AGGREGATE SIZE DISTRIBUTION AND ITS RELATIONSHIP TO PHYSICAL AND CHEMICAL PROPERTIES OF SOME TYPICAL SOILS OF KERALA

By

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THESIS

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DEDICATED TO

THE FOND MEMORY OF

MY FATHER

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C E R T I F I C A T E

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C E R T I F I C A T E

We, the undersigned, members of the Advisory Committee of Smt. Ushakumari, K., a candidate for the degree of Master of Science in Agriculture with Major in Soil Science and Agricultural Chemistry, agree that the thesis entitled "Aggregate size distribution and its relationship to physical and chemical properties of some typical soils of Kerala" may be submitted by Smt. Ushakumari, K., in partial fulfilment of the requirement for the degree.

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C O N T E N T S

LIST OF TABLES

LIST OF FIGURES

Introduction

INTRODUCTION

For food and fibre man has to mainly depend on soils. Therefore, it becomes imperative to keap our soils in proper conditions to meet the ever increasing demands of mankind. It can be achieved either by maintaining their fertility with the judicious use of fertilizers, chemicals and amendments or by keeping them in good physical conditions by adopting appropriate cultural and management practices or both. In short, in addition to "chemical fertility", the soil should also possess " physical fertility", with both attributes being equally essential for overall soil productivity (Hillel, 1971).

Soil structure, which is defined as the mutual arrangement, orientation and organisation of particles in the soil, can be of decisive importance in determining soil productivity as it greatly affects the water, air and thermal regimes in the field. Not only that, it may also influence the mechanical properties of soils, which may in turn affect seed germination, seedling establishment and root growth. Moreover, it can affect the performance of agricultural operations such as tillage, irrigation, drainage and planting (Hillel, 1971).

In Kerala, practically all the research on soils in the previous six decades or so have centred around chemical and fertility aspects with almost a total disregard for physical aspects. Moreover, to develop any stable and viable system of soil management, a preknowledge of physical properties of soils is a necessity. These properties mainly are soil structure, soil texture, soil water retention, infiltration, drainage etc. As pointed out earlier, soil structure is the dominant factor in controlling most of the physical behaviour of soils. In turn, it itself is known to be influenced by such factors as silt and clay content, nature and amount of organic matter in soils, microbial activity, sesquioxides etc. Moreover, natural conditions and soil management practices may have pronounced effects on the genesis and development of soil structure.

A diversity of soil formations is seen in Kerala. The major parts of the uplands consist of laterites. The coarse textured soils of the West Coast are considered as coastal alluvium whereas the relatively young soils on the flood plains of river banks are termed as riverine alluvium. Red loam soils occur in the southern parts of Trivandrum district. Black soils are found in the Chittoor taluk of Palghat district.

As most of the root activity is primarily confined to upper 60 cm layer of soils, the present study was restricted to this zone only. Thus, the present investigation was undertaken with the following objectives.

1. To evaluate the various physico-chemical properties of some typical soils of Kerala.

2. To evaluate the aggregate sise distribution and its possible relationships with some physico-chemical characteristics of soils.

Review of Literature

REVIEW OF LITERATURE

The literature on the various aspects of soil structure is extensive. In the following sections an attempt has been made to review in a systematic manner the work carried out till recently on some important aspects of soil structure and other related physico-chemical properties of soils.

A. General aspects of soil structure

Soil structure has been defined as the arrangement, orientation and organisation of the particles in the soil. Aggregated structure can be characterized either qualitatively (Zakharov, 1927; Baver, 1935 and Kubiena, 1938) by describing the typical shapes of the aggregates, eg., blocky, columnar, platy etc. or quantitatively by measuring their sizes (Tiulin, 1928; Keen, 1933; Yoder, 1936; Alderfer *et al*., 1941; McCalla, 1944; Davidson and Evans, 1960 and Kemper and Chepil, 1965). Such measurements can be made either by dry sieving or wet sieving. Additional methods of characterizing soil structure are based on the size distribution of pores, the mechanical properties of the soil, or the permeability of the soil to air and water (Reeve, 1965).

Rogowski *et al*. (1968) attempted to measure soil structure as a function of rupture stress.

B. Physico-chemical properties influencing soil aggregation

i) Effect of clay and organic matter

The formation and stability of soil aggregates is dependent largely on the quantity and state of clay and the presence of various forms of organic matter. As early as 1934, Russel suggested that the type of aggregate (micro-aggregates or macro-aggregates) that would be generated in a soil would be largely governed by the nature and amount of clay as well as the type and quantity of exchangeable cations present on the colloidal clay and in the soil solution.

The important influence of organic matter in the formation and stability of soil structure has been extensively studied (Demolon, 1932; Baver, 1935 and Martin, 1946). A positive correlation has been established between soil organic matter and aggregation by various workers (Paschall *et al*., 1935; Elson 1941; Rynasiewicz, 1945; Yadav and Banerjee, 1968 and Saatail, 1975).

However, Retser and Russell (1941) found no such correlation. Similar views were also expressed by Elson and Azar (1942).

Emerson (1959) described a model of soil crumbs based on various ways in which the assemblage of clay particles associate and attach to quartz particles of sand and silt to form micro-aggregates or macro-aggregates.

Saini (1966) observed that although clay content was not related to aggregate size, larger water stable aggregates contained more montmorillonite. However, Sankaranarayana and Mehta (1967) obtained a positive correlation between the clay content and the water stable aggregates in some soils of Rajasthan. Sandhu and Bhumbla (1968) reported that aggregation was influenced more by clay than silt in the case of some soils of Punjab. Ehrardt (1967) proposed the importance of calcium saturated clays in the formation of micro-aggregates.

The state of water stable aggregation has also been reported to be influenced by soil polysaccharide gum content (Rennie, 1952; Chesters, 1959 and Toogood and Lynch, 1959). However, contradictory views were expressed by Retser and Russell (1974) and Halstead (1954).

Saini (1966) observed that organic matter and protein contents were not related to water stable aggregate size, but the larger aggregates contained more uronides and free iron oxides.

Deshpande *et al*. (1964) found that a major reduction in structural stability was induced when polysaccharides were removed from a tropical red earth of North Australia which contained only about two per cent organic matter.

Malik and Stevenson (1965) correlated organic carbon and stable aggregates and found a positive correlation between the two. They also stressed the importance of organic matter in imparting stability to soil aggregates. An improvement in soil structure has been reported by incorporating various types of organic materials with the soil (Griffiths and Jones, 1965; Monnier, 1965 and Tabartabar and Hanway, 1968).

Azuma *et al*. (1968) studied sixteen soils of Japan and found that aggregation increased with increasing clay content. They also suggested that the content of polysaccharides, polyuronides and fulvic acid, generally regarded as favourable to the formation of large aggregates, was proportional to the total organic matter content.

Mihalyfaluy (1968) reported that organic manuring helped to increase the water stable aggregates in the surface soils. A similar view was expressed by Yadav and Banerjee (1968) in the case of a forest soil of West Bengal. They also observed that the amount of total water stable aggregates decreased with depth in the soil profile. An increase in water stable aggregates with organic manuring was also reported by De Leenahar (1971).

Chakrabarti (1971) observed that the water stable aggregates were significantly correlated with organic carbon, exchangeable calcium, cation exchange capacity, dispersion ratio and suspension percentage but not with clay and free iron oxides.

In a study of the comparative effect of different polysaccharides on aggregation, Dhoot _et al_. (1974) reported that starch was more effective in aggregation in comparison to other polysaccharides under both aerobic and anaerobic conditions. The addition of some indigenous materials as bajra and wheat straw has also been found to promote aggregation in the soil (Verma and Singh, 1974). These studies also indicated that the application of wheat straw and green manuring of bajra hold special promise in Punjab, Haryana and Rajasthan soils which crust badly.

Yadav and Singh (1976) studied some of the soils of Doonvalley in Uttar Pradesh and found that large water stable aggregates were positively correlated with organic matter content of the surface soil while the proportion of small aggregates was positively correlated with subsoil clay content. Many Alfisols were found to have structural deterioration (Lal, 1976) and eroded easily. The clay fraction of these soils consisted mainly of kaolinite and hydrous oxides of iron. This accorded with earlier observations of rather similar soils by Desphande et al.(1968) and Greenland et al. (1968).

State of decomposition of organic matter is also known to influence the formation and stability of aggregates. Tisdall et al. (1978) observed that the mixing of readily decomposible organic matter encouraged the formation of water stable aggregates. Similarly, Chakraborty et al. (1979) reported that small sized aggregates contained higher proportion of high organic molecular weight humic acid in comparison to larger aggregates.

Soong (1980) observed that decomposed organic matter had pronounced influence on percentage aggregation and mean weight diameter, while the undecomposed form such as particulate matter had little influence.

Chakraborty (1981) reported that percentage of humic acid carbon and fulvic acid carbon increased in the aggregate with increasing aggregate size. An amelioration in soil physical conditions, especially the structural status of soils, was also reported by Martin *et al*. (1981), Pagliai *et al*. (1981) and Tisdall and Oades (1982).

ii) Effects of iron and aluminium oxides and other cations

It is almost universally recognised that lime may improve the physical properties of soils (Baver, 1928; Baver, 1935; Bradfield, 1936 and Peterson, 1947). Ahmad *et al*. (1969) reported that divalent cations like calcium and magnesium played a positive role in inducing water stable aggregates in the ease of two types of soil, viz., red earth and black earth, whereas monovalent cation like sodium and potassium adversely affected the structural status of these soils.

Dehydrated oxides of iron and aluminium have also known to play an important role in the formation of water stable aggregates (Roberts, 1933; Luts, 1936 and Chesters *et al*. 1957). However, Deshpande *et al*. (1964) failed to find substantial evidence to support this view.

Later on, Deshpande and Greenland (1968) reported that the aggregate stability was decreased by the removal of aluminium oxide and small amounts of iron oxide and silica.

Chakrabarti and Das (1969) observed that oxides of iron encouraged the development of macro-aggregates whereas clay, organic matter and exchangeable calcium were helpful in the formation of micro-aggregates.

Van Raij and Peech (1972) and Gallez et al. (1977) have reported that many Ultisols and Oxisols possess stable aggregates and micro-aggregates in contrast to Alfisols. According to these authors there is usually some "active" positively charged aluminium oxide materials in the clay fraction of these soils which act as a strong bonding and flocculating agent.

Hamblin (1977) observed that iron oxide showed a marked influence on aggregation with a tendency to be more important in the smaller aggregate fraction.

Chakraborty et al. (1981) reported a close relationship between the amount of free iron oxide and mean weight diameter of aggregates. They also suggested that exchangeable cations play a prominent role in aggregate formation.

Grierson (1981) observed that state of aggregation improved with decreasing exchangeable sodium percentage on the exchange complex.

iii) <u>Other physical properties</u>

a) Volume - mass relationships

Total porosity and bulk density have often been used to assess soil structure. A knowledge of the apparent density can be used to reduce the variation in the physical evaluation of a range of soils (Forsythe and Dias-Romeo, 1969).

Keen and Raczkowski (1921) observed an inverse relationship between bulk density and clay content of the soil. However, Sen and Deb (1941) found no relationship between soil bulk density and clay content in the case of laterite and red soils of India.

Kandaswamy (1961) observed that pore space was high in clayey soils. Similar views were also expressed by Durairaj (1961) in the case of some South Indian soils. Excessive and unnecessary cultivation, overgrazing and overstocking could also lead to degradation of soil structure and result in decrease of total porosity (Chandler *et al*. 1964).

Ramanathan (1965) reported a positive relationship between clay and pore space. While working on an Ultisol, Medina and Grohmann (1966) observed that the micropores represented 60 to 70 per cent of the total pore space. De Oliveira (1967) observed that the total porosity of some Brazilian soils decreased with cultivation.

Mayalagu *et al*. (1973) observed wide variations in absolute specific gravity and soil bulk density within each profile and among profiles of a toposequence of Madurai. Some tropical soils have been observed to be naturally compacted and have low total porosity (Honisch, 1974; Bridge *et al*. 1975 and Parthasarathy *et al*. 1976).

Lawrence (1977) suggested that pore size distribution obtained from the relationship between moisture content and suction is not dependable in fine textured soils because of their shrinkage. However, Vasquez *et al*. (1977) found that the saturation percentage of a soil was the best indicator of its bulk density. Nevertheless, in swelling soils, considerable changes in bulk density occur due to changes in soil water content (Rao *et al*. 1978).

Coughlan *et al*. (1978) observed that in the black earth no significant variation in void ratio occurred at clay percentages greater than 40. This was attributed to the porosity created around the sand particles owing to differential swelling and shrinkage. Magar et al. (1979) attributed the variation in the bulk density of the surface layer of a black cotton soil due to wetting and drying to the presence of 2 : 1 type clay minerals, exchangeable cations, composition of soil solution and the presence of chemical bonding agents. Sur et al. (1979) demonstrated that aggregate density decreased asymptotically with increase in aggregate size to a minimum constant value, which was a characteristic of a given soil. They have also reported that intra-aggregate and total porosity, however, increased with increase in size of aggregates.

Stengel (1979) was of opinion that textural porosity depends upon the mineral, organic matter and water content of the soil. He suggested a distinction between the textural and structural porosity to be more valuable in characterizing the physical state of a soil than the use of total porosity. Manuchara and Bondareis (1980) demonstrated that water stable aggregates have a higher porosity and low weight. Perecin and Campos (1981) reported that porosity was related to clay content and fabric of the soil.

b) Soil water retention and soil moisture constants

Soil texture as well as soil structure influences the water retention behaviour of the soils. As a general rule a gradual increase in suction will result in the emptying of progressively small pores, until, at high suction values, only the very narrow pores retain water (Childs, 1940). As far as possible, soil moisture retention characteristics should be determined on undisturbed cores or in situ (Lal, 1979b). The relationships between soil moisture suction and moisture content of tropical soils have been studied by several workers such as Charoy (1974), Colmet-Daage and Cucalon (1965), Cooper, (1974), Drover (1966), El-Swaify et al. (1970) Forsythe and Vasquez (1973), Gavande (1968), Kamerling (1975), Lal (1979) Lugo-Lopez (1951) Obi (1974) and Antony (1982). It was generally observed that the moisture characteristic curves obtained on undisturbed soil cores or in situ were significantly different from those determined on disturbed cores.

Ali et al. (1966) studied the soil moisture retention curves of some alluvial, black, red, laterite and lateritic, mountain and forest, desert and saline soils of India. Their data indicated that most of the water was released at a suction of 1 to 2 bars.

Soil moisture characteristic curves are more often influenced by the nature and type of clay (Borden et al., 1974 and Warkentin, 1974) and the nature of action of the exchange complex (Moss, 1964; El-Swaify et al., 1970 and Lognathan and Krishnamoorthy, 1976).

Soil bulk density also markedly influences the moisture retention, as compaction of soil reduced the porosity as well as the size of the pores (Tomboli, 1961; Hill and Summer, 1967; Petersen et al. 1968; Sharda, 1977 and Sharda and Gupta, 1978).

Rajani (1968) studied the soil water retention of the major soil groups of India and found that the moisture retention of the soil decreased in the order black > peaty > lateritic > alluvial > desert.

Roeder and Bornemissza (1968) studied eight lateritic and alluvial soils of Brazil and reported that moisture retention ranged from 20 to 25 per cent at 0.3 bar suction and from 6 to 8 per cent at 12 bars.

Forsythe et al. (1969) have reported that volcanic ash soils in the humid tropics lose their water holding capacity when air dried. Similar results were also reported earlier by Colmet-Daage and Cucalon (1967).

Patricia (1980) conducted a comparative study of the relative efficiency of the ceramic plate and pressure membranes on water retention in different soils and concluded that there was no overall significant difference between the results obtained from the two types of apparatus. Berliner et al. (1980) however, proposed the hanging water columns for measuring water retention at low suction.

c) Field capacity

Field capacity, in a dynamic sense, is not a constant value but represents the range of moisture contents retained in the soil when the macropores have been drained against the gravitational pull. Though conventionally field capacity has been estimated in the United States as equivalent to soil moisture retention when a saturated soil is subject to a suction of 1/3 bar or 1/10 bar, yet still lower suctions have been found to be appropriate in other parts of the world (Wolf and Drosdoff, 1976; Pidgeon, 1972 and Fernandez and Sykes, 1968).

Medine and Grohmann (1966) estimated field capacity at 0.3 bar suction in several tropical soils. In situ measurements of field capacity by Avalla and Rodriques (1973) showed that water was generally being held at suctions lower than 0.3 bar and that the estimate of field capacity at these tensions gave more reliable values.

Various researchers have tried to correlate field capacity with soil components such as bulk density, texture and organic matter content (Miller and Bungar 1963; Hill and Summer, 1967; Sekhon and Arora, 1967; Sharma and Uehara, 1968; Coughlan, 1969; and Jadhav, 1978). Though estimates of field capacity can be obtained from these empirical relationships, the reliability of such data is questionable (Lal, 1979b).

Pidgeon (1972) observed significant correlation between size, composition and field capacity of some soils of Uganda. Tran-Vinh-An and Nguba (1971) reported that 80 to 86 per cent of the variation in water content at field capacity was directly related to the content of clay, silt and organic matter.

d) Wilting point

Wilting point refers to the range of moisture contents at which the rate of water supply to root lags behind the evaporative demand of the atmosphere. This implies that wilting point is not a constant property but varies with crop and the evaporative demand of the atmosphere. However, wilting point is conventionally taken to be equal to tha moisture content retained when the saturated soil is subjected to a suction of 15 bars (Lugo-Lopes, 1952; De Oliveera _et al_., 1966 and Perez-Escolor and Lygo Lepez, 1969). However, Sykes (1969) found a wide variation renging from 7 bars to 39 bars at the permanent wilting point in respect of different crops. He also proposed that wilting point varied with soil, plant species, growth, environment and above all the unsaturated hydraulic conductivity of the soil.

The moisture content at wilting point has also been related to particle size (Babalola, 1972; Whiteman, 1935 and Venkataraman, 1976).

e) Available soil moisture

According to Lal (1979), the available moisture capacity of highly weathered coarse textured soils of humid tropics is generally low. It is in confirmity with the reports of some earlier workers (De Melo, 1974; De Silva _et al_., 1975 and Wahab _et al_. 1976). Also, the availability of water decreases as the soil water suction increases. In other words, the available water is held at relatively low suction (Gavande, 1968; Gavande and Gonzalez, 1969; Honisch, 1974; De Silva et al. 1975 and Wolf and Drosdoff, 1976).

Weert and Lenslink (1974) calculated the water retention capacity of some soils of Surinam as the difference in the percentages of moisture held at pF 2 and 4.

f) Infiltration

Infiltration refers to be the process whereby water enters into the soil through its surface (Horton, 1940) The infiltration flux is the volumetric flow rate of water into the soil per unit area (Richards, 1952). More recently, Hillel (1971) has coined the term "infiltrability" to designate the infiltration flux to avoid the capacity-intensity contradictions in "infiltration capacity" (Horton, 1940) and allows freedom for using "infiltration rate" in other than the more restricted Richards' sense (Richards, 1952).

Lugo-Lopez (1952) reported that infiltration rates of various soils of Puerto-Rico could be improved by incorporating organic matter into the soils. Later, Lugo Lopez et al. (1968) further confirmed this view and suggested that a mulch of sugarcane trash could increase the infiltration rate by 30 per cent as compared to the practice of burning trash in a silty clay soil of Puerto-Rico.

Hay and Subramanyan (1955) observed that ploughing the land greatly enhanced the infiltration rate. Hill and Summer (1964) proposed that the process of infiltration depend on physical condition of a soil. However, Cunningham (1963) and Lal and Cumming (1976) expressed different views. According to them tillage operations resulted in the disturbance and exposure of soil and caused a rapid decline in the infiltration rate.

Agrawal et al. (1974) related the infiltration rate to the textural characteristics of soils of Haryana. The coarser the soil the higher the infiltration. They have also observed low infiltration in the case of structurally unstable soils.

Wolf and Drosdoff (1976) have reported the results of infiltration studies on the ultisols and oxisols of Puerto Rico. They found that infiltration in all soils was very rapid reaching a rate of 9 cm after one hour of continuous flooding.

Adverse effects of compaction on infiltration rates of soils have also been reported by Sharda (1977), Sharda and Gupta (1978); Dixon (1978); and Akram and Kemper (1979). It is primarily due to reduction in the size of pores as the soils are subjected to compaction.

Collis-George and Greena (1979) studied the effect of depth and degree to which column of aggregates of different sizes of a structurally unstable red-brown earth surface soil slaked when water was ponded on the surface. The slaking affected the subsequent infiltration into the soil wilting front advance and cumulative infiltration data indicated that depth of zone of slaking increased as the aggregate size increased.

Moore (1980) suggested that surface sealing can have a significant impact on infiltration and that many of the effects attributed to air entrapment could be explained by seal formation. The water intake rates of tropical soils have been found to be quite high under their natural vegetative cover (Lal, 1976; Wilkinson, 1975; Wilkinson and Aira, 1976 and Lal and Cummings 1979).

Tromble (1980) proposed the importance of cover crop for improving soil structure, reducing run off, controlling erosion and increasing infiltration rate.

Morin *et al*. (1981) observed a fall in the infiltration rate of two soil types of Israel because of the formation of a thin crust at the surface.

Wood *et al*. (1981) examined the impact of livestock grazing system on infiltration rates for rolling plain range land in Texas. They observed that aggregate stability had the greatest influence on infiltration rate, closely followed by soil organic matter content, but rates were also influenced by mulch, standing crop, bulk density and ground cover.

Yacob and Blain (1981) have demonstrated the beneficial effects of legume crops on infiltration rate and structural stability. Fahad *et al*. (1982) attributed low infiltration rates to microporosity and decreased aggregate stability. Similar views were also expressed by Moldenhauer (1970).

Materials and Methods

MATERIALS AND METHODS

The present study was undertaken to evaluate the structural status of some typical soils of Kerala and its relationship to other physical and chemical properties of the soil. For this purpose soil samples were collected from different parts of Kerala. The study was conducted at the College of Horticulture, Vellanikkara during the period 1981-83.

A. Soil samples

Five important soil types of Kerala viz., laterite, red loam, black cotton, coastal alluvium and riverine alluvium were selected for the study. Three profiles from each of the aforesaid soil types belonging to the same series as established by the Soil Survey Unit of Department of Agriculture, Kerala were examined for the collection of soil samples. Samples from different soil types, viz., laterite, red loam, black cotton, coastal alluvium and riverine alluvium, were collected from Trichur, Trivandrum, Palghat, Calicut and Ernakulam districts, respectively. These soil groups, belonged to the most extensively occurring series of Kerala namely, Velappaya, Valiavallampathy, Vellayani, Ponnamattom and Beypore series, respectively.

B. Sampling procedure

Profile pits were dug at three different locations for each soil type. From each profile, samples were collected at four different depths viz., 0-15 cm, 15-30 cm, 30-45 cm and 45-60 cm. Morphological description of each series is given in Appendix I. The details of the profile samples collected are given in Table 1.

C. Field studies

i) Measurements on infiltration rate

Infiltration rates were measured at each location using double ring infiltrometer having 30 cm and 60 cm diameter of inner and outer cylinders, respectively. The level of water was recorded at different time intervals until the amount of water going into the soil per unit time became essentially constant. (Dakshinamurti and Gupta, 1968).

ii) Bulk density

Bulk density of the soil at different depths was determined using core samples of 10 cm length and 4.4 cm diameter. The core samplers were horizontally hammered into the soil and the samples were collected for bulk density determination. The samples were dried to constant weight in an air oven at 105°C. The volume was calculated from the dimensions of the sampler and the bulk density of the soil was calculated as the ratio of the mass of the dry soil to the total volume of the soil. (Dakshinamurti and Gupta, 1968).

Table 1. Details of soil profiles

Sl. No.	Soil group, series & location	Profile No.	Depth (cm)
1	2	3	4
Laterite (Trichur District)			
Velappaya Series			
1.	Churakkattukara	I	0-15
2.			15-30
3.			30-45
4.			45-60
5.	-do-	II	0-15
6.			15-30
7.			30-45
8.			45-60
9.	-do-	III	0-15
10.			15-30
11.			30-45
12.			45-60
Black (Palghat District)			
Valiavallampathy Series			
13.	Karimannu	IV	0-15
14.			15-30
15.			30-45
16.			45-60
17.	Karuvapara	V	0-15
18.			15-30
19.			30-45
20.			45-60

Table 1 contd.

1	2	3	4
21.	Copputhod	VI	0-15
22.			15-30
23.			30-45
24.			45-60
Red Loam (Trivandrum District)			
Vellayani Series			
25.	Vellayani	VII	0-15
26.			15-30
27.			30-45
28.			45-60
29.	-do-	VIII	0-15
30.			15-30
31.			30-45
32.			45-60
33.	-do-	IX	0-15
34.			15-30
35.			30-45
36.			45-60
Riverine alluvium (Ernakulam District)			
Ponnamattom Series			
37.	Kizhumad	X	0-15
38.			15-30
39.			30-45
40.			45-60

Table 1 contd.

1	2	3	4
41.	Chowara	XI	0-15
42.			15-30
43.			30-45
44.			45-60
45.	Alwaye	XII	0-15
46.			15-30
47.			30-45
48.			45-60
Coastal alluvium (Calicut District)			
Beypore Series			
49.	Edakulam	XIII	0-15
50.			15-30
51.			30-45
52.			45-60
53.	-do-	XIV	0-15
54.			15-30
55.			30-45
56.			45-60
57.	-do-	XV	0-15
58.			15-30
59.			30-45
60.			45-60

D. Laboratory studies

(a) Preparation of the samples

A part of each soil sample was kept apart in its natural undisturbed condition for soil structure analysis. The rest of soil sample was air dried, powdered gently and passed through a 2 mm sieve. The samples so prepared were kept in labelled plastic containers for further studies.

(b) Physical properties

(i) Aggregate analysis

The analysis was based on the technique developed by Tiulin (1928) and Yoder (1936) with modifications suggested by Dakshinamurti and Gupta (1968). One hundred gram of the sample was placed in the top sieve of a set of sieves having openings of 4.75, 2.0, 1.18, 0.5, 0.25 mm diameter and saturated by spraying a small quantity of water with a hand atomiser. The sample was then wet sieved in a mechanical oscillator for ten minutes. The fractions retained on each sieve were transferred and dried to constant weight at 105°C. These were then pooled together, dispersed with sodium hydroxide, passed through the same set of sieves, washed with water and the sand fractions retained in each sieve were oven dried and weighed. From the results the following indices were derived.

1. Size distribution
2. Stability index
3. Structural coefficient
4. Mean weight diameter
5. Per cent aggregate stability

ii) <u>Particle size distribution analysis</u>

Particle size distribution analysis of 2 mm sieved soil fraction was done by the International Pipette method as outlined by Piper (1967).

iii) <u>Mean particle density</u>

The particle density (specific gravity) of the soil samples was determined using a specific gravity bottle (Black, 1965).

iv) <u>Moisture retention characteristics</u>

Moisture retention studies on the soil samples passed through the 2 mm sieve were made at 0.3, 1, 3, 5 and 15 bar pressures using pressure plate apparatus. For this, the samples were saturated overnight in rubber rings and these placed in the pressure plate till they reached equilibrium with the applied pressure (24-28 hours). After the attainment of equilibrium, the pressure was released and soil samples were removed to determine the gravimetric soil moisture content. The plates used for the determination of soil water retention at 0.3, 1, 3, 5 and 15 bar were 1, 1, 3, 5 and 15 bar ceramic plates, respectively. (Richards, 1954).

(c) Chemical properties

The chemical characteristics of the soil samples were determined by standard analytical procedure and expressed on moisture free basis.

i) Organic matter

The organic matter of the soil was determined by the method described by Walkley and Black (1934).

ii) pH in water

Soil pH was determined in a pH meter using a soil water ratio of 1 : 2.5 (Jackson, 1958).

iii) Electrical conductivity

Electrical conductivity of soil solution (1 : 2.5 soil : water ratio) was determined using a conductivity bridge (Jackson, 1958).

iv) Cation exchange capacity

The cation exchange capacity determination was made by the ammonium acetate method (Jackson, 1958). In a weighed sample of soil, cations were displaced by ammonium by leaching the soil with neutral ammonium acetate solution. The excess of ammonium acetate was removed by washing with alcohol. The ammonium saturated soil was distilled with sodium hydroxide and the ammonia liberated was absorbed in boric acid and determined by titration with standard hydrochloric acid using methylred methylene blue mixed indicator and the C.E.C. was calculated and expressed in me/100 g of soil.

v) Sesquioxide

Sesquioxide present in the soil was determined by digestion with perchloric acid and nitric acid and the insoluble silica was separated. Sesquioxide was precipitated by adding ammonium hydroxide and the precipitate was dried, ignited, weighed and expressed as percentage of sesquioxide (Hesse, 1971).

E. Statistical analysis

Simple correlation coefficients between

structural indices and some of the physical and chemical properties of soils were calculated as suggested by Snedecor and Cochran (1967). The significance of the correlation coefficients were tested by using Student's 't' test.

Results

RESULTS

The experimental results obtained during the course of present investigation are presented below:-

A. Physical properties of some typical soil groups of Kerala

i) Mechanical composition

The mechanical composition of fifteen profiles included in the present study is given in Table 2. An appreciable variation in soil texture was observed in relation to soil groups. However, soils within the same group were more or less uniform in texture. In laterite soils, the texture varied from sandy clay loam to clay loam with most of the layers exhibiting a sandy clay texture. The surface layers in each soil were coarser in texture in comparison to the lower ones. Also, profile II was finer in texture in comparison to profiles I and II.

The black soils at different locations exhibited clayey texture in all the four layers. All the profiles in this group were observed to be almost

Table 2. Mechanical composition of profile samples

Soil group and location	Profile No.	Depth (cm)	Mechanical composition (per cent)				Textural class
			Coarse sand	Fine sand	Silt	Clay	
1	2	3	4	5	6	7	8
Laterite (Velappaya Series)							
Churakkattukara	I	0-15	57.8	10.8	2.4	29.0	Sandy clay loam
		15-30	48.2	11.0	5.1	35.8	Sandy clay
		30-45	41.9	9.6	2.0	46.5	Sandy clay
		45-60	37.9	19.0	2.2	40.9	Sandy clay
-do-	II	0-15	34.3	12.4	5.0	48.3	Sandy clay
		15-30	40.3	6.7	2.5	50.5	Sandy clay
		30-45	33.6	8.6	10.2	47.6	Sandy clay
		45-60	29.4	19.6	12.3	38.7	Clay loam
-do-	III	0-15	55.7	5.5	9.3	29.5	Sandy clay loam
		15-30	49.4	6.8	10.2	33.6	Sandy clay loam
		30-45	43.6	6.4	5.3	44.7	Sandy clay
		45-60	42.3	5.7	1.6	50.4	Sandy clay

Table 2. contd.

1	2	3	4	5	6	7	8
Black soil (Valiavallampathy Series)							
Karimannu	IV	0-15	20.8	8.5	17.9	52.8	Clay
		15-30	16.8	12.4	14.2	56.6	Clay
		30-45	19.0	6.3	14.4	60.3	Clay
		45-60	7.9	9.1	16.4	66.6	Clay
Karuvapara	V	0-15	29.4	5.1	16.5	49.0	Clay
		15-30	15.4	5.8	18.5	60.3	Clay
		30-45	14.7	2.7	13.3	69.3	Clay
		45-60	12.2	2.5	11.0	74.3	Clay
Upputhod	VI	0-15	10.4	9.5	17.3	62.7	Clay
		15-30	10.8	10.1	14.6	64.5	Clay
		30-45	6.5	12.5	15.1	65.9	Clay
		45-60	9.8	6.9	17.2	66.10	Clay

Table 2. contd.

1	2	3	4	5	6	7	8
Red loam (Vellayani Series)							
Vellayani	VII	0-15	45.5	16.4	4.1	34.04	Sandy clay loam
		15-30	54.9	10.6	1.8	33.60	Sandy clay loam
		30-45	38.7	11.2	4.1	46.0	Sandy clay
		45-60	34.1	11.7	5.9	48.3	Sandy clay
-do-	VIII	0-15	45.4	12.6	5.1	36.9	Sandy clay
		15-30	45.1	6.8	6.1	42.0	Sandy clay
		30-45	33.5	14.8	6.1	45.6	Sandy clay
		45-60	32.1	11.8	8.8	47.3	Sandy clay
-do-	IX	0-15	44.7	15.1	9.9	30.3	Sandy clay
		15-30	29.5	16.6	5.4	48.5	Sandy clay
		30-45	40.4	15.1	2.2	42.3	Sandy clay
		45-60	32.5	13.6	2.8	51.1	Sandy clay

Table 2. contd.

1	2	3	4	5	6	7	8
<u>Ponnamattom</u> (Riverine alluvium)							
Kizhumad	X	0-15	4.8	31.5	36.2	27.5	Clay loam
		15-30	2.8	35.9	33.2	28.2	Clay loam
		30-45	3.2	26.5	36.6	33.7	Clay loam
		45-60	3.1	18.2	43.8	34.9	Clay loam
Chowara	XI	0-15	5.6	34.6	32.7	27.1	Clay loam
		15-30	4.5	38.7	29.0	27.8	Clay loam
		30-45	5.3	35.0	31.2	28.5	Clay loam
		45-60	4.1	28.5	33.3	34.1	Clay loam
Alwaye	XII	0-15	26.8	12.8	45.6	14.8	Loam
		15-30	33.0	3.9	38.8	24.3	Loam
		30-45	2.4	23.8	49.3	24.5	Loam
		45-60	27.0	21.1	38.8	13.1	Loam

Table 2. contd.

1	2	3	4	5	6	7	8
<u>Coastal alluvium</u> (Beypore series)							
Edakulam	XIII	0-15	59.9	17.6	6.1	16.5	Sandy loam
		15-30	44.4	20.2	5.3	30.1	Sandy clay loam
		30-45	53.2	16.2	1.6	28.7	Sandy clay loam
		45-60	52.4	4.1	14.7	28.8	Sandy clay loam
Edakulam	XIV	0-15	19.8	46.0	14.6	19.6	Sandy clay loam
		15-30	57.8	15.2	4.5	22.5	Sandy clay loam
		30-45	42.5	20.5	9.6	27.4	Sandy clay loam
		45-60	53.3	13.5	4.9	28.3	Sandy clay loam
Edakulam	XV	0-15	62.8	17.3	4.9	15.0	Sandy loam
		15-30	56.7	19.2	3.4	20.7	Sandy clay loam
		30-45	45.5	30.7	3.7	20.1	Sandy clay loam
		45-60	54.2	22.6	1.1	22.1	Sandy clay loam

similar in respect of their particle size distribution. A gradual increase in finer fractions (silt + clay) occurred with soil depth in each profile.

The red loam soils also possessed an appreciable uniformity in texture. In each soil most of the layers were sandy clay but for the surface layers of profile VII which were sandy clay loam in texture. In these profiles too, a gradual increase in finer fractions occurred with soil depth.

The soils of riverine alluvium group, viz., profile X and XI, had more or less similar mechanical composition in their respective layers. The textural class assigned was clay loam in each case. However, the third profile of this group viz., Profile XII, was distinctly loamy in texture in all its layers. In each profile, the finer fraction content exceeded 50 per cent in all the layers. However, no regular trend was observed with soil depth.

The soils of coastal alluvium group were found to be coarser in texture. In each soil, the coarser fraction (total sand) content exceeded 60 per cent in all the layers. The soils in this group too exhibited a similarity in the mechanical composition of their respective layers.

In general, black soils were found to be the finest in texture followed by riverine alluvium, laterite, red loam and coastal alluvium soils. Another important feature observed was that laterites and red loam soils had a strikingly similar type of soil texture.

ii) Volume-mass relationships

The data in respect of mean particle density, bulk density and porosity of various soils are presented in Table 3. The data amply indicate a wide variation in these parameters, not only for the soils of different groups but also for the soils of the same group.

The laterite soils the mean particle density varied from 2.65 - 2.88 g/cm^3. The range of variation in bulk density was 1.33 to 1.69 g/cm^3. Soil porosity varied from 38.2 to 52.3 per cent. In all the profiles of this soil group, the surface layer had less porosity in comparison to the lower layers. Profile II had lower values for bulk density and higher values for porosity than profiles I and III.

An appreciable variation in mean particle

Table 3. Volume-mass relationships of profile samples

Soil group (series)	Profile No.	Depth (cm)	Mean particle density (g/cm^3)	Bulk density (g/cm^3)	Porosity (%)
1	2	3	4	5	6
Laterite (Velappaya Series)					
	I	0-15	2.77	1.69	39.10
		15-30	2.82	1.50	46.90
		30-45	2.84	1.63	42.60
		45-60	2.76	1.44	47.70
	II	0-15	2.82	1.54	45.40
		15-30	2.79	1.33	52.30
		30-45	2.75	1.33	51.60
		45-60	2.73	1.40	48.90
	III	0-15	2.65	1.60	38.20
		15-30	2.73	1.64	38.60
		30-45	2.78	1.61	42.10
		45-60	2.88	1.68	41.70
Black (Valiavallampathy Series)					
	IV	0-15	2.60	1.17	55.00
		15-30	2.68	1.21	54.90
		30-45	2.62	1.17	55.30
		45-60	2.74	1.29	52.90

Table 3. contd.

1	2	3	4	5	6
	V	0-15	2.61	1.32	49.40
		15-30	2.68	1.48	44.80
		30-45	2.77	1.43	48.40
		45-60	2.73	1.22	55.40
	VI	0-15	2.57	1.39	45.90
		15-30	2.61	1.31	49.90
		30-45	2.68	1.18	56.00
		45-60	2.79	1.08	61.30
Red loam (Vellayani Series)					
	VII	0-15	2.63	1.35	48.70
		15-30	2.61	1.33	49.00
		30-45	2.65	1.35	49.70
		45-60	2.67	1.35	49.40
	VIII	0-15	2.68	1.47	45.10
		15-30	2.57	1.35	47.50
		30-45	2.62	1.33	49.20
		45-60	2.60	1.31	49.70
	IX	0-15	2.40	1.50	45.80
		15-30	2.55	1.38	45.90
		30-45	2.59	1.31	49.40
		45-60	2.68	1.34	50.00

Table 3. contd.

1	2	3	4	5	6
Riverine alluvium (Ponnamattom Series)					
	X	0-15	2.52	1.16	54.00
		15-30	2.40	1.00	58.30
		30-45	2.47	1.09	55.90
		45-60	2.65	1.19	55.10
	XI	0-15	2.50	1.13	54.80
		15-30	2.49	1.08	56.60
		30-45	2.48	1.21	51.20
		45-60	2.52	1.37	45.60
	XII	0-15	2.46	1.38	43.90
		15-30	2.48	1.32	46.80
		30-45	2.56	1.47	42.60
		45-60	2.64	1.54	41.70
Coastal alluvium (Beypore Series)					
	XIII	0-15	2.50	1.43	42.80
		15-30	2.48	1.30	47.60
		30-45	2.42	1.23	49.20
		45-60	2.56	1.20	53.20
	XIV	0-15	2.40	1.21	49.60
		15-30	2.43	1.23	49.40
		30-45	2.45	1.29	47.40
		45-60	2.39	1.35	43.60
	XV	0-15	2.44	1.47	39.80
		15-30	2.40	1.41	41.20
		30-45	2.39	1.39	41.90
		45-60	2.42	1.40	42.10

density, bulk density and porosity was observed in black soils too. The range of variation in the values of mean particle density, bulk density and porosity was 2.57 to 2.79 g/cm^3, 1.08 to 1.48 g/cm^3 and 44.8 to 61.3 per cent, respectively. Profile IV was less denser than profiles V and VI. In profile VI porosity increased with soil depth. However, no such trend was observed in other two profiles.

In red loam soils, mean particle density varied from 2.40 to 2.68 g/cm^3, bulk density from 1.31 to 1.50 g/cm^3 and porosity from 45.1 to 50 per cent. Profiles VIII and IX were almost similar in respect of their bulk density and porosity values. Also, these profiles exhibited a gradual decrease in bulk density and a corresponding increase in porosity with soil depth. In profile VIII, however, the different layers had uniformity in their bulk density and porosity values.

The range of variation in mean particle density, bulk density and porosity in riverine alluvium soils was 2.40 to 2.65 g/cm^3, 1.00 to 1.54 g/cm^3 and 41.7 to 58.3 per cent, respectively. In general, bulk density increased with soil depth.

In coastal alluvium soils, the mean particle density varied from 2.39 to 2.56 g/cm^3, bulk density from 1.20 to 1.47 g/cm^3 and porosity from 39.8 to 53.2 per cent. Profile XIV was observed to be less denser than the profiles XIII and XV.

These results clearly point out that laterite soils are more dense followed by red loam, coastal alluvium, black and riverine alluvium soils. Also, black soils possessed the maximum porosity wheraas the laterite soils the minimum.

iii) <u>Soil water retention</u>

The data on the amount of water held at various soil moisture tensions are presented in Table 4 and depicted in Fig. 1 to 5. The amount of water held at 1/3 bar is conventionally taken as the field capacity of the soil. This, as determined under laboratory conditions, varied not only between the soil groups but also between the soils of the same group. It varied from 8.86 to 21.98 per cent, 35.99 to 59.18 per cent. 11.49 to 18.67 per cent, 17.57 to 33 per cent and 10.41 to 15.18 per cent, for laterite, black, red loam, riverine and coastal alluvium soils, respectively. It was maximum in the case of black soils followed by riverine soils. Another salient feature observed was that, in general, field capacity tended to increase with soil depth.

Table 4. Moisture retention by soil profile samples (percentage by weight)

Soil group and location	Profile No.	Depth (cm)	Soil moisture tension (bars) 0.3	1	3	5	15	Available water
1	2	3	4	5	6	7	8	9
Laterite (Velappaya Series)								
Churakkattukara	I	0-15	8.86	8.39	6.77	6.69	5.38	3.49
		15-30	13.25	10.97	10.44	9.66	8.72	4.52
		30-45	14.62	13.29	12.39	12.03	10.58	4.03
		45-60	17.24	13.57	11.72	11.32	10.85	6.39
Churakkattukara	II	0-15	19.52	16.42	15.09	13.67	11.79	7.72
		15-30	21.38	18.88	17.05	15.93	14.34	7.03
		30-45	21.80	19.19	17.18	16.62	14.38	7.41
		45-60	21.98	20.21	17.82	17.00	15.22	6.75
Churakkattukara	III	0-15	11.64	9.68	7.92	7.87	6.77	4.87
		15-30	14.92	12.94	10.26	9.76	8.51	6.41
		30-45	18.59	14.92	12.71	12.47	11.66	6.93
		45-60	19.04	15.52	14.90	13.68	13.06	5.98

Table 4. contd.

1	2	3	4	5	6	7	8	9
<u>Black</u> (Vallavallampathy series)								
Karimannu	IV	0-15	41.25	33.16	29.18	28.29	26.04	15.20
		15-30	37.54	32.27	29.72	28.97	27.00	10.54
		30-45	40.86	33.13	31.69	30.66	27.67	13.19
		45-60	43.16	36.46	33.81	32.19	29.10	14.06
Karuvapara	V	0-15	36.97	29.98	28.14	25.83	23.57	13.40
		15-30	35.99	32.61	29.60	28.22	25.09	10.90
		30-45	39.59	34.69	31.26	30.27	29.94	9.66
		45-60	44.05	37.73	33.93	31.94	27.72	16.34
Upputhod	VI	0-15	40.85	33.57	30.84	30.32	26.79	14.06
		15-30	43.37	36.26	35.56	32.76	31.21	12.17
		30-45	47.45	44.72	40.22	36.76	35.52	11.93
		45-60	59.18	46.92	43.78	42.95	37.63	21.55
<u>Red loam</u> (Vellayani series)								
Vellayani	VII	0-15	11.49	11.27	9.07	8.75	8.38	3.11
		15-30	11.80	9.72	8.97	7.74	7.65	4.15
		30-45	13.89	13.43	11.98	11.27	11.09	2.79
		45-60	17.45	16.37	13.94	13.70	13.13	4.32

Table 4. contd.

1	2	3	4	5	6	7	8	9
Vellayani	VIII	0-15	13.48	11.89	9.69	8.81	8.53	4.94
		15-30	14.13	11.34	10.77	10.67	10.32	3.81
		30-45	17.21	16.02	13.27	13.21	12.73	4.48
		45-60	18.46	16.09	14.60	13.75	13.53	4.93
Vellayani	IX	0-15	12.39	10.34	8.76	8.39	8.26	4.03
		15-30	15.54	13.34	11.57	11.09	11.00	4.54
		30-45	16.26	14.82	13.17	13.15	12.71	3.56
		45-60	18.67	15.77	15.14	13.37	12.44	6.23
<u>Riverine alluvium</u> (Ponnamattom series)								
Kizhumad	X	0-15	31.89	25.52	21.12	19.47	14.74	17.15
		15-30	32.86	26.01	22.17	20.17	16.21	16.65
		30-45	32.46	26.85	21.13	20.76	15.85	16.62
		45-60	33.00	25.09	22.03	20.72	16.43	16.57
Chowara	XI	0-15	31.47	26.68	18.08	15.85	12.53	18.94
		15-30	30.93	26.45	19.41	16.83	12.35	18.58
		30-45	26.62	23.53	17.91	16.28	12.88	13.74
		45-60	30.28	25.73	20.04	18.35	16.29	13.99

Table 4. contd.

1	2	3	4	5	6	7	8	9
Alwaye	XII	0-15	17.57	14.32	11.10	10.22	9.44	8.13
		15-30	18.49	15.54	12.90	12.05	11.65	6.84
		30-45	22.81	20.06	17.68	17.41	16.55	6.26
		45-60	22.81	19.97	19.53	18.55	18.21	4.60
<u>Coastal alluvium</u> (Beypore series)								
Edakulam	XIII	0-15	11.67	9.71	7.91	7.35	5.99	5.68
		15-30	12.45	12.13	11.96	11.42	9.83	2.62
		30-45	15.18	13.01	11.07	10.53	9.13	6.05
		45-60	13.79	12.32	10.67	9.66	9.27	4.53
Edakulam	XIV	0-15	10.98	10.47	7.40	7.04	5.70	5.28
		15-30	12.47	10.25	8.85	8.55	6.81	6.66
		30-45	14.30	11.69	10.44	9.70	8.27	6.03
		45-60	12.47	11.33	10.74	10.11	8.35	4.12
Edakulam	XV	0-15	10.41	8.73	6.16	5.48	4.98	5.43
		15-30	10.62	8.86	7.49	6.60	5.83	4.79
		30-45	11.75	9.52	8.99	7.21	7.00	4.74
		45-60	13.21	10.77	10.18	9.60	8.10	5.10

Fig. 1 - SOIL MOISTURE RETENTION CURVE FOR LATERITE SOIL (SURFACE LAYERS)

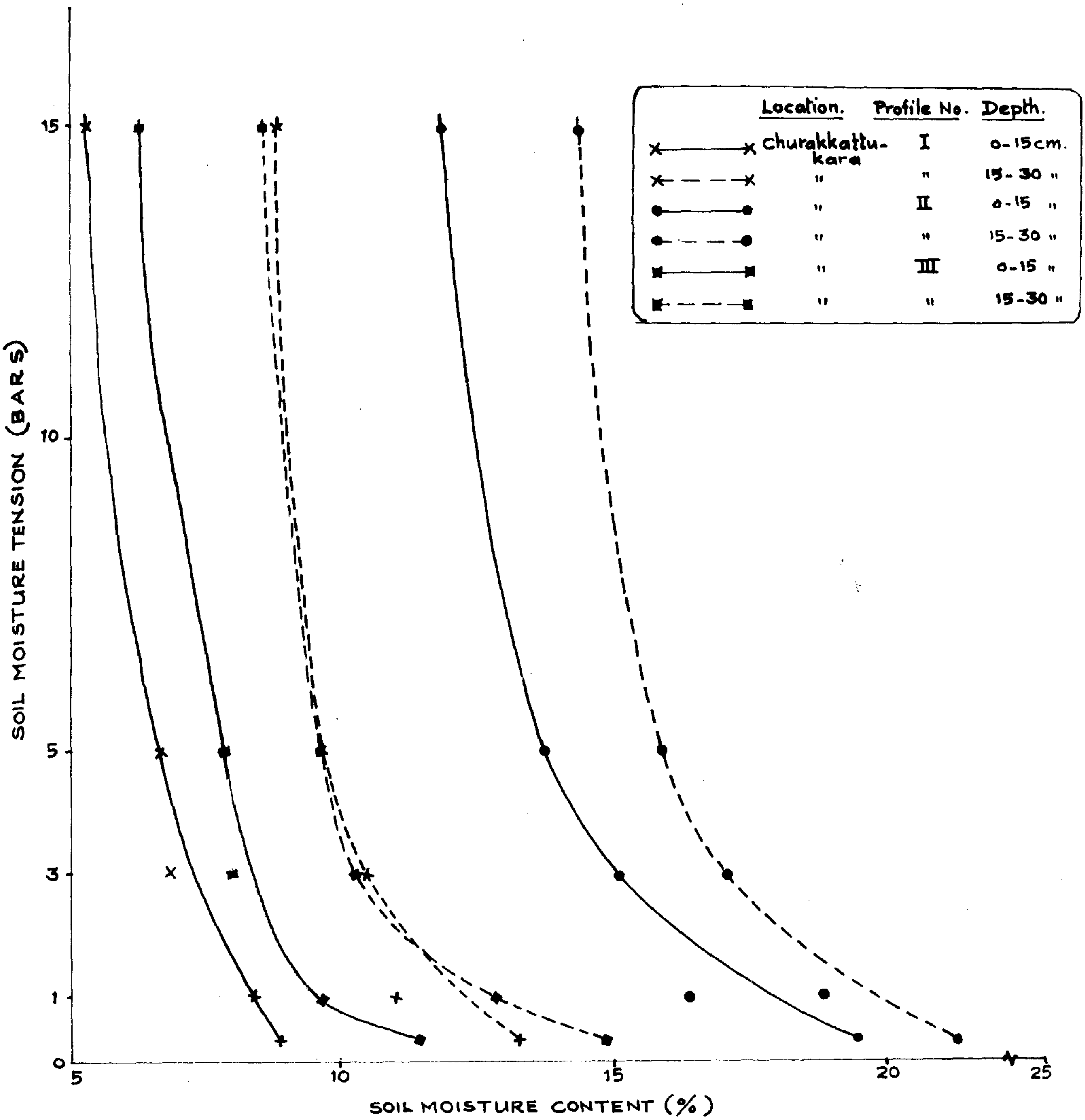


Fig. 2 - SOIL MOISTURE RETENTION CURVE FOR BLACK SOIL.
(SURFACE LAYERS)

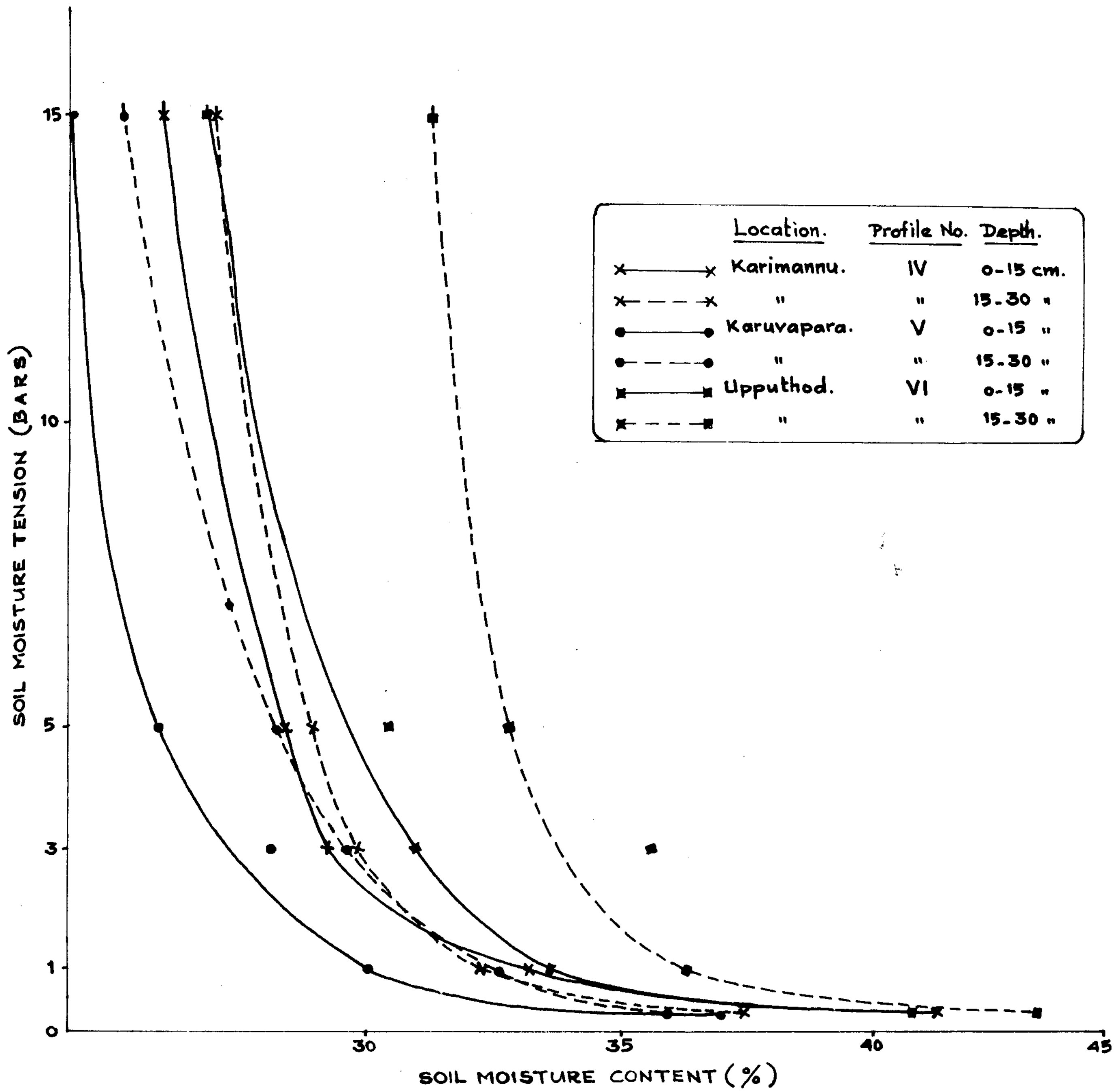


Fig. 3- SOIL MOISTURE RETENTION CURVE FOR RED LOAM SOIL (SURFACE LAYERS)

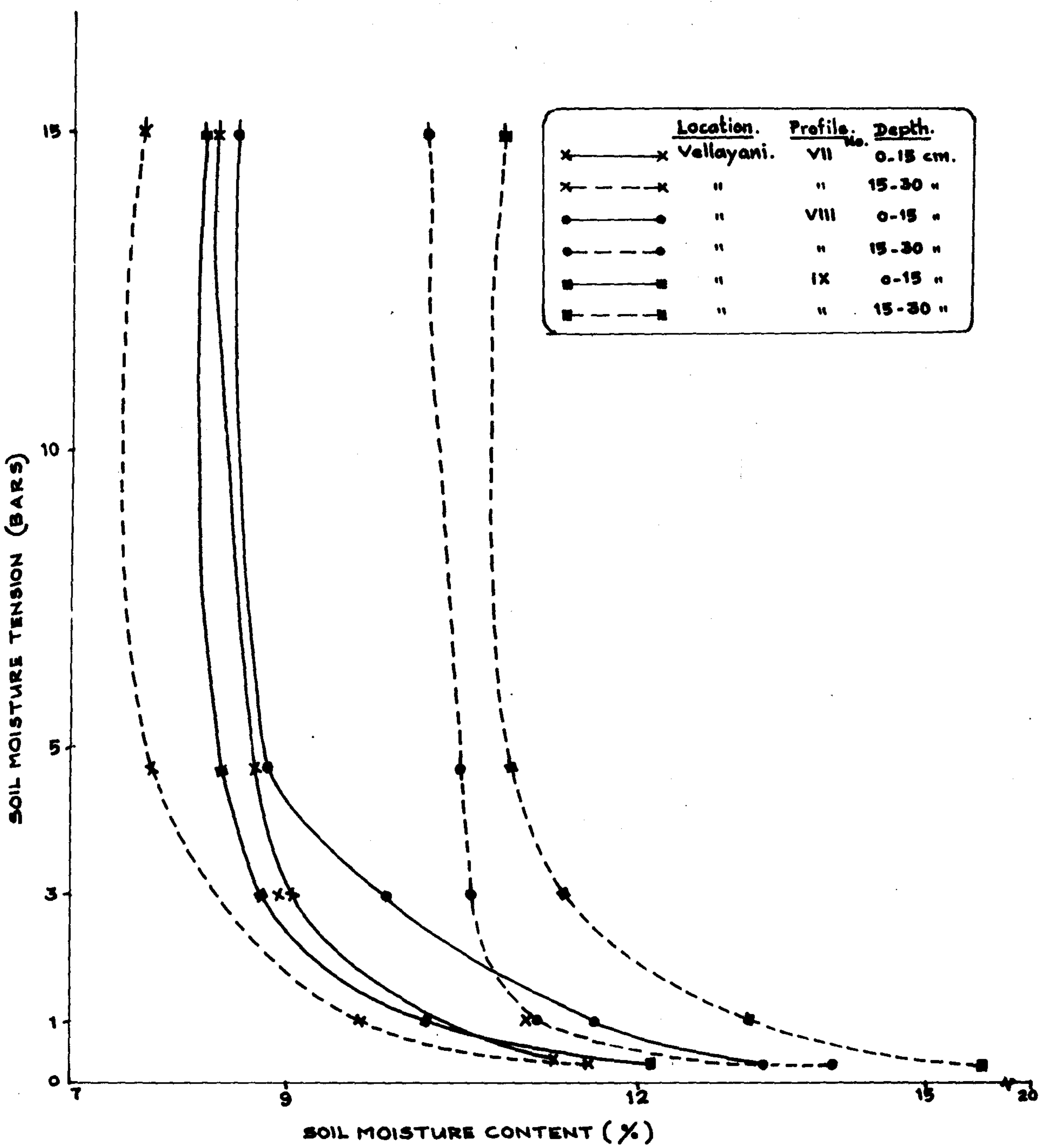


Fig. 4 - SOIL MOISTURE RETENTION CURVE FOR RIVERINE ALLUVIUM-SOIL (SURFACE LAYERS)

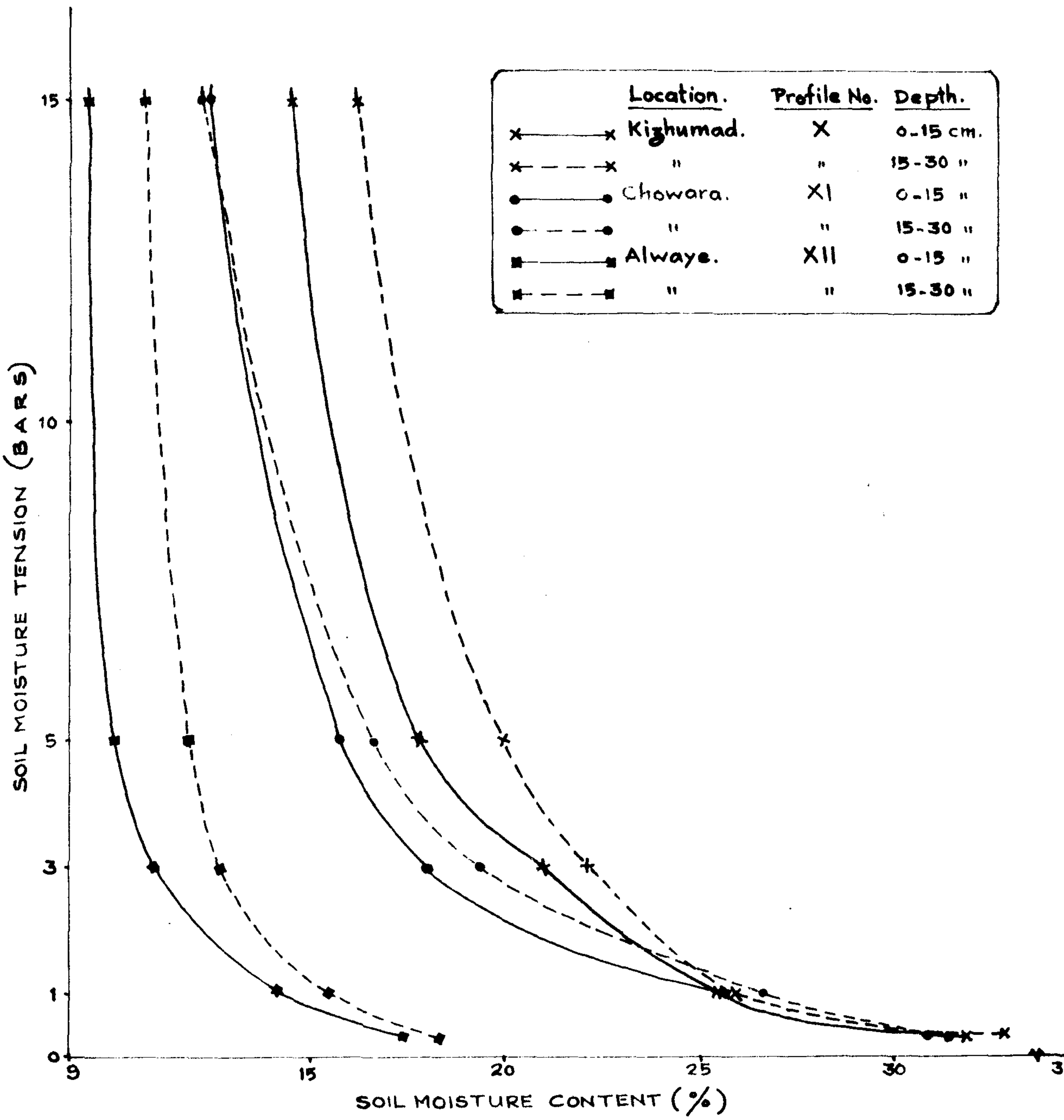
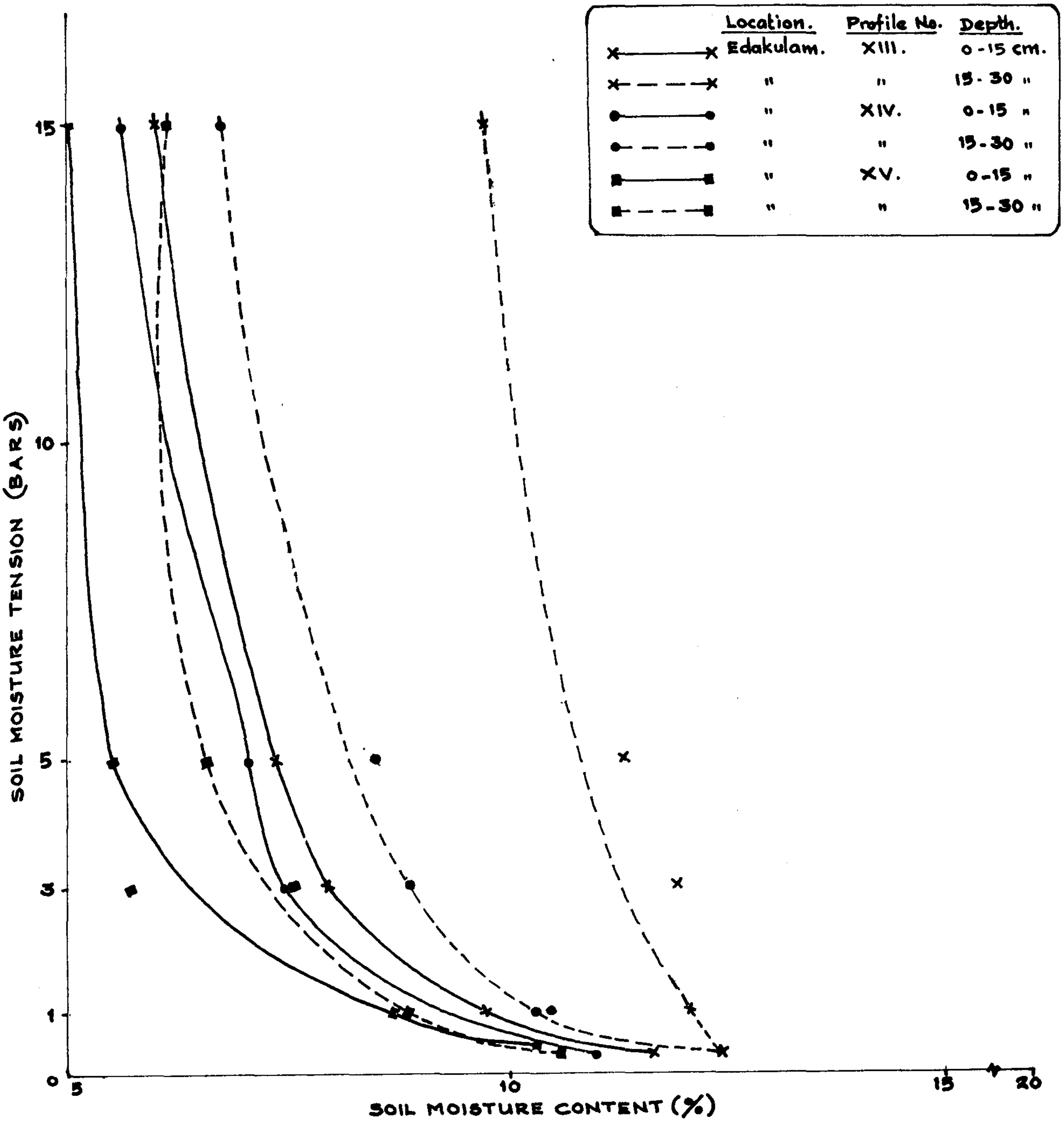


Fig. 5 - SOIL MOISTURE RETENTION CURVE FOR COASTAL ALLUVIUM SOIL (SURFACE LAYERS)



The quantities of water held at 1, 3 and 5 bars also showed trends similar to those observed for field capacity in relation to the type of soil and soil depth. These results also indicate that black soils contain more number of smaller pores in comparison to other soils. On the other hand, coastal alluvium retained very little water at these tensions suggesting thereby the macroscopic nature of pores in these soils.

The amount of water held at 15 bars is conventionally taken as wilting point. Again, black soils were found to retain the highest amount of water at 15 bars followed by riverine alluvium, laterite, red loam and coastal alluvium soils. The range of variation in water retention was 5.38 to 15.22 per cent, 23.57 to 37.63 per cent, 7.65 to 13.53 per cent, 9.44 to 18.21 per cent and 4.98 to 9.83 per cent for laterite, black, red loam, riverine alluvium and coastal alluvium soils, respectively.

Available water, calculated as the difference between the amounts of water held at 1/3 and 15 bar tensions, varied from soil to soil. In laterite soils the range obtained was 3.49 to 7.72 per cent indicating thereby a poor status of these soils in respect of the available water. No regular trend was observed with soil depth. In black soils, however, the range of available water was 9.66 to 21.55 per cent. It suggested a relatively better status of these soils in relation to available water.

In red loam soils, the available water varied from 2.79 to 6.23 per cent. These results reveal a very poor status of available water in these soils. The riverine alluvium soils were slightly better in this respect as the values for available water varied from 6.26 to 18.94 per cent in these soils. However, the coastal alluvium soils were as poor as the red loam soils in their available water status. In the former case, the range of variation was 2.62 to 6.66 per cent.

These results clearly indicate that black soils can retain more water at any given soil moisture tension and are superior to other soil groups in their available water status too. On the other hand, laterite, coastal alluvium and red loam soils have an extremely poor status in this regard.

iv) Infiltration rate

The data on steady state infiltration rate of soils are presented in Table 5. A perusal of the data in the table will point out that water infiltrated rather rapidly in the case of laterite, red loam and coastal

Table 5. Steady state infiltration rate of different soil groups.

Profile No.	Soil group	Location	Infiltration (cm/h)
I	Laterite	Churakkattukara	10.80
II	Laterite	Churakkattukara	4.80
III	Laterite	Churakkattukara	24.00
IV	Black	Karimannu	0.60
V	Black	Karuvapara	0.60
VI	Black	Upputhod	0.80
VII	Red loam	Vellayani	11.70
VIII	Red loam	Vellayani	7.50
IX	Red loam	Vellayani	9.60
X	Riverine alluvium	Kizhumad	0.20
XI	Riverine alluvium	Chowara	0.60
XII	Riverine alluvium	Alwaye	1.20
XIII	Coastal alluvium	Edakulam	18.00
XIV	Coastal alluvium	Edakulam	6.00
XV	Coastal alluvium	Edakulam	10.20

alluvium soils. As high as a figure of 24 cm/h was obtained in profile III of laterite soils. In the other two profiles of the same group too, the figures were very high; being 10.8 and 4.8 cm/h for profile I and profile II, respectively. In red loam soils it varied from 9.6 to 11.7 cm/h. The coastal alluvium soils also yielded high figures ranging from 6 to 18 cm/h.

Profile X of riverine alluvium group was found to be the least pervious having an infiltration rate of 0.2 cm/h. Profile XI of the same group showed an infiltration rate of 0.6 cm/h which was on par with the rate for profiles IV and V of black soils. Profile VI of the latter group exhibited a value of 0.8 cm/h while profile XII of the former group showed a relatively higher value of 1.2 cm/h.

Thus, the black and riverine alluvium soils were considerably less pervious in comparison to laterite, red loam and coastal alluvium soils.

B. <u>Physico-chemical characteristics of some typical soil groups of Kerala</u>

The results of physico-chemical analysis are presented in Table 6. All soils, except black soils, were found to be acidic in reaction. However, the extent of acidity varied from soil to soil. The pH values were in the range of 5.00 to 5.30, 4.70 to 6.00, 4.80 to 5.75 and 4.55 to 5.45 for laterite, red loam, riverine and coastal alluvium soils, respectively. In the case of black soils the pH varied from 7.90 to 9.10. Profile VI of black soils was found to be slightly more alkaline in reaction than Profiles IV and V.

As regards electrical conductivity (E.C.), the data clearly indicate that black soils were leading in this respect in comparison to soils of other groups. Electrical conductivity varied from 140 to 1000 micromhos/cm at 25°C in black soils. In other soil groups, the range of variation was 15 to 75 micromhos/cm at 25°C. The data further indicate that all the soils were relatively nonsaline in nature.

As expected, the cation exchange capacity (CEC) was found to be highest in black soils; the range being 45.06 to 54.22 me /100g. In other soil groups, it varied from 4.32 to 9.96, 3.22 to 4.46, 5.74 to 19.46 and 4.75 to 8.75 me /100g for laterite, red loam, riverine and coastal alluvium soils, respectively.

Table 6. Physico-chemical characteristics of profile samples

Soil group (series)	Profile No.	Depth (cm)	Organic matter (%)	CEC (me / 100 g of soil	Sesqui-oxide (%)	EC (micromhos/ cm)	pH
1	2	3	4	5	6	7	8
<u>Laterite</u> (Velappaya series)							
	I	0-15	0.54	4.32	23.5	30.0	5.15
		15-30	0.49	7.72	22.5	24.0	5.20
		30-45	0.27	4.68	23.7	30.0	5.30
		45-60	0.49	5.15	27.0	24.0	5.20
	II	0-15	1.20	9.33	24.0	27.0	5.25
		15-30	1.99	9.96	30.1	15.0	5.10
		30-45	1.06	9.25	29.7	18.0	5.25
		45-60	1.03	8.10	32.9	20.0	5.00
	III	0-15	0.59	8.76	26.8	24.0	5.00
		15-30	0.66	8.23	27.5	18.0	5.20
		30-45	0.66	6.87	27.8	24.0	5.00
		45-60	0.57	9.51	29.0	30.0	5.15

Table 6. contd.

1	2	3	4	5	6	7	8
Black (Valiavallampathy series)							
	IV	0-15	1.94	45.06	14.8	140	7.90
		15-30	0.90	46.89	14.7	180	8.25
		30-45	1.18	52.28	14.9	150	8.30
		45-60	1.03	54.22	15.7	210	8.50
	V	0-15	1.63	45.99	14.0	210	8.80
		15-30	0.89	46.66	17.8	150	8.15
		30-45	0.99	51.37	14.8	150	8.30
		45-60	0.95	51.78	14.2	180	8.30
	VI	0-15	1.37	52.87	15.6	270	8.60
		15-30	0.97	52.87	17.2	360	9.05
		30-45	0.90	52.96	19.3	600	9.10
		45-60	0.89	53.09	17.0	1000	9.00

Table 6.contd.

1	2	3	4	5	6	7	8
Red loam (Vellayani series)							
	VII	0-15	0.61	3.52	22.60	18.0	6.00
		15-30	0.63	3.89	22.60	24.0	5.25
		30-45	0.59	4.15	24.10	27.0	5.50
		45-60	0.49	4.46	26.90	30.0	4.75
	VIII	0-15	0.79	3.85	22.00	30.0	4.80
		15-30	0.69	4.02	28.10	24.0	4.95
		30-45	0.50	3.22	27.20	21.00	4.70
		45-60	0.46	4.04	31.70	24.00	4.80
	IX	0-15	0.84	3.36	21.30	27.00	4.85
		15-30	0.59	4.27	29.40	26.00	4.65
		30-45	0.60	3.95	28.20	35.00	4.90
		45-60	0.63	4.27	30.20	21.00	4.75

Table 6. contd.

1	2	3	4	5	6	7	8
<u>Riverine alluvium</u> (Ponnamattom series)							
	X	0-15	2.60	13.28	17.60	75.00	5.00
		15-30	2.34	13.27	18.80	30.00	5.35
		30-45	1.78	19.46	20.90	33.00	5.20
		45-60	1.12	14.00	26.60	36.00	5.25
	XI	0-15	1.66	12.61	17.70	33.00	4.80
		15-30	1.70	14.80	15.20	27.00	4.90
		30-45	1.01	8.49	15.70	27.00	4.90
		45-60	1.50	12.79	19.90	27.00	5.65
	XII	0-15	1.35	5.74	18.76	27.00	5.17
		15-30	1.22	6.73	15.60	36.00	5.55
		30-45	1.03	15.01	23.90	45.00	5.40
		45-60	0.83	6.75	20.00	30.00	5.75

Table 6. contd.

1	2	3	4	5	6	7	8
Coastal alluvium (Beypore series)							
	XIII	0-15	1.39	4.75	17.60	24.00	5.35
		15-30	0.81	8.45	15.20	18.00	5.20
		30-45	0.47	8.31	16.70	21.00	5.35
		45-60	0.42	8.21	16.70	33.00	5.40
	XIV	0-15	0.61	5.85	20.30	21.00	5.45
		15-30	0.44	5.86	15.90	24.00	4.85
		30-45	1.00	8.75	15.70	18.00	4.55
		45-60	0.55	6.10	15.50	18.00	4.75
	XV	0-15	0.65	5.15	17.60	21.00	4.95
		15-30	0.41	5.84	15.60	18.00	5.05
		30-45	0.62	7.26	24.40	21.00	5.00
		45-60	0.34	6.44	15.50	24.00	4.90

The organic matter status of the soils varied from soil to soil even within the same soil group. While profile II of laterite group had a fair distribution of organic matter in all its layers, the other two profiles, I and III, were found to be poorer in this respect. The black soils had a more or less even distribution of organic matter ranging from 0.89 to 1.94 per cent. In red loam soils, it varied from 0.50 to 0.84 per cent. The profile X (riverine alluvium group) distinctly exhibited a relatively higher status in respect of organic matter; the range of riverine alluvium group being 0.83 to 2.60 per cent. The other two profiles of the same group also had a fair distribution of organic matter in their respective layers. In coastal alluvium soils, profile XIII had more organic matter in its surface layer in comparison to other two profiles. In all soils, the surface layer were found to be relatively richer in organic matter content.

As far as the content of sesquioxides is concerned, the laterite and red loam soils were found to be richer in it, the range being 22.0 to 32.9 per cent. The riverine and coastal alluvium soils had almost a similar status in respect of sesquioxides, that varied from 15.2 to 26.6 per cent. In black soils it varied from 14.0 to 19.3 per cent. In both laterite and red loam soils, the sasquioxida content increased with soil depth whareas no such variation was observed in other groups.

C. Soil structure

The data on distribution and indices of water stable aggregates ara presented in Tables 7 and 8, respectively. It is quite evident that tha water stable aggregates ware not distributed evenly in different layers of various profiles (Table 7). Considering the different sizes of aggregates together, aggregates greater than 0.25 mm were found to be in appreciable amount in all the soils except for a few layers in riverine and coastal alluvium soils. Nevertheless, soils of these groups too, contained a fairly good distribution of aggregates greater than 0.25 mm in their other layers.

In the case of red loam soils, which were observed to have a more or less even distribution of aggregates greater than 0.25 mm in their respective layers. In other soils, it varied from 50 to 65 per cent. In riverine alluvium soils, the range of variation was 30 to 80 per cent. It was closely

Table 7. Distribution of water stable aggregates

Soil group (series)	Profile No.	Depth (cm)	Aggregate per cent					
			< 0.25 mm	0.25 - 0.5 mm	0.5 - 1.18 mm	1.18 - 2.0 mm	2.0 - 4.75 mm	4.75 - 8.00 mm
1	2	3	4	5	6	7	8	9
Laterite (Velappaya series)								
	I	0-15	39.01	17.95	16.71	7.46	13.36	5.51
		15-30	2.80	36.69	12.38	7.21	20.68	20.24
		30-45	43.40	18.01	10.27	7.40	12.38	8.54
		45-60	29.40	12.93	9.04	11.94	26.0	10.69
	II	0-15	32.30	14.82	24.35	9.57	15.37	3.59
		15-30	34.65	26.60	20.71	7.72	9.34	0.98
		30-45	20.58	17.22	19.03	10.18	21.68	11.31
		45-60	27.20	17.86	22.93	9.26	16.55	6.20
	III	0-15	28.09	21.07	16.07	10.63	18.61	5.53
		15-30	29.98	10.65	13.28	13.32	21.46	6.81
		30-45	20.76	17.86	12.73	12.32	24.77	11.56
		45-60	21.91	13.65	9.45	16.65	30.91	7.43

Table 7. contd.

1	2	3	4	5	6	7	8	9
Black (Valiavallampathy series)								
	IV	0-15	37.57	20.95	25.70	5.33	4.74	5.71
		15-30	46.66	15.21	27.95	8.86	2.88	0.44
		30-45	31.38	20.76	40.35	5.71	1.88	0.00
		45-60	29.00	20.32	34.39	9.15	6.81	0.33
	V	0-15	30.61	20.01	20.08	9.31	9.20	10.79
		15-30	40.17	20.12	27.74	5.77	5.31	0.89
		30-45	35.08	26.10	27.96	6.02	4.19	0.65
		45-60	18.62	17.94	39.56	13.52	7.85	2.51
	VI	0-15	13.43	15.45	23.12	14.70	14.54	18.76
		15-30	19.59	12.65	34.47	16.85	10.73	5.71
		30-45	23.36	10.16	33.72	18.77	11.60	2.39
		45-60	8.60	19.60	35.14	21.08	12.31	3.28

Table 7. contd.

1	2	3	4	5	6	7	8	9
Red loam (Vellayani series)								
	VII	0-15	49.88	24.25	18.34	3.71	3.12	0.70
		15-30	46.90	32.23	16.25	2.28	1.94	0.40
		30-45	44.36	36.04	15.08	2.48	1.92	0.12
		45-60	43.26	26.48	22.64	4.16	2.95	0.51
	VIII	0-15	39.28	33.22	16.27	4.65	4.74	1.84
		15-30	40.87	31.46	22.04	2.77	2.60	0.26
		30-45	36.45	33.01	23.34	4.01	2.47	0.82
		45-60	44.90	32.48	19.59	2.29	0.67	0.17
	IX	0-15	37.52	30.06	16.84	5.58	7.05	2.95
		15-30	44.50	31.35	14.98	3.85	4.66	0.66
		30-45	36.50	32.67	24.01	3.46	3.01	0.35
		45-60	39.66	29.70	20.44	4.55	4.47	1.81

Table 7. contd.

1	2	3	4	5	6	7	8	9
Riverine alluvium (Ponnamattom series)								
	X	0-15	62.74	23.24	11.24	1.92	0.86	0
		15-30	50.45	21.89	22.21	3.81	1.34	0.30
		30-45	70.01	21.35	6.80	1.27	0.57	0
		45-60	58.57	26.42	12.02	1.67	0.92	0.40
	XI	0-15	52.12	20.37	5.11	18.97	3.43	0
		15-30	43.77	22.86	24.34	6.01	2.86	0.16
		30-45	54.06	19.92	16.47	5.50	3.55	0.50
		45-60	47.50	24.30	20.97	3.31	2.95	0.97
	XII	0-15	47.54	16.67	18.30	7.32	8.82	1.33
		15-30	32.22	17.88	26.74	10.42	9.01	3.73
		30-45	22.39	16.53	21.84	9.85	14.37	15.02
		45-60	19.04	16.51	23.98	10.54	14.33	15.61

Table 7. contd.

1	2	3	4	5	6	7	8	9
Coastal alluvium (Beypore series)								
	XIII	0-15	37.67	35.20	15.41	2.95	6.18	2.59
		15-30	27.36	27.03	22.26	8.95	9.12	5.28
		30-45	40.60	32.72	16.04	5.51	4.39	0.74
		45-60	43.67	39.19	15.64	1.23	0.27	0
	XIV	0-15	45.74	37.75	10.95	1.78	3.02	0.76
		15-30	46.18	30.55	15.49	3.32	3.82	0.64
		30-45	61.90	16.27	18.10	2.53	1.01	0.19
		45-60	30.64	29.95	36.99	1.58	0.84	0
	XV	0-15	38.20	35.63	22.99	1.52	1.06	0.60
		15-30	40.88	36.89	20.82	1.12	0.29	1.29
		30-45	37.78	39.61	19.13	1.62	1.33	0.53
		45-60	43.10	35.37	20.20	1.07	0.26	0

Table 8. Indices of water stable aggregates in soil profile samples

Soil group	Profile No.	Depth (cm)	Mean weight dia-meter (mm)	Stabi-lity index (%)	Structu-ral co-efficient	% Aggre-gate stabi-lity
1	2	3	4	5	6	7
<u>Laterite</u> (Velappaya series)						
	I	0-15	1.13	17.45	0.31	31
		15-30	2.21	44.73	0.87	87
		30-45	1.29	16.89	0.28	28
		45-60	1.90	10.17	0.26	26
	II	0-15	1.16	25.44	0.44	44
		15-30	1.81	33.24	0.48	48
		30-45	1.84	34.30	0.61	61
		45-60	1.36	32.53	0.52	52
	III	0-15	1.36	19.83	0.41	41
		15-30	1.52	14.61	0.30	30
		30-45	1.94	28.21	0.57	57
		45-60	1.91	22.98	0.50	50
<u>Black</u> (Valiavallampathy series)						
	IV	0-15	0.94	46.55	0.53	53
		15-30	0.61	43.09	0.47	47
		30-45	0.81	57.01	0.60	60
		45-60	0.80	58.28	0.62	62
	V	0-15	1.43	52.85	0.60	60
		15-30	0.64	45.51	0.50	50
		30-45	0.50	47.70	0.54	54
		45-60	1.12	60.62	0.68	68

Table 8. contd.

1	2	3	4	5	6	7
	XI	0-15	0.68	41.19	0.44	44
		15-30	0.55	48.88	0.52	52
		30-45	0.52	40.16	0.42	42
		45-60	0.54	45.46	0.48	48
	XII	0-15	0.79	24.89	0.34	34
		15-30	1.04	35.93	0.52	52
		30-45	1.87	35.98	0.60	60
		45-60	1.95	32.70	0.62	62
Coastal alluvium (Beypore series)						
	XIII	0-15	0.73	32.43	0.47	47
		15-30	1.12	47.65	0.63	63
		30-45	0.61	37.30	0.57	57
		45-60	0.36	28.11	0.41	41
	XIV	0-15	0.49	28.88	0.40	40
		15-30	0.53	28.73	0.38	38
		30-45	0.39	21.30	0.26	26
		45-60	0.53	36.20	0.53	53
	XV	0-15	0.47	25.60	0.40	40
		15-30	0.47	19.48	0.33	33
		30-45	0.46	22.76	0.37	37
		45-60	0.38	24.40	0.36	36

Table 8. contd.

1	2	3	4	5	6	7
	VI	0-15	2.20	68.40	0.76	76
		15-30	1.35	61.07	0.70	70
		30-45	1.66	46.64	0.62	62
		45-60	1.33	71.70	0.81	81
Red loam (Vellayani series)						
	VII	0-15	0.52	17.75	0.26	26
		15-30	0.44	26.70	0.26	26
		30-45	0.43	31.14	0.41	41
		45-60	0.54	34.15	0.44	44
	VIII	0-15	0.66	34.37	0.46	46
		15-30	0.50	36.03	0.47	47
		30-45	0.61	41.50	0.53	53
		45-60	0.42	35.52	0.44	44
	IX	0-15	0.82	33.55	0.47	47
		15-30	0.56	27.93	0.38	38
		30-45	0.55	34.03	0.48	48
		45-60	0.66	38.60	0.49	49
Riverine alluvium (Ponnamattom series)						
	X	0-15	0.32	31.99	0.33	33
		15-30	0.46	44.70	0.46	46
		30-45	0.26	26.20	0.27	27
		45-60	0.36	37.25	0.38	38

followed by coastal alluvium soils having a range of 40 to 70 per cent. Profile X and XI of riverine alluvium group were found to be almost similar whereas profile XII of the same group had a relatively better status in respect of aggregates greater than 0.25 mm.

Mean weight-diameter is another important index of soil aggregation. Its values for the soils under investigation are given in Table 8. A perusal of data in the table would reveal that mean weight-diameter varied markedly even within the same soil. In laterite soils, it showed lower values in the surface layer (0 - 15 cm) in comparison to the lower layers. Overall, it varied from about 1.13 to 2.21 mm in these soils. Again, the second layer of profile I gave a higher value of 2.21 mm. The black soils showed a range of variation of 0.50 to 2.20 mm. These soils exhibited relatively higher values for mean weight-diameter in their surface layers in comparison to the lower ones. Profile VI showed the highest values in all its layers. The red loam soils had a narrow range of variation in mean weight-diameter the range being 0.42 to 0.82 mm. However, riverine and coastal alluvium soils exhibited wider ranges of 0.26 to 1.95 mm and 0.36 to 1.12 mm, respectively.

Other indices that are commonly employed to assess the state and stability of aggregation in soils are stability index, structural coefficient and per cent aggregate stability per cent aggregate stability is obtained by multiplying structural coefficient with 100. These indices were also calculated and their values are presented in Table 8. The data amply demonstrate an appreciable variation in their indices not only amongst soils of different groups but also within the soils of the same group. Stability index varied from about 10.17 to 44.73 per cent, 45.51 to 71.70 per cent 17.75 to 41.50 per cent, 24.89 to 48.88 per cent and 19.48 to 47.65 per cent for laterite, black, red loam, riverine and coastal alluvium soils, respectively. On the basis of stability index, once again the superiority of black soils to other soils in respect of state of aggregation is established. Riverine and coastal alluvium soils were found to be almost similar in this respect closely followed by laterites and red loam soils.

The per cent aggregate stability varied from

26 to 87 per cent, 47 to 81 per cent, 26 to 53 per cent, 27 to 62 per cent and 26 to 63 per cent for laterites, black, red loam, riverine and coastal alluvium soils, respectively. Again, the data establish the superiority of black soils in degree of aggregation to other soils.

Thus, these results show that black soils have distinctly superior aggregation in comparison to the rest of the soils under investigation. Laterite soils come next closely followed by riverine alluvium, coastal alluvium and red loam soils.

D. Statistical analysis

In order to evaluate the effects of clay, organic matter, CEC and sesquioxides on aggregation, coefficients of simple correlation (r) were worked out considering mean weight diameter and structural coefficient as indices of soil aggregation. The r-values between different soil properties and structural indices are presented in Table 9. A positive correlation between clay and mean weight-diameter was observed in laterite, black and coastal alluvium soils. However, red loam and riverine alluvium soils yielded negative correlation. Organic matter was found to be positively correlated with mean weight-diameter in all the soil groups but for riverine

Table 9. Coefficient of simple correlation (r) between structural indices and soil properties

Soil group	Mean weight diamter with				Structural coefficients with			
	Clay	Organic matter	CEC	Sesqui-oxide	Clay	Organic matter	CEC	Sesqui-oxide
Laterite (n = 12)	0.294	0.016	0.232	0.094	0.137	0.165	0.448	-0.063
Black soil (n = 12)	0.374	0.210	0.643*	0.002	0.418	0.203	0.679*	0.196
Red loam (n = 12)	-0.290	0.647*	-0.408	-0.292	0.433	0.032	-0.0297	0.409
Riverine alluvium (n = 12)	-0.688*	-0.554	-0.386	-0.178	-0.293	-0.496	-0.330	-0.0158
Coastal (n = 12)	0.410	0.413	0.125	-0.188	0.410	0.384	0.458	-0.177

*Significant at 5% level

alluvium. CEC, like clay content, was positively correlated with mean weight-diameter in laterite, black and coastal alluvium soils. As far as the sesquioxides are concerned, a positive correlation with mean weight-diameter was obtained only in laterite and black soils.

Structural coefficient was positively correlated with clay in each soil group except riverine alluvium soils. A similar trend was observed in relation to organic matter. However, CEC yielded positive correlation in all soil group but for the red loam and riverine alluvium soils. The sesquioxides gave positive correlation with structural coefficient only in black and red loam soils.

Discussion

DISCUSSION

The present study was undertaken with a view to assess the structural status and its inter-relationships with some physico-chemical properties of some typical soil groups of Kerala, namely, laterite, black, red loam soil, riverine and coastal alluvium soils.

A. Physical properties of some typical soils of Kerala

i) Texture

The study has revealed that the soils of Kerala exhibit appreciable variations in texture ranging from clay to loam. However, within the same soil group an uniformity in texture has been noticed. As expected the black soils were clay in texture. The finer fraction content increased with soil depth (Venugopal, 1969).

Laterite soils were found to be sandy clay in texture. In all these soils there were signs of downward migration of clay and the lower layers tended to be finer in texture. It may be expected in view of typical tropical conditions of high rainfall and temperature that are prevalent in this part of Kerala (Antony, 1982).

The red loam soils were also predominantly sandy clay in texture in their respective layers. In this case too, a downward migration of finer fractions was noticed. According to Koshy (1962) these soils have been formed by the admixture of the coastal sand with aeolin deposits from the east followed by a process of imperfect laterization. This might be the reason for their striking similarity with laterite soils in texture.

As expected, the soils of riverine alluvium group were finer in texture as compared to soils of coastal alluvium group. In riverine alluvium group, the finer fractions exceeded 50 per cent in all the layers whereas in coastal alluvium group, the coarser fractions predominated in all the layers (60 per cent). No regular trend with soil depth was observed in either group. The riverine soils are relatively young and are produced by their periodical deposition of finer materials by flood water in river banks and these may perhaps explain the rather uniform nature of their profile morphology. On the other hand, coastal alluvium soils are formed by the admixture of the sand of the western coast with varying proportion of laterite materials occurring in the eastern border of the region and this mode of formation could explain the coarse nature of the texture. (Koshy, 1962).

ii) Volume-mass relationships

Thera was an appreciable variation in particle density in relation to soil groups. Laterite soils are found to have higher values of mean particle density. It could be expected as these soils are generally rich in oxides of iron (Antony, 1982). Again, laterite soils possessed relatively higher bulk density followed by red loam, coastal alluvium, black and riverine alluvium soils. Because of the predominance of coarser materials in laterite, red loam and coastal alluvium soils, it may be possible for these soils to attain high bulk density in comparison to black and riverine alluvium soils which were relatively richer in finer particles. Porosity is calculated from the particle density and bulk density, and therefore the factors which influence these parameters will affect porosity too. One such factor is clay. The porosity was positively correlated with clay content, in red loam ($r = 0.640^{*}$), riverine alluvium ($r = 0.622^{*}$) and coastal alluvium ($r = 0.610^{*}$) soils. The correlations were found to be significant. An increase in porosity with clay content has also been reported by Kandaswamy (1961), Durairaj (1961), Varkey (1963), Ramanathan (1965) and Perecun and Campes (1981).

iii) Soil water retention

A wide variation in moisture retained at 1/3 bar, known as field capacity, was observed in most of the soils studied. It was highest for black soils followed by riverine alluvium, laterite, red loam and coastal alluvium soils. These variations could be attributed to the differences in clay content of various soils. All soil groups gave positive correlation between clay content and field capacity (Table 10); laterite ($r = 0.778^{**}$) red loam ($r = 0.863^{**}$), riverine alluvium ($r = 0.763^{**}$) and coastal alluvium ($r = 0.719^{**}$) gave highly significant correlations. As black and riverine alluvium soils are relatively rich in clay content, they may be expected to hold more water in comparison to other soils at 1/3 bar. Another feature observed was that field capacity, in general, increased with soil depth. It may be explained on the basis of the fact that in most cases the content of finer fractions increased with soil depth.

Moisture held at other tensions also followed

Table 10. Relationship of clay with porosity and moisture retention at 1/3 bar and 15 bar (Coefficient of simple correlation)

Soil groups	Porosity	Moisture retention	
		1/3 bar	15 bar
Laterite (n = 12)	0.560	0.778**	0.581*
Black (n = 12)	0.158	0.444	0.540
Red loam (n = 12)	0.640*	0.863**	0.870**
Riverine alluvium	0.622*	0.763**	0.241
Coastal alluvium (n = 12)	0.610*	0.719**	0.936**

* Significant at 5% level

** Significant at 1% level

similar trends as in the case of field capacity (Fig. 1 to 5). These values were maximum in black soils and minimum in coastal alluvium soils. The water retained by the soils at 15 bar is commonly referred to as the wilting point, although it may slightly vary from crop to crop, and with the evaporative demand of the atmosphere. The wilting point was found to be maximum in black soils and minimum in coastal alluvium soils. There existed a positive correlation between clay content and wilting point (Table 10) for all the soil groups. In the case of laterite ($r = 0.581^{*}$) red loam ($r = 0.870^{**}$) and coastal alluvium ($r = 0.936^{**}$) the relationship was significant. Thus, it may be inferred that nature and quantity of clay in each soil primarily govern the water retention at different tensions. These results lend credence to findings of Trans-vink-An and Nguba (1971); Pidgeon (1971); Border <u>et al</u>. (1974); Warkentdn (1974); Venkataraman (1976) and Antony (1982).

The difference between the field capacity and wilting point was referred to as the available water. As expected, it was found to be maximum in black soils. On the basis of data obtained, the laterite, red loam and coastal alluvium soils can be designated as " poor " in respect of their available water status. Lal (1979) also reported that the available water content of highly weathered coarse textured soils of humid tropics is generally low. Similar views were expressed earlier by De Melo (1974); De silva *et al* (1975); and Wahab *et al*. (1975).

iv) Infiltration

Infiltration rates were found to be exceptionally higher in the case of laterite, red loam and coastal alluvium soils. For these groups of soils the infiltration rate ranged from 5 cm/h to as high a figure as 24 cm/h. On the other hand, the black and riverine alluvium soils exhibited markedly lower values varying from 0.22 to 1.2 cm/h indicating thereby the less pervious nature of these soils. The high rates of infiltration in the case of laterite soils may be attributed to the presence of large quantity of gravels, sometimes even exceeding 70 per cent (Antony, 1982). Wolf and Drosdoff (1976) found that infiltration in Ultisols and Oxisols of Peurto Rico was very rapid reaching a rate of about 10 cm/h. Higher rates of infiltration, as observed in the present study, have also been reported for other humid tropical soils by workers such as Kamerling (1975);

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Lal (1976); Lal and Cumming (1979) and Antony (1982). Soil texture is also known to play a predominant role in controlling the process of infiltration. As black and riverine alluvium soils were richer in clay, they exhibited relatively low values of infiltration rates. This fact is further brought out clearly when one refers to profile 12 of riverine alluvium group which was slightly coarser in texture in comparison to other two profiles of the same group. In this profile comparatively higher infiltration rate of 1.2 cm/h is obtained. These findings are in agreement with the findings of Agrawal et al. (1974).

B. Physico-chemical characteristics of some typical soil groups of Kerala

All soils except black soils, exhibited an acidic reaction. It is quite tenable as most of the soils have developed under intense humid conditions where leaching has depleted their surface and subsurface layers of the basic cations. In comparison, black soils have developed under moderate conditions of temperature and rainfall; thus the soils acquiring an alkaline reaction. Moreover, the nature and amount of clay as well as exchangeable cations present in these soils may have influenced the soil reaction.

As regards, electrical conductivity, though the black soils recorded relatively higher values, they were practically non-saline in nature. CEC was maximum in black soils. It may be attributed to the presence of 2:1 (expanding) type of minerals in them (Sharda, 1977). The low CEC exhibited by other soils might be due to the predominance of 1:1 type of minerals in these soils.

The organic matter status of laterite, red loam and coastal alluvium soils was rather low. It may be due to the fast decomposition of organic matter under the tropical conditions (Antony, 1982). However, in the case of black and riverine alluvium soils, the condition seemed to be rather conducive for the accumulation of organic matter. As expected, laterite and red loam soils contained relatively large amount of sesquioxide persumably due to rapid weathering conditions (Koshy, 1962).

C. Soil Structure

Most of the workers have used the percentage of aggregates larger than 0.25 mm as the basis for the comparison as proposed by Tiulin (1928). This method has the limitation as it does not utilize the entire range of aggregates. Neverthless, in the present study this index has been observed to give a fairly reliable index of structure of soils. On the basis of data obtained, black soils are found to be superior to the other soils. Laterite soils also exhibited satisfactory values for the index. Red loam, riverine and coastal alluvium soils showed more or less similar type of trend in respect of this index. These results were in conformity with the findings of Chakraborty et al. (1981).

In the present study mean weight-diameter and structural coefficient were considered as the indices of soil aggregation. The mean weight-diameter which is a statistical index of aggregation gives an estimate of the average size of the water stable aggregates. The maximum values for mean weight-diameter were obtained in the case of black soils. A fairly high value for mean weight-diameter was also exhibited in laterite soils. A wider variation was observed in riverine and coastal alluvium soils. Red loam soils had rather narrow range of variation. The relatively larger values obtained in the case of black, laterite and to some extent in riverine alluvium soils, may probably be due to the presence of large quantities of such cementing agents as organic matter, sesquioxides and clay in these soils (Deshpande et al., 1964; Azuma et al., 1968; Yadav and Banerjee, 1968; Chakrabarti & Das, 1969; Van Raj and Peech, 1972; Kolarkar et al., 1974; Galles et al., 1977 and Greenland, 1979). Positive correlations were obtained between mean weight-diameter and such physico-chemical characteristics as clay, organic matter, CEC and sesquioxide content in laterite and black soils. The correlation between mean weight-diameter and CEC was found to be significant for black soils ($r = 0.643^{*}$).

The degree to which the soil aggregates resist dispersion is another characteristic used to evaluate the stability of soil aggregates. The stability index was found to be maximum in black soil. Other soil groups exhibited more or less a similar type of trend in their stability index. These variations in stability index may be attributed to differences in the contents of organic matter, clay and sesquioxides. Similar views were also expressed by Sharma and Uehara (1968), Uehara et al. (1972) and De Vleeschauwer et al. (1979).

Another important structural index to assess the degree of aggregation in soil is structural coefficient which when multiplied by 100 is referred to as per cent aggregate stability. Again black soils exhibited high values for structural coefficient, confirming thereby a better state of aggregation in these soils. These soils were followed by laterite, riverine alluvium, coastal alluvium and red loam soils. A positive correlation (laterite, r = 0.137, black r = 0.418, red loam, r = 0.433, coastal alluvium, r = 0.410) existed between clay and structural coefficient in all the soil groups except riverine alluvium. A similar trend was observed in relation to the organic matter content of these soils. However, the positive correlation between CEC and structural coefficient was significant only in the case of black soil ($r = 0.679^{**}$). A positive correlation between sesquioxide and structural coefficient was obtained only in black and redloam soils. (Black soil, r = 0.196, red loam, r = 0.409) These results are in confirmity with the work of Ameer (1970). In riverine soils, which are comparatively of recent origin, such relationships could not naturally be observed (Antony, 1982).

Summary

SUMMARY

In the present study an attempt has been made to evaluate the structural indices in relation to some of the physico-chemical properties of five major soil groups of Kerala namely, laterite, black, red loam, riverine alluvium and coastal alluvium belonging to five extensively occurring series viz., Valappaya, Valiavallampathy, Vellayani, Ponnamattom and Baypore series, respectively. Three profiles were chosen from each soil group and from each profile, soil samples were collected from four depths, 0-15, 15-30, 30-45 and 45-60 cm. Utmost care was taken to keep the soil samples in their natural undisturbed conditions to carry out structural analysis. A portion of each sample was analysed for structural indices by wet sieving and the other portion was subjected to routine analysis. The main findings are summarised below.

1. In general, the soils of Kerala exhibited an appreciable variation in soil texture varying from clay to loam. However, within the same soil group an uniformity in texture has been noticed.
2. Laterite soils are found to be sandy clay in texture.

In all these soils there were signs of downward migration of clay and the lower layers tended to be finer in texture.

3. The black soils were clay in texture. Their finer fraction content increased with soil depth.

4. The red loam soils too were predominantly sandy clay in texture. In this case also a downward migration of finer fractions was noticed.

5. Soils of riverine alluvium group were relatively finer in texture, as the finer fractions exceeded 50 per cent in all the layers. Amongst the three profiles of this group, two were clay loam and one was loamy in texture.

6. Coastal alluvium soils were found to be coarser in texture and the coarser fraction (total sand) content exceeded 60 per cent in all the layers. The texture was predominantly sandy clay loam.

7. An important feature observed was that laterites and red loam soils had a strikingly similar type of soil texture.

8. Particle density was highest for laterite soils

and lowest for coastal alluvium soils.

9. Laterite soils are more dansa followed by red loam, coastal alluvium, black and riverine alluvium soils. The clay content was found to increase the porosity and decrease the bulk density.

10. Black soils can retain more water at any given moisture tension and are superior to other soil groups in their available water status too. A positive correlation existed between clay and water retention in all soils.

11. Infiltration rates of all the soils were appreciably high, except for black soils and riverine alluvium which were considerably less pervious.

12. All the soils except black soils were found to be acidic in reaction with comparatively low CEC. Black soils are alkaline in reaction with high CEC. All the soil groups studied were non-saline in nature.

13. Organic matter content varied not only between the soil groups but also within the soil group. In all these soils, the surface layers were found to be

relatively richer in organic matter content.

14. Laterite and red loam soils were found to be richer in sesquioxide content compared to other soil groups and was found to increase with soil depth.

15. The aggregates greater than 0.25 mm were found to be in appreciable amounts in all the soils except for a few layers in riverine and coastal alluvium soils. Black soils have distinctly superior aggregation in comparison to the rest of the soils under investigation.

16. The mean weight-diameter which is a statistical index of soil aggregation showed a positive correlation with clay, organic matter, CEC and sesquioxide content in laterite and black soils. Stability index was found to be maximum in black soils.

17. Black soils exhibited high values for structural coefficient. These soils were followed by laterite, riverine alluvium, coastal alluvium and red loam soils. A positive correlation existed between clay, and structural coefficient in all the soil

groups except riverine alluvium. Similar relationship was observed with respect to organic matter too.

18. In riverine alluvium soils which are comparatively of recent origin, no positive relationship could be observed between structural indices and other physical and chemical properties.

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* Originals not seen.

Appendix

Appendix

Morphological descriptions of typifying pedon of each series

a) Velappaya series

Horizon	Depth (cm)	Description
AP	0 - 12	Dark brown (10 YR 5/3; gravelly sandy clay loam; weak, medium, subangular blocky; moist-friable; slightly sticky and slightly plastic; common fine roots, moderately rapid permeability; gradual wavy boundary.
B_2	12 - 49	Dark red (2.5 YR 3/6); gravelly sandy clay; moderate, medium, subangular blocky structure; moist-firm; sticky and plastic; very few, fine roots, slow permeability, clear wavy boundary.
B_3	49 - 64 +(15+)	Dark reddish brown; firm; quarriable laterite with few faint mottlings.

Source: Office of the Assistant Soil Survey Officer, Trichur.

b) Valiavallampathy series

Horizon	Depth (cm)	Description
AP	0 - 10	Black (10 YR 2/1) Moist; silty clay loam; moderate, medium, subangular blocky; firm; sticky and plastic; few, fine roots; calcium carbonate nodules and shells present; mode safely slow permeability; clear, smooth boundary (8 - 17 cm thick).
B_1	10 - 40	Very dark brown (10 YR 2/2) moist, silty clay loam; strong, coarse, subangular blocky; very firm; very sticky and very plastic; few fine roots; lime shells and nodules present, moderately slow permeability; diffuse, smooth boundary (25 - 40 cm thick).
B_2	40 - 50	Yellowish brown (10 YR 5/6) moist; silty clay loam; strong coarse subangular blocky; very firm; very sticky and very plastic; few granular iron nodules present; slow permeability (60 - 80 cm thick).

Source: Office of the Assistant Soil Survey Officer, Palghat.

Appendix

Morphological descriptions of typifying pedon of each serios

a) Velappaya series

Horison	Depth (cm)	Description
AP	0 - 12	Dark brown (10 YR 5/3; gravelly sandy clay loam; weak, medium, subangular blocky; moist-friable; slightly sticky and slightly plastic; common fine roots, moderately rapid permeability; gradual wavy boundary.
B_2	12 - 49	Dark red (2.5 YR 3/6); gravelly sandy clay; moderate, medium, subangular blocky structure; moist-firm; sticky and plastic; very few, fine roots, slow permeability, clear wavy boundary.
B_3	49 - 64 +(15+)	Dark reddish brown; firm; quarriable laterite with few faint mottlings.

Source: Office of the Assistant Soil Survey Officer, Trichur.

b) Valiavallampathy series

Horizon	Depth (cm)	Description
AP	0 - 10	Black (10 YR 2/1) Moist; silty clay loam; moderate, medium, subangular blocky; firm; sticky and plastic; few, fine roots; calcium carbonate nodules and shells present; moderately slow permeability; clear, smooth boundary (8 - 17 cm thick).
B_1	10 - 40	Very dark brown (10 YR 2/2) moist, silty clay loam; strong, coarse, subangular blocky; very firm; very sticky and very plastic; few fine roots; lime shells and nodules present, moderately slow permeability; diffuse, smooth boundary (25 - 40 cm thick).
B_2	40 - 50	Yellowish brown (10 YR 5/6) moist; silty clay loam; strong coarse subangular blocky; very firm; very sticky and very plastic; few granular iron nodules present; slow permeability (60 - 80 cm thick).

Source: Office of the Assistant Soil Survey Officer, Palghat.

c) Vellayani series

Horizon	Depth (cm)	Description
AP	0.22	Strong brown (7.5 YR 5/6 dry) yellowish red (5 YR 4/6) moist; sandy loam; weak medium granular loose; friable; nonsticky, non-plastic; plentiful roots; rapid permeability; clear smooth boundary (15 - 25 cm thick).
B_1	22 - 60	Yellowish red (5 YR 4/8) moist; sandy loam, medium, weak granular; friable; slightly sticky, slightly plastic; plentiful roots; moderately rapid permeability; diffused wavy boundary (30 - 50 cm thick).
B_2	60 - 150	Yellowish red (5 YR 5/8) moist; sandy clay loam; weak, medium, subangular blocky; friable; sticky and plastic; few roots; moderately rapid permeability (100 cm thick).

Source: Office of the Assistant Soil Survey Officer, Trivandrum.

b) Valiavallampathy series

Horizon	Depth (cm)	Description
AP	0 - 10	Black (10 YR 2/1) Moist; silty clay loam; moderate, medium, subangular blocky; firm; sticky and plastic; few, fine roots; calcium carbonate nodules and shells present; mode safely slow permeability; clear, smooth boundary (8 - 17 cm thick).
B_1	10 - 40	Very dark brown (10 YR 2/2) moist, silty clay loam; strong, coarse, subangular blocky; very firm; very sticky and very plastic; few fine roots; lime shells and nodules present, moderately slow permeability; diffuse, smooth boundary (25 - 40 cm thick).
B_2	40 - 50	Yellowish brown (10 YR 5/6) moist; silty clay loam; strong coarse subangular blocky; very firm; very sticky and very plastic; few granular iron nodules present; slow permeability (60 - 80 cm thick).

Source: Office of the Assistant Soil Survey Officer, Palghat.

d) Punnamattom series (Pnt)

Layer	Depth (cm)	Description
1	0 - 43	Pale brown (10 YR 6/3); silty loam; medium weak crumb structure; moist friable slightly sticky and plastic; plentiful roots; moderately rapid permeability, clear smooth boundary.
2	43 - 113	Yellow (10 YR 7/6); silty clay loam; medium moderate sub angular blocky structure; firm; slightly sticky and slightly plastic, few roots, presence of mica flakes; gradual smooth boundary; moderate permeability.
3	113 - 140^{+}	Strong brown (7 YR 5/6); silty clay; coarse subangular blocky structure; firm; sticky and plastic; roots absent; moderately slow permeability.

Source: Office of the Assistant Soil Survey Officer, Ernakulam.

e) Beypore series (Bpr)

AP	0 - 36	Red (2.5 YR 4/4); Sandy loam; dark reddish brown (2.5 YR 3/4) when moist; structureless, single grain; loose, non sticky and non plastic; few quarts gravels present; abundant fibrous roots; very rapid permeability; clear smooth boundary (20 - 45 cm thick).
B	36 - 66	Dark red (2.5 YR 3/6) when moist; sandy loam; structureless single grain; loose, non sticky and non plastic; few quarts gravels present; plentiful roots; rapid permeability; gradual wavy boundary (30 to 60 cm thick).
B_{22}	66 - 102	Red (2.5 YR 4/6) when moist; sandy loam; structureless massive loose, non sticky and non plastic; few quarts gravels present; plentiful roots; rapid permeability; diffuse boundary; (45 to 60 cm thick).
B_{23}	102 - 140	Red (2.5 YR 4/6) when moist; loam; weak fine granular structure; friable, slightly sticky and non plastic; few roots; moderately rapid permeability (Thickness more than 60 cm).

Source: Office of the Assistant Soil Survey Officer, Calicut.

AGGREGATE SIZE DISTRIBUTION AND ITS RELATIONSHIP TO PHYSICAL AND CHEMICAL PROPERTIES OF SOME TYPICAL SOILS OF KERALA

By

USHAKUMARY, K.

ABSTRACT OF THE THESIS

Submitted in partial fulfilment of the requirements for the Degree

Master of Science in Agriculture

Faculty of Agriculture
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1983

ABSTRACT

The present study was undertaken to evaluate the structural indices of some typical soil groups of Kerala namely, laterite, black, red loam, riverine and coastal alluvium and to relate them to some physico-chemical properties of soils. Soil groups were selected from five extensively occurring series namely, Velappaya, Valiavallampathy, Vellayani, Ponnamattom and Beypore series covering Trichur, Palghat, Trivandrum, Ernakulam and Calicut districts, respectively. Three profiles were chosen from each series and from each profile, samples were collected at four depths viz., 0-15, 15-30, 30-45 and 45-60 cm.

The experimental results revealed that the aggregates greater than 0.25 mm were found to be in appreciable amount in all the soils except for few layers in riverine and coastal alluvium. This indicated good structural status of the soils. Black soils have distinctly superior aggregation in comparison to the rest of the soils under investigation. Some of the physico-chemical properties like clay, organic matter, CEC and sesquioxide plays an important role in building soil structure in most of the soil group except riverine

alluvium. This is because of the comparatively recent origin of riverine alluvium soils.

The texture of the soils varied from clay to loam. The black soils were exclusively clay in texture. Riverine alluvium and coastal alluvium were found to be of clay loam and sandy clay loam in texture, respectively. An increase in finer fraction content with depth was observed. Black soils could retain more water at any given tension and were also superior in available water status. Infiltration rates were high in all soil groups except for black soil and riverine alluvium which were uniformly finer in texture. Except black soils, all other soils were acidic in reaction and have comparatively low CEC. Black soils showed highest value for CEC. Laterite and red soils were richer in sequioxide content compared to other soil groups.

Thus the results clearly indicates that black soils were relatively well aggregated as compared to other soil groups. They were also superior to other soil groups in respect of CEC and available water status, Laterite, red loam and coastal alluvium soils were highly pervious whereas black and riverine alluvium soils relatively less pervious. The former groups of soils were also very poor in respect of their available water status. The rate and stability of aggregation in these soils were more or less of similar type.