91	48	117	330/471
II	5.05 (3,M)	0.064 (0,L)	0.60 (4,M)	21.0 (6,M)	87.1 (2,L)	91	60	106	330/462
III	4.75 (2,L)	0.064 (0,L)	0.66 (5,M)	19.0 (5,M)	53.7 (1,L)	84	71	117	320/551
IV	4.82 (2,L)	0.094 (0,L)	0.86 (6,M)	35.1 (9,H)	57.6 (1,L)	78	25	117	220/691
V	4.94 (2,L)	0.21 (0,L)	0.67 (5,M)	22.7 (6,M)	75.2 (1,L)	84	60	117	420/561
VI	4.96 (2,L)	0.069 (0,L)	0.60 (4,M)	14.8 (4,M)	99.7 (2,L)	91	83	106	320/442
VII	4.96 (2,L)	0.069 (0,L)	0.60 (4,M)	22.1 (6,M)	131.9 (3,M)	91	60	94	120/463
VIII	5.21 (3,M)	0.059 (0,L)	0.84 (6,M)	34.3 (9,H)	75.2 (1,L)	78	25	117	330/691
IX	5.56 (4,M)	0.043 (0,L)	0.43 (3,M)	19.0 (5,M)	57.6 (1,L)	97	71	117	440/351
X	5.51 (4,M)	0.049 (0,L)	0.55 (4,M)	25.1 (7,H)	169.2 (4,M)	91	48	83	240/474

FERTILITY INVESTIGATIONS AND TAXONOMY OF THE SOILS OF REGIONAL AGRICULTURAL RESEARCH STATION, PATTAMBI

By

K. P. DEEPA

ABSTRACT OF A THESIS

Submitted in partial fulfilment of the requirement for the degree of

Master of Science in Agriculture

Faculty of Agriculture

KERALA AGRICULTURAL UNIVERSITY

Department of Soil Science and Agricultural Chemistry

COLLEGE OF HORTICULTURE

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1995

ABSTRACT

The Regional Agricultural Research Station, Pattambi has entered it seventh decade of activities. The total area of the station is 63.64 ha and it includes both upland and low land. A detailed survey of the soil in the area of the station has not been made by the Soil Survey Department and hence a taxonomic classification of the soil and fixing of the soil series as per the soil taxonomy has not been done so far. Therefore the present study was formulated to find out the morphological and physico-chemical characteristics of soil profiles of selected blocks, to analyse the surface soil samples from all the blocks for fertility parameters, to classify the soils under taxonomy and to prepare the soil fertility map of the station.

The soils had predominantly red hues. Good structural development was noticed in all soils except in ill drained areas. Coarse fragments formed a predominant part in the soil samples collected.

In general the soils were acidic in nature. Organic carbon content was low irrespective of crops grown. The nitrogen content of all soils were also low. No regular pattern of distribution with depth was obtained for total

reserves of N, P_2O_5, K_2O, CaO, MgO and Na_2O which were low. Total Fe_2O_3 content was fairly high.

The cation exchange capacity calculated by NH_4OAc method was low for all the soils. Among the exchangeable bases, Ca formed the predominant cation.

With regard to the available nutrient content of soils, nitrogen status of the soil worked out based on the organic carbon content showed that it was high in C block, low in blocks I and IX and medium in the remaining 19 blocks. Nutrient index worked out for available P content showed that it was medium in 12 blocks i.e., E, M, K, I, II, III, IV, V, VI, VII, IX, X and high in the remaining 10 blocks. For available K, the nutrient index values indicated that it was low in 10 blocks and medium in 12 blocks. Based on the nutrient indices, the fertility map of the station was prepared.

Based on the profile soil sample analysis, classification of the soils under Soil Taxonomy was attempted upto the subgroup level. Among the nine profiles, only 3 i.e., F, I and V fell under Inceptisols and the remaining 6 i.e., B, C, I, VIII, IX and X were under Entisols.