STUDIES ON SOME FOREST SOILS OF KERALA

BY

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THESIS

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C E R T I F I C A T E

This is to certify that the thesis herewith submitted contains the results of bonafide research work carried out by Shri K.M. Thomas under my supervision. No part of the work embodied in this thesis has been submitted earlier for the award of any degree.

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C O N T E N T S

LIST OF ILLUSTRATIONS

INTRODUCTION

INTRODUCTION

The age old adage "Forests are the wealth of a country" is doubly true of Kerala. Forests cover an area of about 10,640 sq. kilometers of this State which is approximately 27.4 percent of the total land area. Timber trees of great economic and commercial importance are found in these forests which contribute about 5 crores of Rupees annually to the State exchequer.

Forests are confined to the eastern half of the State occupying mainly the rolling plains and mountains of the Western Ghats. They stretch from one end of the State to the other and merge with the forests of the adjoining Madras and Mysore States. The whole forest area is traversed by a net work of streams and rivers. The heavy rainfall which is fairly well distributed in the two monsoons, coupled with the hot humid conditions due to the equatorial position of the State, provide very congenial conditions for the luxuriant growth of forests.

Different types of forests are found in Kerala mainly because of differences in altitude and the consequent variation in rainfall and temperature. The tropical evergreen, moist deciduous and shola forests are the most prominent types and occupy the largest area.

The tropical evergreen forests represent the most luxuriant type of vegetation in Kerala and develop under heavy rainfall, high humidity and a short dry season. This type of forests is found in elevations ranging from 240 to 1050 m. The average rainfall of the evergreen forest areas is 350 cm., but this type also occurs in areas with rainfall as low as 200 cm. The special feature of these forests is that the leaves of the trees are always green and last for more than a year. Except in rare cases and under exceptional circumstances the trees are never leafless. These forests contain a greater number of trees and a larger variety of species than the other types. But as compared to the deciduous type of forests, the useful species of trees in the evergreen forests is relatively low. Hopea parviflora (Konga), Dysoxylum malabaricum (Agil), Vitex altissima (Myla), Artocarpus hirsuta (Anjil) and Artocarpus integrifolia (Pilavu) are the main species of trees present in these forests.

Moist deciduous type of forests usually occurs in areas of lower elevation and lesser rainfall than are required for the development of the evergreen forests. The composition in these forests is mixed and irregular. Economically, this type is the most important as valuable trees like Tectona grandis (Teak) and Dalbergia latifolia (Rosewood) are obtained from these forests.

Shola is a closed evergreen forest in which the trees are short and rarely exceed 50 to 60 feet in height. They are mostly distributed on the rolling downs of the hills, at the heads of streams where there is good drainage and sufficient moisture. Sholas enjoy a cool, pleasant climate, the temperature ranging from 65°F to 80°F with high humidity. The annual rainfall varies from 300 to over 500 cm. There is a considerable admixture of species in these forests and they consist chiefly of Actinodaphne hookeri, Bauhinia racemosa, Cinnamomum sulphuratum etc. which are of little economic importance. There is regular addition of leaf litter to the floor of these forests, but it undergoes such rapid decomposition that there is no visible accumulation of humus on the surface. The dense stand of trees and the heavy leaf fall effectively cover and protect the soil from erosion in these forests.

The growing demand for wood, particularly for industrial purposes, underlines the need for bringing new areas under forests and for increasing the productivity of the existing forest land. Tree planting campaigns, such as, "Vanamohotsava" are attempts at creating public interest in trees and forestry and thus aim at ultimately increasing our forest area. To enhance the productivity of the existing forest land, the accepted policy is to gradually convert sizable areas of the mixed forests into pure plantations of economically valuable species like Teak, Eucalyptus, Bombax and Mahagony.

The rising demand for natural rubber and other plantation products and the acute need to conserve foreign exchange have compelled the Government to convert forests containing trees of little economic value into plantations of rubber, tea, coffee etc. Wherever climate and elevation are favourable, spice crops like cardamom are being grown in forests without destroying the stand of trees. Detailed examination of forest soils to assess their suitability for growing different species of trees and crops is, therefore, a pre-requisite for successful implementation of such development programme.

It has been observed that when large scale deforestation and subsequent afforstation are undertaken, tree growth is sometimes poor and plantations fail to thrive. There are indications that clearfelling the natural forest and planting the area with a pure crop may hasten laterisation and possibly lower the fertility of the soil.

Very little work has been done hitherto on the forest soils of India. A few studies have been carried out on the soils of the Himalayan region, but the forest soils of Peninsular India have received hardly any attention. The present investigation is perhaps the first attempt at a systematic study of the different types of forest soils found in Kerala State. Its main objectives are:-

(1) to study the morphological features, physico-chemical characters and the fertility status of the forest

soils of Kerala representing different vegetational types; and

(2) to assess the extent of soil deterioration due to deforestation and conversion into plantations.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Kellogg *et al* (1957) defined forest land as "land bearing a stand of trees at any age or stature, including seedlings and of species attaining a minimum of 6 feet average height at maturity or land from which such a stand has been removed, but which has not been put to any other use".

1. Climate and growth of forests:

Villeneuve (1946) stated that in general, temperature and precipitation determine the forest regions and the composition of the forests.

According to Coile (1952), climate expressed as inches of rainfall, number of frost free days per year, or defined indirectly by latitude and longitude is correlated with the growth of forests, independent of soil factors.

Waheedkhan and Yadav (1962) held the view that although there are numerous factors which govern the growth of forest vegetation, the physical and chemical nature of the soil is perhaps only next to the factor of climate in determining the distribution of natural vegetation.

Chandrasekharan (1962) considered that the different types of vegetation met with in Kerala are due to difference in altitude and the consequent variations in rainfall and temperature.

2. <u>Soil and growth of Forests</u>:

In Madhya Pradesh, Troup (1921) observed a superior growth of teak on soils formed from trap formation, metamorphic rocks and Vindhyan sand stones. Teak grows well on these sedimentary rocks which are leached least by the action of water.

Haig (1929) found that the site index of red pine in Connecticut increased as the percentage of the finer fractions (silt plus clay) increased in the A horizon.

Hickok *et al* (1931) noted a low degree of correlation between site index and individual soil attributes, such as, soil series, texture and the character of the A_0 horizon and of the sub soil for red pine in Connecticut. They also found no relation between the acidity of any soil horizon and site index. But a better correlation was observed with total nitrogen and site index.

Heiberg (1941) reported that height growth of forest trees commonly planted in NewYork was greater on mull soils than on more humus types.

Lunt (1939) found no correlation between site index of oak and various soil characteristics associated with fertility, viz., total nitrogn, exchangeable calcium, available potassium, available phosphorus and total exchangeable bases.

Diebold (1935) concluded from a study of the relationship between soil types and forest site quality in East Central and South Central NewYork that deep, well drained soils with an alkaline influence in the sub soil were best for the natural hardwood forests whereas shallow soils and those with poor internal drainage were of low quality for the local hardwoods.

Donahue (1939) observed that poor internal drainage was related to failures or to poor growth in coniferous plantations.

Stoeckeler (1948) found soil texture as measured by the amount of silt and clay in the A and B horizons combined to be an important factor affecting site quality of aspen.

Livingston (1949) studying the relation between soil properties and the natural occurrence of forest and grass land communities in Colorado has reported that the former occur on coarse textured soils with a conglomerate substrate, whereas the latter occur on adjacent fine textured soils.

Alatonen (1950) showed that there is fairly good correlation between forest type and soil texture on the one hand and profile characteristics on the other.

On the basis of detailed examination of soil samples, Bhatia (1954) found a direct correlation between teak growth and soil fertility factors, such as, pH, exchangeabl calcium, magnesium and phosphorus, but no direct correlation was obtained for nitrogen, organic matter and carbon-nitrogen ratio.

Thomas (1955) stated that although the climatic factor is of major importance, the soil factor may become the determining one in the distribution of tropical forests. Forests are the cause rather than the effect of fertility in tropical forest soils.

3. Physical properties and their relationship to soil formation:

Engler (1919) observed that the volume weight of soil will be lower for surface soil from mixed forest stands than for soil from certain pure stands. He has also pointed out that the porespace of soils supporting mixed stands may be somewhat higher than that of those supporting pure stands. The porespace of agricultural and pastural soils is lower than that of adjacent forest soils.

Burger (1923) reported that the porespace of forest soils veried from 28 to 69 percent, while Albert and Penschuk (1926) found that it rangd from 37 to 63 percent.

Gulisashvili and Stratanovitch (1935) concluded that in the Leningrad region, total and non-capillary porosity were the most important physical properties of forest soils. They found that low air capacity was associated with poor growth of trees.

Sen and Deb (1940) showed that heavy soils have the highest ingition losses, moisture contents, sticky points etc. Volume expansion, apparent and real specific gravity and the total exchangeable bases, however, bear no relation to the clay contents. The loss on ignition is a better index of the colloid oontent of laterite and red soils than the percentage of clay. Physical constants are influenced more by their content than by the composition of the clay.

4. <u>Physical factors and their influence on chemical weathering in tropical soils:</u>

Bear (1955) emphasised that for movement of clay from surface horizons to lower horizons there must be two conditions, viz., dispersion of clay in the surface horizons and its flocculation in the lower horizons. Even under excessive water supply, the clay migrates to low depths of 3 to 5 feet because of the fluctuating condition of the ground water table. Clay movement takes place only after a sustained period of rainfall and plant growth conditions that induce a lowering of the concentration of the soil solution and therefore also a state of dispersion.

Schaufelberger (1955) studying the formation of clays in tropical soils suggested that montmorin groups are formed in basins having impeded leaching of bases, kaolinite clays are formed in base poor acid basin soils and well drained soils, admixtures of hydragillite and montmorillonite originate from the parent rock laterite or sediments.

Caillere _et al_ (1956) by X-ray analysis of the material found on dolerite and gabbro subjected to laterisation found montmorillonite to be present in the first and second zones of alteration of the parent rock, but only kaolinite was associated with the hydroxides of iron and aluminium in the laterite crust.

Vine (1956) noticed that in oil palm areas where coarse sand is predominent in the soils there is almost always an increase in clay content from the top 8 inches downwards.

Lutz and Chandler (1957) stated that mottling results from local accumulation of iron compounds, organic colloids or other coloured materials. It may also result from localised oxidation of iron compounds such as frequently occurs in imperfectly drained sub soils.

5. Chemical Properties:

(a) Carbon, nitrogen and C/N ratio:- Heyward and Barnette (1936) observed that the mean carbon-nitrogen ratios of the organic matter in various horizons of long leaf pine soils were, litter - 101:1, F layer - 47:1 and A1 horizon - 33:1.

Isaack and Hopkins (1937) found the carbon-nitrogen ratio in forest floor material of Douglas fir stands to be about 57:1 and in the underlying mineral soil about 24:1. Carbon-nitrogen ratios exceeding 20:1 are very common in forest soils.

Satyanarayanan et al (1946) in a study of uncultivated soils of India observed that the general level of carbon and nitrogen in most soils was low and the carbon-nitrogen ratios fluctuated from 5.0 to 25.0. In the red soil profiles of the humid regions, there were indications of leaching of organic matter with accumulation in the lower horizons. Surface soils from the perhumid zone contained high amounts of carbon and nitrogen which decreased with depth.

Duchaufour (1950) estimated the forest humus and its C/N ratio in the A1 horizons of 42 well aerated forest soils and found that the lowest ratios occurred within the pH range 5.0 to 7.0. In the neighbourhood of pH 5.0, the C/N ratio increased considerably with slight decrease in pH. The total organic matter content of the horizon tended to increase as the C/N ratio increased, but remained low in podsols as the result of its downward movement to the illuvial horizon.

Puri and Gupta (1961) studying the humus in coniferous forests of the Kulu (Himalayas) noted that there was significant correlation between organic matter, nitrogen and calcium content. Both nitrogen and calcium tended to increase with increase in organic matter. The amount of organic matter and nitrogen decreased considerably in the lower layers of the soil.

According to Allison (1957) the nitrogen content of the surface 6 inches of virgin soils in the various regions of the United States is as follows:

Brown forest soils of the North East:	0.05 - 0.2%
Prairie soils of the Central States:	0.10 - 0.25%
Chernozem soils of the Eastern Dakotas, Kanses etc.	0.15 - 0.3%

Lucas and Davis (1961) found that the C/N ratio of forest soils rich in organic matter varied from 60 to 1.

Yadav and Pathak (1963) showed that the C/N ratio of forest soils of India varied from 1.1 to 25.4.

In a study of the profiles in Chakrata division of forests of Uttar Pradesh, Yadav (1963) found that nitrogn varied from 0.013 to 0.427 percent and organic matter from 0.172 to 8.310 percent. The C/N ratio ranged from 1.5 to 25.4, the majority of samples falling in the range 8.0 to 12.0. He also found that the values of C/N ratio did not bear any definite relation with the depth of the profile.

(b) Phosphorus:- Nye and Bertheux (1957) in a comparative study of forest and savannah soils of the Gold Coast observed that forest soils contained more phosphorus than the savannah soils. Carbon/phosphorus ratio averaged 233 in the forest soils and 247 in the savannah soils. Nitrogen/phosphorus ratio for the forest soils was 21.6 as against 19.5 for the savannah soils.

Walker and Adom (1959) found that the decrease of total phosphorus with increasing degree of leaching in weakly weathered soils was due to decreasing volume weight (bulk density) associated with higher levels of organic matter rather that the actual loss of phosphorus. There was evidence of an increasing loss of phosphorus by leaching, with increasing degree of weathering both as organic phosphorus from solution and as inorganic phosphorus from the soft weathering rock.

Bates and Baker (1960) observed that in Nigerian forest soils, phosphorus was accumulated in the surface soil. Below 2 inches, there was a marked fall in total phosphorus refleeting a large decrease in amount of organic phosphorus. Thereafter, total phosphorus was fairly constant down the profile.

Goel and Agarwal (1960) noticed considerable variation in the total phosphorus content in different sized particles depending upon the type of soil. They found that the amount was highest in clay and lowest in sand fractions.

Raychaudhuri and Landey (1960) were of the view that soils which contain a high amount of clay and silt retained more phosphorus and showed low availability of this element. They noticed that the availability of phosphorus increased in the alluvial saline (Punjab) and alluvial sand (Rajasthan) soils but decreased in red (Mysore), loamy (Uttar Pradesh) and laterite (Kerala) soils with decreasing pH values.

Yadav and Pathak (1963) found that soils of different forests in India exhibited great variation in the amount of available P_2O_5 ranging from 0.1 to 21.0 mg. per 100 g. soil. Although the black, laterite and desert soils are known to be characteristically poor in available P_2O_5, they appeared to display moderate phosphorus availability persumably as result of the growing forest vegetation. Their studies also showed that a high accumulation of organic matter led to pronounced reduction in phosphorus availability. The distribution patterns in the profile showed that the content of total phosphorus was more in the surface than in the sub soil, but no definite trend with depth as such was discernible.

In the alluvial soils of Uttar Pradesh and red loams of Mysore which were very clayey, Yadav and Pathak noted that the clay fraction was associated with a greater retention of phosphorus.

(c) Soil Acidity:- Hesselman (1926) reported that soils supporting conifers tended to be more acid than those supporting hardwoods as the leaves of the conifers contained more acid and low basic buffer content as compared to most hardwood leaves.

Doyne (1935) suggested that surface soils are less acid than the deeper layers because of the stand of species of trees whose foliage contains a high content of bases.

Wiedemann (1937) pointed out that silvicultural operations, such as, heavy thinnings and reproduction cuttings reduced soil acidity in some instances. His investigations showed that low pH of forest soils is not incompatible with high site quality. He also found that many hundreds of measurements of the degree of acidity in spruce soils of Germany failed to give any clear indication of site quality.

Ruffin (1855) noticed that calcareus soils usually supported grass. According to Lutz and Chandler (1957), the existence of natural prairies on calcareus soils, for example, the Black Belt in Alabama and Mississippi, in forest regions demonstrate that soil alkalinity is more favourable for grass than trees.

Yadav (1963) in his work on the forest soils in Chakrata division of Uttar Pradesh found that the cation exchange capacity of the soils varied from 9.4 to 44.0 m.e/ 100 g. soil and was dependent primarily on the content of organic matter and the fine fractions. The top A1 horizon had the highest capacity resulting from an accumulation of humus. He also observed that at higher elevations the iron oxide was leached from the A horizon and deposited in the B horizon, thereby indicating some podsolisation. Calcium was greater in the A1 horizon and decreased markedly in the lower horizons. Magnesium oxide manifested an erratic behaviour with the depth of the profile. As for potassium, there was no definite pattern of distribution with the depth, but it was generally observed that potash content increased with increase in elevation.

Auten (1933) reported that agricultural utilization of forest soils in the Central United States resulted in the loss of a large proportion of the exchangeable calcium and magnesium from the A1 horizons.

Chandler (1941) presented data which indicated that hardwood stands in New York State return annually to the soil about 65 lb. of calcium an acre.

Lutz and Chandler (1957) found that the amount of calcium utilized annually for wood production in forests (rotation about 100 years) varied from 5.0 to 20.0 lb. per acre. They also showed that magnesium, like calcicum, may accumulate in the B horizon of podsols. The amount annually utilized for wood production in forests was 1.0 to 5.5 lb. per acre.

Gordon and Lipman (1926) expressed the view that soils which contain a large excess of magnesium over calcium are frequently infertile.

McMurtrey and Robinson (1938) stated that ever after oxidation complex ions and iron formed with organic matter hold the iron, in solution at pH concentrations which would precipitable ferric hydroxide.

Ignatieff (1941) found large amounts of ferrous iron in water logged forest soils in Canada, but very little was found in well drained soils.

Lutz and Chandler (1957) observed that forest soils contain ample supplies of iron in available form for deep rooted vegetation, such as, trees. In nurseries, deficiency of this element may occur particularly if the soil has a high pH.

Effects of deforestation on the soil characteristics

Beneficial effects:- Muller (1887) recognised that soils having a mor type of humus layer were frequently benefitted by complete removal of the stand as it hastened the decomposition of the unincorporated organic matter, decreased acidity, favoured nitrification and activated the soil fauna.

Ehrenberg (1922) found that when organic matter was destroyed by fire, the acidity was reduced, substantial amounts of calcium, magnesium, potash and phosphorus were mobilised and leaching increased. He also noticed that fires resulted in a release of elements contained in the soil minerals.

Wittich (1930) observed that the porespace of sandy soils in North Eastern Germany was increased as a result of clear cutting.

Shibata et al (1951) after studying for a period of 21 years the effect of clear felling forest land, reported that in the cleared area, litter decomposed more rapidly, soil acidity was less and contents of total nitrogen and exchangeable calcium were higher in the lower layers than in the forested area. They, however, concluded that the favourable effects of clear felling area likely to disappear within some years and hence recommended rapid afforestation.

Burgy and Scott (1952) investigated the effects of fire and ash on the infiltration capacity of soils and found that ash on the surface did not render soil impervious and soil in burned ash covered plots was wetted as readily as that in vegetation covered plots. They also observed that burning increased the larger particle size distribution in the soil to a slight extent.

McDonald (1955) studying the effects of clear felling found that no marked physical changes had been caused to the soil consequent on clear felling. No difference in moisture content was noted between soils from forest and cleared land during wet and dry periods.

Biswell and Schultz (1957) found no evidence of surface run off and erosion following prescribed burning in pine stands even on sloping lands. Partially decomposed duff and debris remaining after burning at 4 to 5 years intervals maintained infiltration and percolation capacity at sufficiently high levels to prevent accelerated run off.

Subba Rao and Ramacharlu (1957) suggested that heating stabilised the aggregates already present in the soil and also produced a slight new aggregation. This stabilization of the aggregates towards water increased steadily with increasing temperature of heating up to 360°C at which temperature the aggregates became quite stable. Higher temperatures did not alter their stability.

Hatch (1959) studied the effect of burning on Eucalyptus forest soils of Western Australia and concluded that controlled burnings, with temperature not exceeding 320 to 450°C had no effect on pH, soluble salts, organic carbon, nitrogen and exchangeable cations of the soil.

Miller and Fitz (1959) found that scrub burning on New Zealand hill soil resulted in high pH in the upper top soil which decreased to near neutral in 8 to 10 weeks and then fell slowly for the rest of the sampling year. After spring burning, growth of grass cover was vigorous, but in the following spring growth was good only after fertilizing.

Coltharp (1960) observed no pronounced changes in soil texture, bulk density, perosity or permeability after clear cutting of trees in the woodland. But there was an increase in soil humus content and a decrease in undecomposed organic matter. Maximum rates of run off decreased slightly due to increased infiltration rate.

Chirikov and Solovev (1960) noted that increasing application of wood ash increased soil pH, decreased hydrolytic and total acidity, and mobilised difficultly soluble phosphorus.

Siviridova (1960) pointed out that clear felling of trees increased the content of humus, easily hydrolysable nitrogen, available phosphorus, exchangeable calcium and potash in the humus horizon. Felling also enhanced the total perosity and the moisture retaining capacity of the 2 to 10 cm. and 10 to 20 cm. layers in the soil. The moisture reserves in the top 100 cm. of soil were also increased by felling.

Detrimental effects.

Wiedemen (1928) deplored clear cutting of forests as "murder of the forest organism". He suggested that the "lime cycle" may be disrupted by clear cutting since in the absence of stand on the ground the lime which would normally be absorbed by roots will be washed down and lost.

Ehrenburg (1922) suggested that erosion after fires in forests may result in loss of both ash material and fertile top soil with consequent depletion of the nutrient capital of the site. He also found that some part of the nutrients was leached to much deeper layers and that another part moved into the drainage water and was entirely lost.

Rawitscher (1946) working on tropical soils concluded that deforestation led to increased leaching and removal of essential bases thus resulting in reduced crop yield.

Trimble (1949) found that timber cutting caused ground disturbances which led to erosion and humus destruction. Opening the stand increased air movement and facilitated the oxidation of soil humus and compaction of the soil. In cleared areas, after 30 years, all the organic matter had disappeared from the surface accompanied by active sheet erosion.

Chevalier (1949) stated that once the forest is removed the soil becomes senile ie. ferruginous concretions form a pan at shallow depth. Later the ferruginous crust appears on the surface, erosion completes the removal of the overlying soil exposing a barren sheet of lateritic iron stone.

Albert (1944) reported that in the Ivory Coast, a laterite crust had been formed within 35 years as a result of felling forest to plant cacao and then coffee. Both crops failed and erosion caused exposure and hardening of the crust.

Riquier (1953) observed that clearing destroyed the organic matter and checked its subsequent accumulation. It greatly increased the pH and the quantity of assimilable nutrients, but this benefit was more than outweighed by the erosion induced. Similarly, the improvement in physical properties was only temporary. Two crops after felling impoverished the soil of its nutrients to such an extent that reforestation or regeneration of such areas became difficult.

Fuller (1955) found that by burning soil, part of the soil nitrogen was lost whereas the other nutrients were not volatilised but got concentrated and changed to more soluble forms. Soluble salts in the ash as a result of downward movement consequent on leaching raised the pH of the soil in the profile. Controlled burning increased the exchangeable bases and the availability of phosphorus. A decrease in the organic matter and C/N ratio to a depth of 8 to 12 inches was also noted.

Maran (1955) observed that after felling old coniferous plantations, the active and exchange acidity of the soil decreased. Loosening the soil and growing a cover crop of potatoes, rye or oats after clear felling and burning, increased the availability of potassium and calcium to young reforested seedlings; while this effect was noticeable in semi arid regions, the reverse was found true in the case of humid slopes.

Tarrant (1956) showed that the pH was increased with increasing burn severity. Severe burning resulted in the decrease of the nitrogen content of the soil and increased the acid-soluble P_2O_5 and exchangeable potash contents. Cation exchange capacity was not affected by light burning but was decreased by severe burning.

Suarez (1957) in a study of the effect of soil burning as an agronomic practice observed that it reduced the run off, but increased erosion because of the lack of soil cover. Nutrient losses were found to be small.

Dryness and Youngberg (1957) investigated the effect of logging and slash burning on soil structure and found that severe burning decreased the proportion of clay and increased the proportion of sand in the soil. This practice also results in considerable decrease in the organic matter content and the state of aggregation.

MATERIALS AND METHODS

MATERIALS AND METHODS

Five typical soil profiles were collected from three different types of forests located in five forest divisions of Kerala State, viz.,

1. Palode - Trivandrum Division (Moist deciduous forests)
2. Thulapally - Ranni Division (Tropical evergreen forests)
3. Devikulam - Munnar Division (Shola forests)
4. Parambikulam - Parambikulam Division (Tropical evergreen forests)
5. Tholpetty - Wynad Division (Moist deciduous forests)

In addition, one profile and a few soil samples were also collected from deforested land adjoining the tropical evergreen forest at Thulapally, Ranni Division. The location of the profiles is shown in Map I.

Data on monthly average rainfall of the localities from where the soil profiles were collected are presented in table I and represented graphically in figure 1.

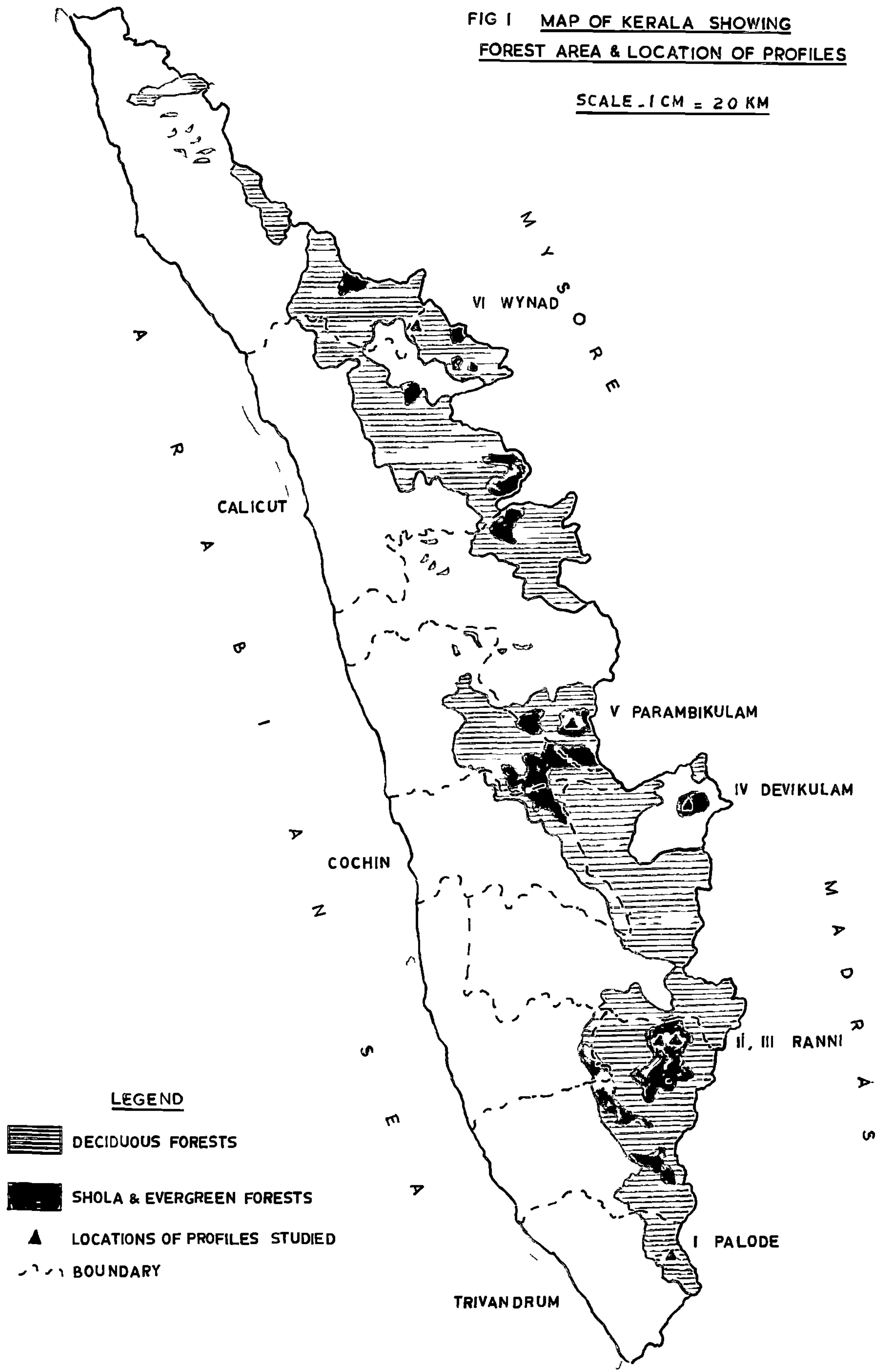
FIG I MAP OF KERALA SHOWING
FOREST AREA & LOCATION OF PROFILES
SCALE - 1 CM = 20 KM
MYSORE
VI WYNAD
ARABIAN SEA
CALICUT
V PARAMBIKULAM
IV DEVIKULAM
COCHIN
MADRAS
II, III RANNI
I PALODE
TRIVANDRUM
LEGEND
DECIDUOUS FORESTS
SHOLA & EVERGREEN FORESTS
LOCATIONS OF PROFILES STUDIED
BOUNDARY

TABLE - I

AVERAGE MONTHLY RAINFALL IN m.m. OF LOCALITIES FROM WHERE SOIL PROFILES WERE COLLECTED

MONTH	PALODE	RANNI	DEVIKULAM	PARAMBIKULM	WYNAD
January	16.6	19.0	18.6	5.5	--
February	33.9	86.8	23.9	16.5	9.1
March	37.6	155.7	46.7	22.9	19.3
April	172.2	307.3	128.2	127.6	125.7
May	310.1	368.3	241.7	219.0	164.1
June	342.5	706.1	522.0	299.2	306.6
July	266.9	645.1	719.3	706.8	396.3
August	112.4	609.6	425.1	400.7	320.5
September	147.0	381.0	275.3	172.7	146.1
October	305.1	431.8	292.0	246.6	139.9
November	206.1	228.6	160.6	63.2	85.6
December	53.7	66.0	47.4	44.5	1.8
ANNUAL	2004.1	4005.3	2900.8	2325.2	1715.0
Number of years to make up the average	10	10	10	4	10

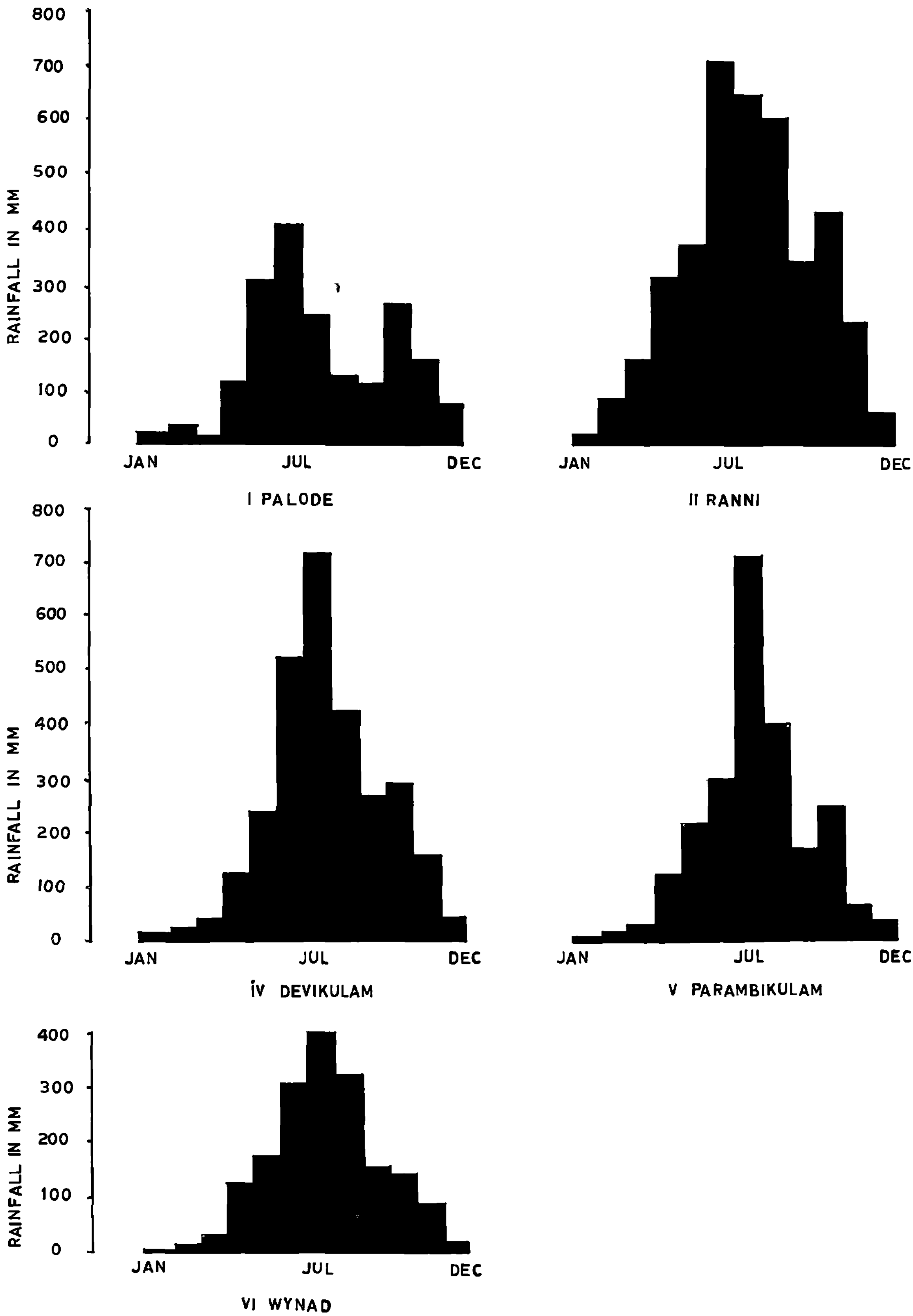

FIG 2 AVERAGE MONTHLY RAINFALL IN MM OF LOCALITIES FROM WHERE SOIL PROFILES WERE COLLECTED

MORPHOLOGICAL CHARACTERS OF SOIL PROFILES

Profile I

Location	-	Mangayam, Palode Range, Trivandrum Division.
Elevation	-	240 to 300 m.
Topography	-	Rolling and hilly.
Vegetation	-	Deciduous trees like Xylia, Rose wood etc. Surface covered with herbaceous fleshy perennials and annuals.
Depth in Cm. 0 to 25	-	Very dark brown (10 YR 2/2) silt loam; Massive; non-calcareous; well drained; abundant roots; few iron gravel up to 3 mm. size; few earth warms; clear and wavy boundry.
25 to 56	-	Dark brown (7.5 YR 4/4) clay loam; granular; non-calcareous; well drained; few roots; a weathered boulder of 25 cm. diameter; red mottling common; clear wavy boundary.
56 to 150	-	Strong brown (7.5 YR 5/6) clay loam; sub-angular blocky; well drained; few roots; non-calcareous; mixed with the weathered parent material

in the process of laterisation; merges with the laterite bed below.

Profile II

Location	- Thulapally, Ranni Division.
Elevation	- 300 to 350 m.
Topography	- Rolling, hilly.
Vegetation	- Tropical evergreen forest, main types of trees are Hopea parviflora (Konga) Dysoxylum malabaricum (Agil), Artocarpus hirsuta (Anjil) etc. Surface covered with herbs and shrubs.
Depth in Cm.	
0 to 48	- Dark reddish brown (5 YR 3/4) clay loam; crumb; non-calcareous; abundant root; yellow and red mottlings common; pebbles and quartz grains up to 2 cm. size; clear and wavy boundary.
48 to 75	- Yellowish red (5 YR 4/6) gravelly loam; granular; friable; non-calcareous; few roots; quartz grains distributed througnout; well drained; occasional yellow mottling; clear wavy boundary.
75 to 150	- Red (2.5 YR 4/8); laterite; vermicular; roots absent; red mottling very

prominent with occasional yellow mottling; laterite layer; unsuitable for quarrying owing to high content of of quartz grains.

Profile III

Location	-	Thulapally, Ranni Division. Clear felled and burnt area.
Elevation	-	300 to 350 m.
Topography	-	Rolling and hilly.
Vegetation	-	Teak seedlings intercropped with rice after deforestation.
Depth in cm.		
0 to 5	-	Reddish brown (5 YR 4/3) loam; transported silt and clay with abundant fibrous roots; no structure; clear and distinct boundary.
5 to 42	-	Dark reddish brown (5 YR 3/3) loam; single grain; non-calcareous; few roots; no mottlings; well drained; quartz grains of 1 to 2 cm. distributed throughout; diffuse boundary.
42 to 150	-	Reddish brown (5 YR 4/4) clay; structureless; non-calcareous; few roots; no mottling; excessively well

drained; quartz grains of 1/4 to 1/2 cm. distributed throughout.

Profile IV

Location	-	Devikulam, Munnar Division.
Elevation	-	1620 m.
Topography	-	Hilly and mountainous.
Vegetation	-	Shola forests, main types of trees are Actinodaphne hookeri, Bauhinia racemosa, Cinnamomum sulphuratum etc. Surface covered with lantana and fleshy herbs.
Depth in cm.		
0 to 34	-	Dark reddish brown (5 YR 2/2) loamy sand; crumb; friable; non-calcareous; quartz grains of 2 cm. diameter present; abundant roots; well-drained; yellow and black mottling common; clear, well defined wavy boundary.
34 to 75	-	Strong brown (7.5 YR 5/8) loamy sand; blocky; friable; non-calcareous; very few roots; partially weathered pieces of rocks; black and yellow mottlings; wavy and diffuse boundary.

75 to 150 - Red (2.5 YR 4/8) gravelly silt loam; sub-angular blocky; non-calcareous; well drained; highly weathered rock fragments and quartz grains present; roots absent.

Profile V

Location - Parambikulam, Parambikulam Division.

Elevation - 750 to 900 m.

Topography - Hilly.

Vegetation - Evergreen forests, main types of trees are Myristica sp., Artocarpus sp., Calophyllum elatum etc. Surface covered with herbs and small shrubs.

Depth in cm.

0 to 65 - Dark brown (10 R 3/3 dry) clay loam; blocky; friable; non-calcareous; abundant roots; few quartz grains; well drained; earthworms in plenty; red and black mottlings; wavy and diffuse boundary.

65 to 95 - Dark reddish brown (2.5 YR 3/4 dry; clay with admixture of quartz grains; granular; friable; non-calcareous; roots scanty; few earthworms; slight yellow and red mottling; diffuse boundary.

95 to 150	-	Dark red (2.5 YR 3/6 dry) sandy clay loam; sub-angular blocky; friable; non-calcareous; dark, red and yellow mottling; mica flakes prominent; roots absent.

Profile VI

Location	-	Bavali, Begur Range, Wynad Division
Elevation	-	960 to 1050 m.
Topography	-	Hilly.
Vegetation	-	Moist deciduous forest, main types of trees are Teak, Terminalia tomentosa, Grewia tiliaefolia etc. Surface covered with Eupatorium sp. and grasses.

Depth in cm.		
0 to 60	-	Dark reddish brown (5 YR 3/2 dry) clay loam; massive; friable; non calcareous; quartiz grains; roots abundant; well drained; no mottling; no earthworms; clear and well defined boundary.
60 to 97	-	Dark red (2.5 YR 3/6 dry) coarse sandy loam; granular; friable; non-calcareous; no earthworms; well drained; yellow mottling prominent

with slight red and black admixture; hard layer; very few roots; diffuse boundary.

97 to 120 - Red (2.5 YR 4/6 dry) coarse sand; loose; non-calcareous; earthworms absent; well drained; black, yellow and red mottling common; very hard layer; root penetration difficult.

Below 120 - Parent rock.

COLLECTION, PREPARATION AND ANALYSIS OF SOIL SAMPLES

The collection, preparation and analysis of soil samples were carried out by standard methods as described by Piper (1950) and Jackson (1960).

1. Collection of soil samples:- In all the centres, pits 150 cm. x 90 cm. x 150 cm. were dug and profile features studied. Soil samples were collected from each horizon.

2. Preparation of soil samples:- The air-dried samples were ground in a porcelain mortar with a wooden pestle and passed through a 2 mm. sieve. The weight of gravel and soil was separately noted. Tho soil thus prepared was used for subsequent laboratory examination.

3. Chemical analysis:-

(a) Moisture:- 20 g. soil was dried in an air oven at 100 to 105°C to constant weight and the loss in weight was expressed as percent on oven dry basis.

(b) Loss on ignition:- 20 g. soil was ignited under a rose head flame at 700°C for 8 hours to constant weight and the loss on ignition was expressed as percent of the soil on moisture free basis.

(c) Organic carbon:- The air-dry soil finely ground to pass through 0.5 mm. sieve was used for this estimation. The wet digestion method of Walkley and Black (1934) was adopted.

(d) Hydrochloric acid extract:- 20 g. air-dry soil was digested with 200 ml. of constant boiling point hydrochloric acid on a sand bath for six hours. The extract was filtered and made up to 500 ml.

(e) Acid insolubles:- The residue after extraction was dried in an air oven, ignited to constant weight and reported as the acid insoluble fraction.

(f) Total sesquioxides:- The sesquioxides were precipitated as the hydroxides in an aliquot of the hydrochloric acid extract by the addition of ammonium hydroxide. The precipitate was filtered, ignited to constant weight and reported as percent of the moisture free weight of the soil.

(g) Calcium:- Calcium was precipitated in the filtrate obtained after the separation of the sesquioxides as calcium oxalate and estimated volumetrically by titration against standard potassium permanganate.

(h) Magnesium:- Magnesium was precipitated in the filtrate from calcium separation as magnesium ammonium phosphate, filtered, washed free of chloride, dried, ignited and weighed as magnesium pyrophosphate.

(i) Phosphoric acid:- Phosphorus was precipitatd in a suitable aliquot of the hydrochloric acid extract as ammonium phosphomolybdate in nitric acid midium. The precipitate was filtered, washed free of acid and dissolved in a known excess of standard alkali and the excess determined by titration with standard acid. From the volume of alkali consumed the P_2O_5 content was calculated.

(j) Potassium:- Potassium was precipitated as potassium sodium cobaltinitrite in glacial acetic acid medium, and estimated gravimetrically.

(k) Nitrogen:- Nitrogen was estimated by the Kjeldahl method using sulphuric-salycilic acid mixture.

(l) Available phosphorus:- Available phosphorus was extracted with Bray's reagent (0.03 N Ammonium fluoride in 0.025 N hydrochloric acid), the colour developed with molybdate reagent and stannous chloride and estimated, colorimetrically using a Klett's Summerson colorimeter.

(m) Available K_2O:- Available K_2O was extracted with Morgan's Reagent (Sodium acetate and glacial acetic acid). In the extract, K_2O was determined turbidimetrically using a Klett's Summerson colorimeter after developing turbidity by the addition of sodium cobaltinitrite in a medium of equal quantities of isopropyl and methyl alcohol.

(n) pH:- pH was determined in 1:2.5 soil water suspension using a photovolt meter (model 115).

(o) Cation exchange capacity:- 10 g. of the soil was leached with neutral ammonium acetate solution to displace the cations. The adsorbed ammonium was determined by steam distillation with magnesium oxide and absorption in excess of standard acid followed by titration with standard alkali. The number of milliequivalents of ammonium ions absorbed per 100 g. of the soil gave its cation exchange capacity.

4. Physical Determination:-

(a) Colour:- The colour of the soil samples was determined using Munsell's soil colour chart.

(b) Mechanical Analysis:- The mechanical composition of the soils was determined by the International Pipette method after oxidation of the organic matter with hydrogen peroxide.

(c) Moisture equivalent:- Moisture equivalent was calculated by the indirect method using the formula.

Moisture equivalent = (Moisture holding capacity - 21) x 0.635.

(d) Single value constants:- Maximum water holding capacity, apparent density, absolute specific gravity, porespace and volume expansion were determined by using Keen Raczkowski box.

5. Separation and Analysis of Clay fraction:-

(a) Separation of the clay:- Ammonium carbonate method proposed by Puri was adopted.

50 g. soil was taken in a beaker, 250 ml. N. Ammonium carbonate added and boiled gently until the volume was reduced to half. 25 ml. of 0.5 N. sodium hydroxide was then added and the solution diluted to 250 ml. The volume was again reduced to half. The suspension was sieved through a 70 mesh sieve and collected in a 500 ml. beaker marked at 8.6 cm. above the bottom. The clay was collected by decantation, air-dried and stored in stoppered bottles.

(b) Moisture:- 2 g. of the clay was dried in an electric oven at 100 to 105°C for 8 hours and the loss in weight was expressed as percent of the oven dry weight of the clay.

(c) Loss on ignition:- 2 g. clay was ignited in a muffle furnace by slowly raising the temperature and allowing it to remain for half an hour at 900°C. The loss on ignition was calculated as percentage on oven dry basis.

(d) Preparation of clay fusion extract:- The sodium carbonate fusion method was adopted. 2 g. of clay was fused with sodium carbonate in a platinum crucible. The melt was dissolved in dilute hydrochloric acid.

(e) Silica:- The fusion extract in hydrochloric acid was evaporated to dryness and dehydrated by heating in an air oven at 150°C for about six hours. The residue was treated with dilute hydrochloric acid, filtered, washed, ignited and weighed. The weight was reported as SiO_2 on oven dry basis.

(f) Sesquioxides:- The filtrate from silica estimation was made upto 500 ml. and in an aliquot of the solution the sesquioxides were estimated gravimetrically.

(g) Iron oxide:- Iron oxide was estimated volumetrically in an aliquot of the fusion extract by reducing the ferric iron to ferrous condition. It was then estimated by titration with standard potassium permanganate.

(h) Aluminium Oxide:- Aluminium oxide was obtained from the difference between the sesquioxides and the iron oxide.

(i) Total cation exchange capacity:- Total cation exchange capacity was determined by the neutral ammonium acetate method.

RESULTS

RESULTS

I. Physical Determinations.

(a) Mechanical analysis:- The results of mechanical analysis of the soils are presented in table II.

In general the soils from Parambikulam, Palode and Wynad are heavier in texture than those from Devikulam and Ranni. The percentage of gravel is relatively high in the profiles from Palode, Ranni and Wynad.

The variation in textural separates of the soils is represented in figure 3. The amount of clay varies from 2.0 to 40.0 percent in the different soils. It is highest in the Palode Profile (26.0 to 34.0 percent) and lowest in the Devikulam profile (2.0 to 8.0 percent). The clay content is highest in the second layer of all the profiles except in the Devikulam profile where the maximum clay is found in the first horizon. In the Wynad profile, the clay content of the first horizon is only 14.0 percent. It increases to 40.0 percent in the second horizon and thereafter it decreases with depth.

The content of silt in the soils varies from 6.0 to 26.0 percent. The highest values are obtained for the Devikulam profile (20.0 to 26.0 percent) and the lowest for the Wynad profile (6.0 to 14.0 percent). In the Palode profile the silt content ranges from 12.0 to 14.0 percent and remains nearly constant with depth. The clay

TABLE - II

MECHANICAL COMPOSITION OF FOREST SOILS

Location.	Depth in cm.	Percent on oven dry basis					Clay ratio (Sand +Silt/ Clay)	Textural class.
		Gravel	Coarse sand	Fine sand	Silt	Clay		
Palode	0 - 25	28.0	37.1	24.9	12.0	26.0	2.8	Clay loam.
	25 - 56	36.0	31.3	22.7	12.0	34.0	1.9	Gravelly clay loam
	56 -150	48.0	30.2	23.5	14.1	32.2	2.1	Gravelly clay loam
Ranni	0 - 48	33.7	28.7	29.3	20.0	22.0	3.6	Loam.
	48 - 75	32.7	37.5	26.5	9.0	27.0	2.7	Clay loam.
	75 -150	45.0	49.3	22.6	11.1	17.3	4.9	Gravelly loam.
Devikulam	0 - 34	20.8	38.6	29.4	24.0	8.0	11.5	Loamy sand.
	34 - 75	4.7	37.5	40.5	20.0	2.0	49.0	Loamy sand.
	75 -150	2.3	33.9	37.8	26.3	2.0	49.0	Silty loam.
Parambikulam	0 - 65	2.8	31.2	29.8	19.0	20.0	4.0	Loam.
	65 - 95	22.7	24.3	23.7	14.0	38.0	1.6	Clay.
	95 -150	16.4	23.4	26.4	18.1	32.1	2.1	Clay loam.
Wynad.	0 - 60	21.5	29.4	46.6	14.0	14.0	6.1	Loam.
	60 - 97	46.0	26.5	33.5	6.0	40.0	1.5	Gravelly clay.
	97 -120	39.2	25.6	34.2	12.0	28.2	2.6	Gravelly clay loam

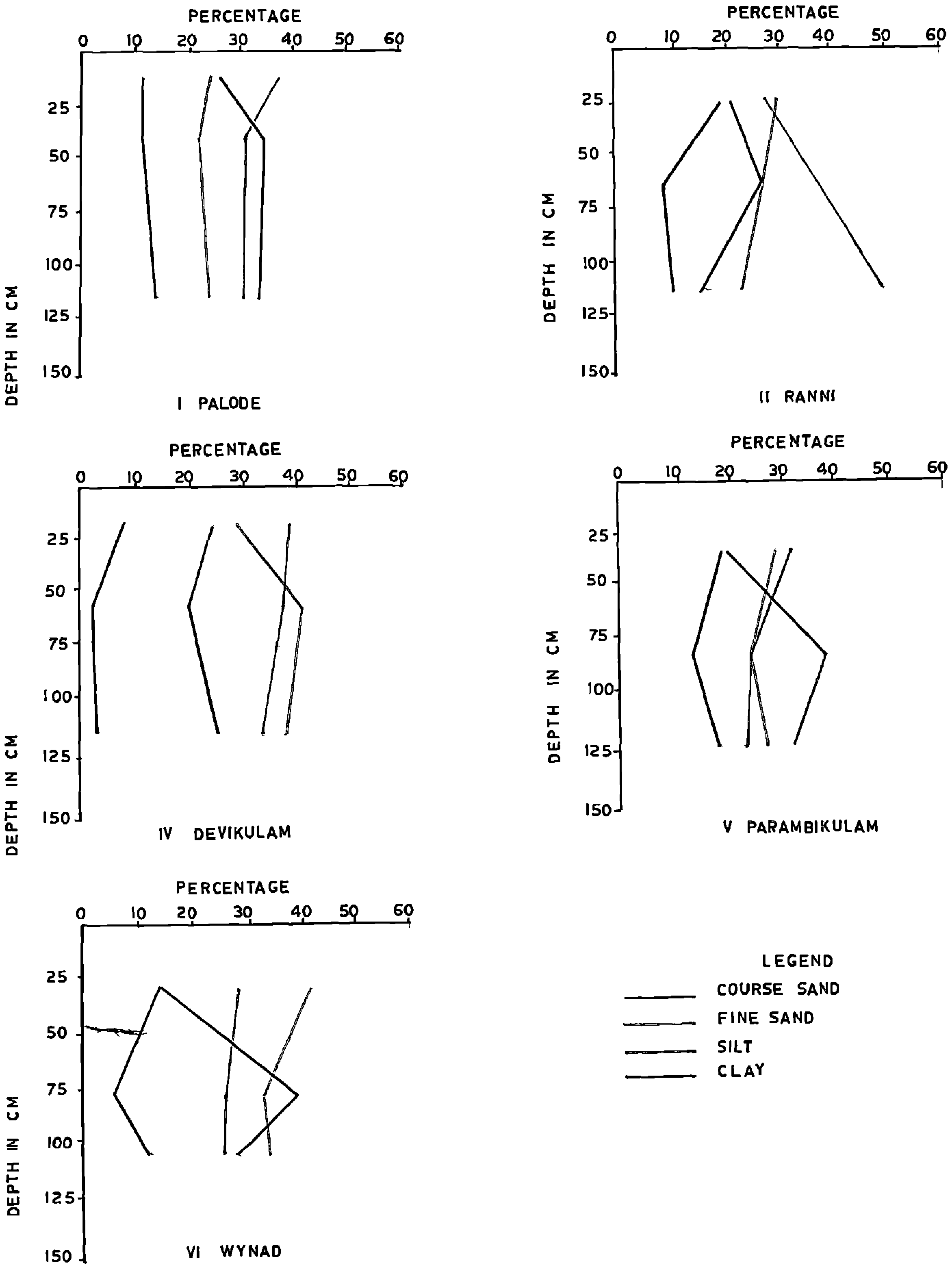

FIG 3 VARIATION IN THE MACHANICAL COMPOSITION OF SOILS WITH DEPTH IN THE DIFFERENT PROFILES

ratio (sand + silt/clay) varies from 1.5 in the Wynad profile to 49.0 in the Devikulam profile. This ratio is uniformly lowest in the second horizon in all the profiles except the Devikulam profile in which the ratio increases with depth.

(b) Loss on ignition:- The data in table V show that the loss on ignition in the different profiles varies from 4.6 to 20.3 percent. The Devikulam profile records the highest values (14.8 to 20.3 percent) and the Wynad profile the lowest (4.6 to 7.5 percent). The loss on ignition in the profiles from Palode and Parambikulam remains fairly constant with depth.

(c) Single value constants:- The single value constants of the soils are given in table III.

(1) Water holding capacity:- The water holding capacity of the soils varies from 28.8 to 48.9 percent. The Devikulam profile shows the highest values (40.3 to 48.9 percent) and the Wynad profile the lowest (28.0 to 35.7 percent). The water holding capacity of the different horizons of the Palode profile is fairly uniform with depth. The value of this physical constant increases with depth in the Parambikulam and Wynad profiles, but decrease with depth in the Ranni profile.

(2) Moisture equivalent:- The moisture equivalent value are found to vary considerably in the different profiles and range from 5.0 to 16.6 percent. It is highest in the

TABLE - III

SINGLE VALUE CONSTANTS OF FOREST SOILS

Locality	Depth in cm.	Water holding capacity (Percent)	Moisture equivalent (Percent)	Bulk density	Sp., gravity.	Porespace (Percent)	Volume of expansion (percent)
Palode	0 - 25	40.84	12.6	1.46	2.35	52.2	3.75
	25 - 56	41.94	13.3	1.18	2.40	51.9	5.02
	56 -150	40.0	12.1	1.21	2.30	51.1	5.43
Ranni	0 - 48	38.67	11.2	1.32	2.52	52.2	6.50
	48 - 75	31.60	6.7	1.41	2.45	45.6	2.07
	75 -150	28.80	5.0	1.46	2.47	42.6	2.60
Devikulam	0 - 34	48.9	17.5	1.11	2.02	47.6	8.48
	34 - 75	40.3	12.2	1.23	2.37	49.2	2.04
	75 -150	47.2	16.6	1.17	2.20	54.3	3.30
Parambikulam	0 - 65	34.6	8.6	1.38	2.25	39.4	6.28
	65 - 95	39.5	11.7	1.27	2.25	43.8	4.04
	95 -150	42.1	13.4	1.20	2.21	45.3	2.98
Wynad	0 - 60	28.8	5.0	1.48	2.52	44.7	3.88
	60 - 97	35.7	9.3	1.31	2.34	50.4	7.10
	97 -120	34.2	8.4	1.34	2.40	49.1	5.40

Devikulam profile (12.2 to 17.5 percent) and lowest in the profile from Wynad (5.0 to 9.3 percent). The variation of this physical constant with depth is rather irregular.

(3) Bulk density and specific gravity:- The bulk density of the soils varies from 1.11 to 1.48. The lowest values are recorded in the Devikulam profile.

The specific gravity varies from 2.02 to 2.52. The Parambikulam profile shows a uniform value for this physical constant throughout the profile.

(4) Porespace:- The porespace of soils of the different profiles ranges from 39.4 to 54.3 percent. It is highest in the Palode profile (51.1 to 52.2 percent) and lowest in the Parambikulam profile (39.4 to 45.3 percent).

(5) Volume expansion:- The volume expansion of the soils varies from 2.0 to 8.5 percent. In the Ranni, Devikulam and Parambikulam profiles, the surface soils show the maximum values whilst in the Palode and Wynad profiles, the subsoils record the highest values.

II. Chemical Analysis.

(a) Soil reaction (pH):- The pH values of the soils are shown in table V.

All the soils studied are acidic in reaction, the pH ranging from 4.2 to 6.4. The soils of the Palode prof are strongly acid (pH 4.2 to 4.3) while those of the Parambikulam profile are only slightly acid (pH 6.4).

Marked variations in pH within the profile are observed only in the Devikulam profile where the lower horizons are more acid.

(b) Organic carbon, total nitrogen and C/N ratio:- The data in table IV indicate that the organic carbon content of the soils varies from 0.14 to 5.56 percent. The Devikulam profile shows the highest values (0.14 to 5.56 percent) and the Wynad profile the lowest (0.42 to 1.16 percent). The organic carbon content decreases with depth in all the profiles.

The nitrogen status of the soils studied ranges from 0.04 to 0.46 percent (table IV). The profile from Devikulam shows the highest content (0.04 to 0.46 percent) and that from Parambikulam the lowest (0.10 to 0.19 percent) The level of nitrogen steadly decreases with depth in the Ranni, Devikulam and Parambikulam profiles, but in the Palode and Wynad profiles it decreases in the second horizon and again increases in the third horizon.

The carbon/nitrogen (C/N) ratio of the soils varies from 2.8 to 20.2, most of the values ranging between 5.0 and 12.0. The variation of organic carbon and total nitrogen with depth is illustrated in figure 4. In general, the ratio tends to decrease down the profiles and the lowest ratio of 2.8 is obtained in the third horizon of the Wynad profile.

(c) Analysis of the hydrochloric acid extract: - The

TABLE - IV

CARBON/NITROGEN RELATIONSHIPS IN FOREST SOILS

Locality.	Depth in cm.	PERCENT ON OVEN DRY BASIS			C/N ratio
		Organic carbon.	Organic matter.	Nitrogen.	
Palode	0 - 25	2.44	4.20	0.24	10.2
	25 - 56	1.82	3.13	0.09	20.2
	56 -150	1.15	1.98	0.12	9.6
Ranni I	0 - 48	3.77	6.48	0.31	12.2
	48 - 75	0.97	1.66	0.13	7.5
	75 -150	0.53	0.91	0.05	10.6
Devikulam	0 - 34	5.56	9.56	0.46	12.1
	34 - 75	0.49	0.84	0.05	9.8
	75 -150	0.14	0.24	0.04	3.6
Parambikulam	0 - 65	1.57	2.70	0.19	8.3
	65 - 95	0.44	0.76	0.11	4.0
	95 -150	0.41	0.71	0.10	4.1
Wynad	0 - 60	1.16	2.00	0.16	7.2
	60 - 97	0.56	0.96	0.10	5.6
	97 -120	0.42	0.72	0.15	2.8

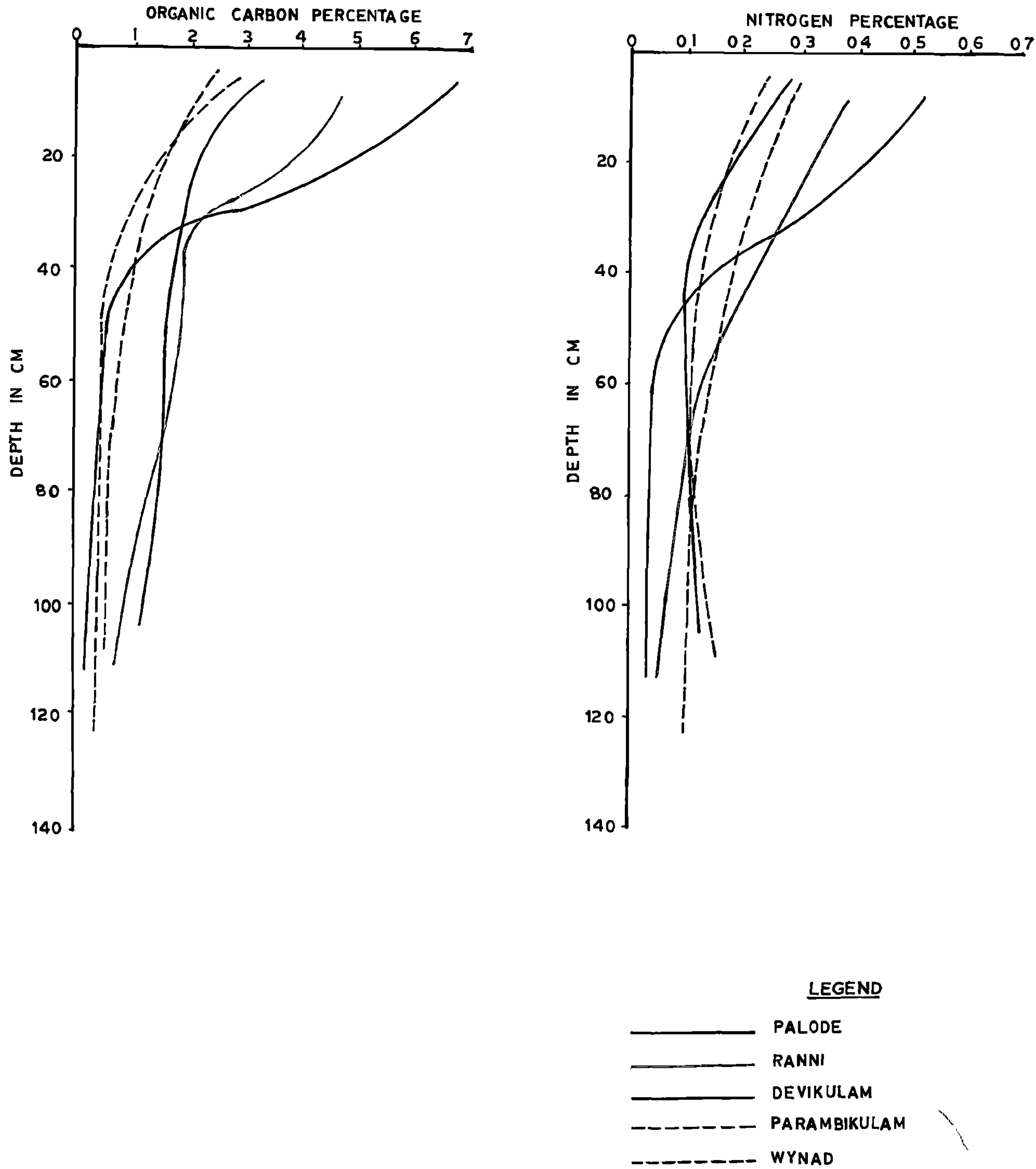

FIG 4 VARIATION OF ORGANIC CARBON & TOTAL NITROGEN WITH DEPTH IN THE DIFFERENT PROFILES

results of analysis of the hydrochloric acid extracts of soils are recorded in table V.

The proportion of hydrochloric acid insoluble silica and sand in the soils ranges from 31.3 to 81.3 percent. The highest values (62.1 to 81.3 percent) are obtained in the Wynad profile and the lowest values (31.3 to 49.5 percent) in the Devikulam profile.

The sesquioxide content of the soils varies from 14.1 to 53.5 percent. The profile from Devikulam contains the highest amount (31.0 to 52.4) and the profile from Wynad the lowest (14.1 to 30.0 percent). In general, the sesquioxide content is higher in the subsoil in all the profiles, but its variation with depth is found to be erratic.

The P_2O_5 status of the soils ranges from 0.05 to 0.35 percent. It is highest in the profile from Devikulam (0.25 to 0.32 percent) and lowest in the profile from Wynad (0.05 to 0.17 percent). The K_2O content varies from 0.06 to 0.39 percent. It is highest in the Ranni profile (0.249 to 0.394 percent) and lowest in the Devikulam profile (0.062 to 0.119 percent). The P_2O_5 and K_2O values are generally high for the second horizons of the profiles.

The CaO content of the different soils varies from 0.03 to 0.36 percent. The maximum values (0.30 to 0.36 percent) are shown by the profile from Wynad and the

TABLE - V

CHEMICAL COMPOSITION OF FOREST SOILS

Locality	Depth in cm.	pH	Percent on oven dry basis: Loss on ignition	Insoluble silica & sand	Sesqui-oxides	P_2O_5	K_2O	CaO	MgO	Cation exchange capacity in m.e/100 g.
Palode	0 - 25	4.2	11.1	64.7	26.1	0.09	0.18	0.13	0.11	8.3
	25 - 56	4.3	11.7	59.2	31.4	0.16	0.18	0.08	0.18	6.5
	56 -150	4.2	11.2	57.9	32.6	0.11	0.14	0.03	0.16	5.7
Ranni	0 - 48	5.3	16.3	53.1	38.3	0.14	0.37	0.27	0.04	10.0
	48 - 75	5.0	12.9	54.5	39.3	0.16	0.39	0.19	0.21	3.2
	75 -150	5.1	11.2	62.0	36.4	0.10	0.25	0.22	0.10	2.1
Devikulam	0 - 34	5.5	20.3	49.5	31.0	0.32	0.06	0.28	0.13	16.4
	34 - 75	4.5	14.8	45.9	40.2	0.35	0.11	0.05	0.10	3.1
	75 -150	4.8	16.3	31.3	52.4	0.25	0.12	0.12	0.12	1.1
Parambikulam	0 - 65	6.4	8.6	72.6	21.2	0.05	0.12	0.22	0.10	9.3
	65 - 95	6.4	9.8	61.0	53.5	0.15	0.11	0.17	0.13	6.2
	95 -150	6.4	10.5	57.2	32.2	0.17	0.09	0.14	0.11	6.5
Wynad	0 - 60	5.2	4.6	81.3	14.1	0.09	0.24	0.35	0.34	8.9
	60 - 97	5.2	7.5	62.1	30.0	0.17	0.34	0.36	0.41	12.7
	97 -120	5.3	6.3	67.1	26.8	0.05	0.32	0.30	0.25	9.9

minimum values (0.03 to 0.13 percent) by the profile from Palode. The level of MgO ranges from 0.04 to 0.40 percent. Like calcium, maximum content (0.25 to 0.40 percent) of this element is observed in the Wynad profile. The profile from Parambikulam shows the lowest level of MgO (0.10 to 0.13 percent). The magnesium content is highest in general in the second horizon.

(d) Available phosphorus and potassium:- The data relating to the available P_2O_5 and K_2O in the soils are presented in table VI.

It may be noted that the soils studied are generally low in available P_2O_5. The highest value (0.0063 percent) is recorded in the profile from Wynad, though the level of total P_2O_5 in this profile is low. The content of available K_2O in the Parambikulam and Wynad profiles is uniformly high (0.012 to 0.023 percent). The third layer of the Ranni profile has an unusually high level of available K_2O (0.055 percent) unlike the other horizons of this profile.

The variation of total and available P_2O_5 and K_2O with depth in the different profiles is illustrated in figure 5 and 6.

(e) Cation exchange capacity:- The data in table V show that the soils vary widely in cation exchange capacity (1.1 to 16.4 m.e/100 g.soil). The highest value is obtained for the surface soil of the Devikulam profile and the lowest for the third horizon of the same profile.

(32)

TABLE - VI

TOTAL AND AVAILABLE PHOSPHORUS AND POTASSIUM IN FOREST SOILS

Locality	Depth in cm.	Percent on oven dry basis			
		Total P_2O_5	Available P_2O_5	Total K_2O	Available K_2O
Palode	0 - 25	0.09	0.0026	0.18	0.019
	25 - 56	0.16	0.0002	0.18	0.012
	56 -150	0.11	0.0002	0.14	0.017
Ranni I	0 - 48	0.14	0.0014	0.37	0.015
	48 - 75	0.16	trace	0.39	0.007
	75 -150	0.10	trace	0.25	0.055
Devikulam	0 - 34	0.32	0.0011	0.06	0.027
	34 - 75	0.35	0.0005	0.11	0.010
	75 -150	0.25	trace	0.12	0.006
Parambikulam	0 - 65	0.05	0.0007	0.12	0.023
	65 - 95	0.15	trace	0.11	0.018
	95 -150	0.17	trace	0.09	0.012
Wynad	0 - 60	0.09	0.0016	0.24	0.021
	60 - 97	0.17	0.0063	0.34	0.016
	97 -120	0.05	0.0051	0.32	0.019

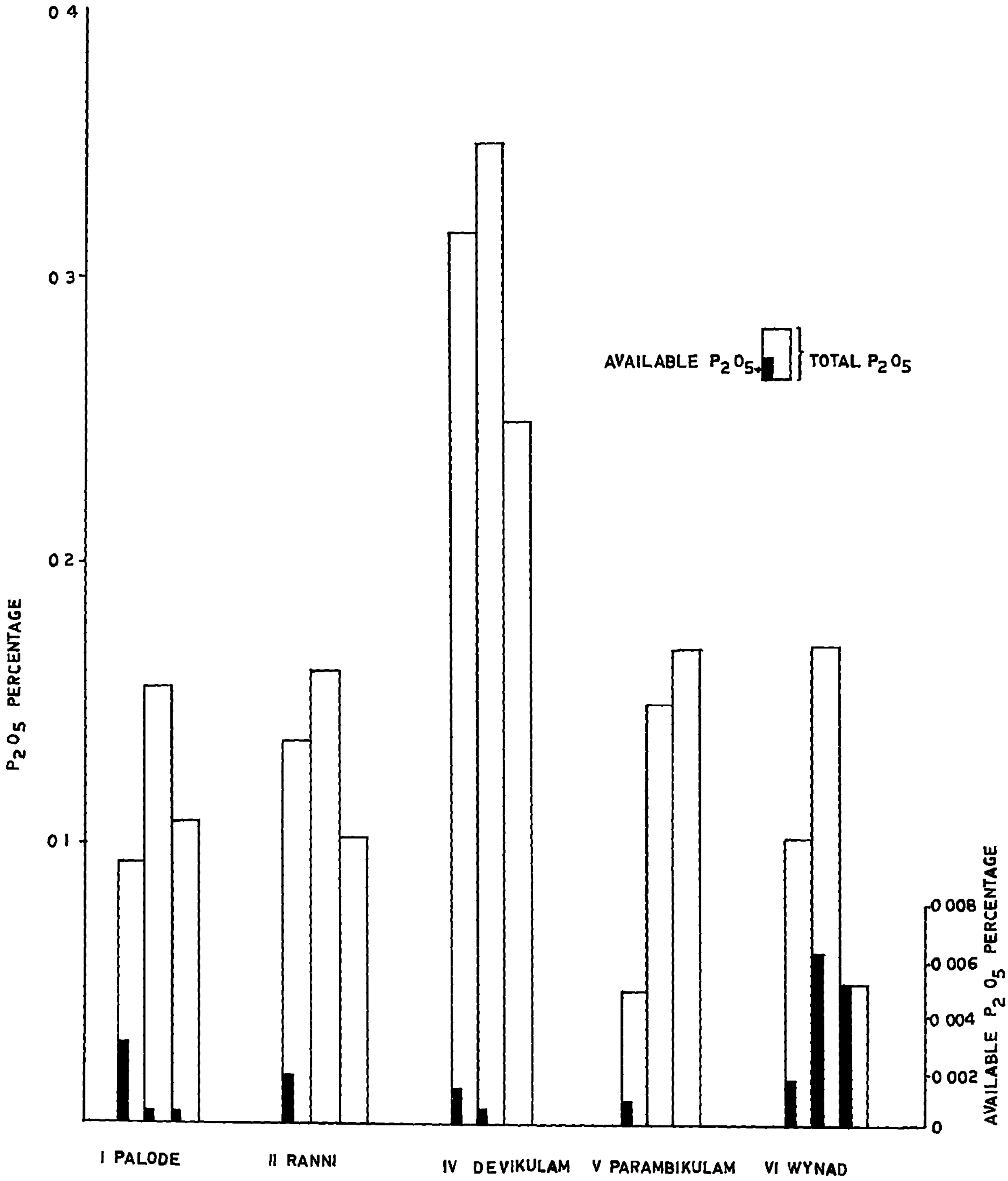

FIG 5 VARIATION OF TOTAL & AVAILABLE P_2O_5 WITH DEPTH IN THE DIFFERENT PROFILES (SUCCESSIVE LAYERS FROM LEFT)

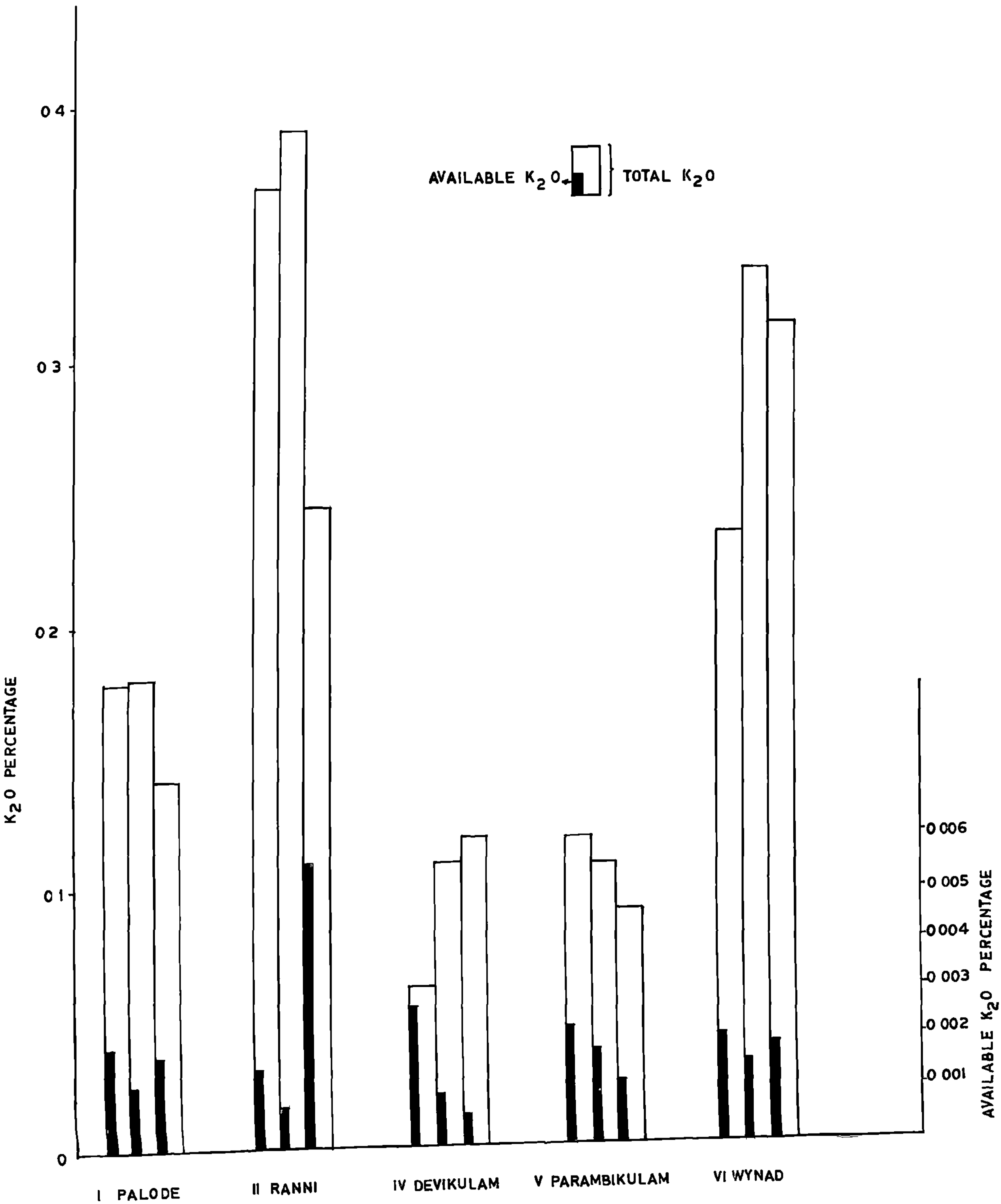

FIG 6 VARIATION OF TOTAL & AVAILABLE K_2O WITH DEPTH IN THE DIFFERENT PROFILES (SUCCESSIVE LAYERS FROM LEFT)

The cation exchange capacity decreases with depth in all the profiles except the Wynad profile.

Studies on the effects of deforestation on soil characteristics.

I. Physical determination.

(a) Mechanical analysis:- The results of mechanical analysis of profile samples from the forest as well as the deforested land are presented in table VII.

The proportion of gravel is very high in the forest profile (20.3 to 45.0 percent) as compared to the profile from deforested land (1.1 to 20.7 percent). The coarse sand fraction increases steadily with depth in the former whereas it decreases steadily in the latter. The fine sand fraction in both the profiles decreases with depth. The clay content of the soils varies from 17.0 to 27.0 percent in the forest profile and from 14.0 to 42.0 percent in the profile from the deforested land. In the former profile, the maximum amount of clay (27.0 percent) is found in the second horizon but in the latter the clay content increases uniformly down the profile (14.0 to 28.0 to 42.0 percent). Mechanical eluviation of clay from the top soil and its accumulation in the subsoil are therefore observed in the profile from the deforested land. The clay ratio decreases with depth in the profile from the deforested land, but varies in an irregular manner in the other.

TABLE - VII

MECHANICAL COMPOSITION OF SOILS FROM FOREST LANDS AND CLEARED AREA

Location	Depth in cm.	Gravel %	Mechanical Composition (Percent on oven dry basis)				Clay ratio sand + silt/ clay	Textural class
			Coarse sand	Fine sand	Silt	Clay		
Forest land	0 - 48	20.3	28.7	29.3	20.0	22.0	3.6	Loam
	48 - 75	32.7	37.5	26.5	9.0	27.0	2.7	Clay loam
	75 -150	45.0	49.0	22.6	11.1	17.3	4.9	Gravelly loam
Cleared land	0 - 5	20.7	37.0	31.0	18.0	14.0	6.1	Loam
	5 - 42	11.7	24.2	29.4	18.2	28.2	2.6	Clay loam
	42 -150	1.1	17.8	24.2	16.0	42.0	1.4	Clay

(b) Loss on ignition:- The data in table VIII show that loss on ignition decreases from 16.3 to 11.2 percent with depth in the forest profile, but remains fairly uniform in the profile from the deforested land.

(c) Single value constants:- The single value constants of the soils studied are presented in table VIII.

The water holding capacity of soils of the forest profile varies from 28.8 to 36.7 percent and that of the profile from the deforested land from 32.4 to 42.0 percent. This single value constant decreases with depth in the forest profile, but no regular variation is noted in the other profile.

The bulk density of the soils ranges from 1.32 to 1.46 in the forest profile and from 1.22 to 1.40 in the other profile. In both profiles the bulk density of the soils of the third layer is higher than that of the surface horizon. No marked difference is observed in the specific gravity of the soils of both the profiles.

The porespace varies from 42.6 to 52.2 percent in the forest profile and from 47.0 to 52.7 percent in the profile from the deforested land. It decreases steadily with depth in the former but remains fairly constant in the other.

The volume expansion of the soils ranges from 2.6 to 6.5 in the profile from the forest area and from 5.5 to 9.3 in the profile from the cleared land. It decreases

TABLE - VIII

SINGLE VALUE CONSTANTS OF SOILS FROM FOREST LAND AND CLEARED AREA

Locality.	Depth in cm.	Water holding capacity. (Percent)	Apparent density.	Specific gravity.	Porespace (Percent)	Volume expansion (percent)
Forest land	0 - 48	38.7	1.32	2.52	52.2	6.5
	48 - 75	31.6	1.41	2.45	45.6	4.1
	75 -150	28.8	1.46	2.47	42.6	2.6
Cleared land	0 - 5	39.4	1.28	2.32	51.4	9.3
	5 - 42	42.0	1.22	2.28	52.7	8.9
	42 -150	32.4	1.40	2.42	47.0	5.5

uniformly down the profile in the former while there is no significant decrease with depth in the latter.

II. General Chemical Characteristics.

(a) Soil reaction (pH):- The pH of soils (table X) ranges from 5.0 to 5.3 in the forest profile and from 4.9 to 6.2 in the profile from the deforested land.

(b) Organic carbon, nitrogen and C/N ratio:- Organic carbon content of the soils (table IX) varies from 0.53 to 3.77 percent in the forest profile and from 0.82 to 3.97 percent in the other profile. The data reveal that organic matter has accumulated in greater amounts in the lower horizon of the profile from the deforested land.

The nitrogen content of the soils ranges from 0.05 to 0.31 percent in the forest profile and from 0.17 to 0.27 percent in the other profile. Nitrogen is found to have accumulated to a greater extent in the lower horizons of the profile from the deforested land.

The carbon/nitrogen ratio varies from 7.5 to 12.2 in the profile from the forest and from 4.8 to 14.9 in the other profile.

(c) Cation exchange capacity:- The cation exchange capacity (table X) ranges from 2.1 to 10.0 m.e/100 g. soil in the profile from the forest and from 4.6 to 9.7 m.e/ 100 g. soil in the profile from the cleared land. No marked difference is observed in the cation exchange capacity of the surface soils of both the profiles, but considerable variation is noted in this property between the subsoils.

TABLE - IX

CARBON/NITROGEN RELATIONSHIPS IN SOILS FROM FOREST LAND AND CLEARED AREA

Locality	Depth in cm.	Percent on oven dry basis			C/N ratio
		Organic carbon.	Organic matter.	Nitrogen	
Forest land	0 - 48	3.77	6.48	0.31	12.2
	48 - 75	0.97	1.66	0.13	7.5
	75 -150	0.53	0.91	0.05	10.6
Cleared land	0 - 5	3.97	6.84	0.27	14.9
	5 - 42	1.92	3.32	0.23	8.3
	42 -150	0.82	1.41	0.17	4.8

(d) Acid insolubles:- The amounts of hydrochloric acid insoluble silica and sand in the soils show little variation between the two profiles. It is highest in the third layer of the forest profile and in the surface soil of the other.

III. Analysis of Hydrochloric acid extracts.

The analytical data of hydrochloric acid extracts of the soils presented in table X show that the sesquioxide content varies from 36.4 to 39.3 percent in the profile from the forest and from 30.9 to 42.3 percent in the profile from the deforested land. It increases progressively down the profile from the deforested land while it remains almost uniform in the profile from the forest area.

No appreciable difference is observed in the P_2O_5 and K_2O contents of the two profiles.

The distribution of CaO and MgO in soils of both the profiles is similar except that the level of CaO in the forest profile is generally higher.

The data recorded in table XI reveal that there is considerable difference in the available P_2O_5 and K_2O contents of the two profiles. The profile from the deforested land contains a higher proportion of available P_2O_5 whereas the forest profile contains more of available K_2O.

IV. Analysis of Clay.

Data on the chemical analysis of the clay fraction

TABLE - X

CHEMICAL CHARACTERISTICS OF SOILS FROM FOREST LAND AND CLEARED AREA

Locality	Depth in cm.	pH	Percent on oven dry basis							Cation exchange capacity m.e.percent
			Loss on ignition	Insoluble silica & sand	Sesquioxides	P_2O_5	K_2O	CaO	MgO	
Forest land	0 - 48	5.3	16.32	53.10	38.30	0.14	0.37	0.27	0.23	10.0
	48 - 75	5.0	12.86	54.50	39.30	0.16	0.39	0.19	0.21	3.2
	75 -150	5.1	11.22	62.00	36.40	0.10	0.25	0.22	0.10	2.1
Cleared land	0 - 5	6.2	13.08	62.20	30.90	0.19	0.49	0.22	0.39	9.7
	5 - 42	4.9	13.13	52.10	37.01	0.15	0.09	0.12	0.15	6.3
	42 -150	5.1	12.16	45.50	42.30	0.18	0.18	0.15	0.16	4.6

TABLE - XI

TOTAL AND AVAILABLE PHOSPHORUS AND POTASSIUM IN SOILS FROM FOREST LAND AND CLEARED AREA

Locality	Depth in cm.	Percent on oven dry basis			
		Total P_2O_5	Available P_2O_5	Total K_2O	Available K_2O
Forest land	0 - 48	0.14	0.0014	0.37	0.015
	48 - 75	0.16	trace	0.39	0.007
	75 -150	0.10	trace	0.25	0.055
Cleared land	0 - 5	0.19	0.0022	0.49	0.006
	5 - 42	0.15	0.0006	0.09	0.006
	42 -150	0.18	0.0011	0.18	0.023

TABLE - XII

CHEMICAL ANALYSIS OF CLAY FROM FOREST LAND AND CLEARED AREA

Locality.	Depth in cm.	Loss on ignition percent.	Percent on ignited basis			Gem-mol ratios			Cation exchange capacity m.e. per-cent.
			SiO_2	Fe_2O_3	Al_2O_3	$\frac{SiO_2}{Al_2O_3+Fe_2O_3}$	$\frac{SiO_2}{Al_2O_3}$	$\frac{SiO_3}{Fe_2O_3}$	
Forest land	0 - 48	15.41	27.9	17.2	37.2	0.98	1.28	4.18	24.2
	48 - 75	14.95	26.7	17.6	36.9	0.94	1.22	4.00	24.8
	75 -150	15.23	27.4	18.9	37.5	0.92	1.22	3.75	23.4
Cleared area	0 - 5	12.50	28.3	17.4	37.4	1.01	1.31	4.27	26.2
	5 - 42	11.95	27.2	18.1	36.7	0.96	1.25	4.09	26.8
	42 -150	14.50	27.9	17.8	37.2	1.02	1.28	4.18	25.7

of the soils are presented in table XII. No marked difference is observed in the loss on ignition of clays from both the profiles. The SiO_2 content varies from 26.7 to 27.9 percent in the forest profile and from 27.2 to 28.3 percent in the profile from the deforested land. No significant difference is noticed in the Fe_2O_3 and Al_2O_3 content of the clays of the two profiles. The silica/sesquioxide ratio, silica/alumina ratio and silica/ferric oxide ratio show very little variation between the clays of the two profiles.

The cation exchange capacity of the two clays shows little variation and ranges from 23.4 to 24.8 m.e/100 g. clay in the forest profile and from 25.7 to 26.8 m.e/100 g. clay in the profile from the deforested land.

DISCUSSION

D I S C U S S I O N

In the five forest soils studied, there is a close resemblance in certain soil characteristics which is obviously due to the similarity in the climatic and biotic conditions under which these soils have developed. The climate is of the hot humid type in which, soil formation is predominantly pedochemical in nature. Both physical and chemical weathering are active under such climatic conditions. Difference in microclimate brought about by relief and vegetation as well as by the type of litter produced under different plant communities have probably caused certain variations in the morphological, physical and chemical characteristics of these soils.

There is very little accumulation of litter in the various soils examined. The high microbiological activity in these soils due to the existing hot humid conditions, appears to be mainly responsible for the absence of litter in these forests.

From the morphological observations recorded in Chapter 3, it is seen that the colour of the soils is usually dark reddish brown to dark brown at the top and changes to red in the subsoil. The brown colour is probably due to dehydrated form of iron oxide - turgite or haematite (Glinka, 1927) and the darkness imparted is indicative of an accumulation of humus in the surface soil.

These differences in colour between the surface soil and subsoil are generally more pronounced in the profiles from the evergreen forest at Ranni and the shola forest at Devikulam.

The soil structure is usually of the crumb type in the surface layer and becomes blocky or massive in the subsoil, except in the profiles where laterite occurs in the lower layers. Such type of structure provides favourable environment for proper root development and good air-moisture relationships. Roots are abundant in the surface horizon in all the profiles but pentetration is restricted to a large extent in the sub-soils of Palode and Ranni forests where laterite is found in the lower horizon and in the Wynad profile where the subsoil is extremely hard due to compaction caused by quartz grains and clay.

All the profiles are non-calcareous. The acid leaching that has taken place in these soils is responsible for this condition.

The data on mechanical analysis indicate that the texture of the soils ranges from loamy sand to clay. This is further evidence that chemical weathering is probably the predominant soil forming process in these soils. The soils from the moist deciduous forests at Wynad and Palode area of comparatively heavy texture possibly due to the more favourable conditions existing in these localities for chemical weathering. The content of gravel is higher in the Palode and Ranni profiles because typical laterite occurs in the lower layers of these profiles. Mechanical eluviation of clay from the top soil and its accumulation in the subsoil are well marked in all the profiles. In the Wynad profile, the clay has moved to a greater depth and together with the quartz grains forms a hard and impervious layer at a depth of about 120 cm.

The loss on ignition is highest in the Devikulam profile due to the higher amounts of organic matter present. But this profile has an unusually low content of clay in all the horizons. Similarly, the Wynad profile contains the highest amount of clay, but the loss on ignition recorded for this profile is the lowest. These results indicate that the loss on ignition is closely correlated with the organic matter and not the clay content.

The soils examined show only slight variation in water holding capacity. The surface soils recorded the maximum values which is obviously due to a greater concentration of organic matter on the surface. The higher values shown by the subsoils of Parambikulam and Wynad profiles can only be attributed to the higher content of clay in these layers. For the same reason, the subsoils of these profiles give a higher value for volume expansion. No appreciable difference is observed in the specific gravity of the various soils which indicates that their chemical make-up is similar.

The pH values reveal that all the soils are acidic in reaction. The acidity can only be attributed to the long and continued leaching that these soils have been subjected to. The pH range of these soils viz., 4.2 to 6.4, may not adversely affect the growth of the crops because as pointed out by Stone and Lemmon (1957) seedlings and trees in general develop best at pH values between 4.5 and 6.0 in forests. The soils from Palode show the highest acidity which may be the result of more drastic leaching as evidenced by the greater downward movement of clay in this profile and its comparatively low base status. Hesselman (1926) noted that soils develop greater acidity if the leaves of the trees occupying the land contain a higher amount of acid. The surface soil of Devikulam profile, on the other hand, is less acid than the subsoil. Doyne (1935) observed a similar condition in places where the leaves of the trees contain a high content of bases.

The soils studied are characterised by a high amount of organic matter and nitrogen in the surface layer. The Devikulam profile recorded the highest values obviously because of the luxuriant vegetation caused by the heavy precipitation and high atmospheric humidity in this area. The carbon and nitrogen contents, in general, decrease with depth in the profiles. There is, however, evidence of leaching of these two elements and their accumulation in the lower horizons of the profiles from the moist deciduous forests of Palode and Wynad. The carbon/nitrogen ratio of soils varies from 2.8 to 20.7 which is in agreement with the findings of Satyanarayan et al (1946), Yadav and Pathak (1963) and Yadav (1963) on the forest soils of India. The low ratios observed in the lower horizons of Wynad, Parambikulam and Devikulam profiles may be due to the high infiltration of nitrogen into these layers. Russel (1961) attributes such fall in carbon/nitrogen ratio to the inclusion of ammonium ions held by the clay in a form in which they can be displaced only by treatment with a strong acid. The normal carbon/nitrogen ratio observed in the top soils indicates that the process of decomposition of organic matter is quite rapid in these forests.

The results of analysis of the hydrochloric acid extracts reveal that the sesquioxides have been leached considerably from the top soil into the subsoil. In general, this situation is more pronounced in profiles from higher elevations like Devikulam, Parambikulam and Wynad. The difference in the mobility of sesquioxides in the various profiles, however, appears to be due to the consequent amount of complexing agents in the leaching medium (Bloomfield 1955).

The P_2O_5 and K_2O contents of the soils are fairly high compared to average Indian soils. The second horizons in the profiles have a higher level of these nutrients due to long and continued leaching. Walker and Adam (1959) have furnished evidence to show that an increasing loss of phosphorus by leaching occurs with increasing degree of weathering both as organic phosphorus from solution and as inorganic phosphorus from the soft weathering rock. The clay content is also high in the second horizons of the profiles. Raychaudhuri and Landley (1960) found that soils which contain a high amount of clay and silt retained more phosphorus. This is further substantiated by the observations of Goel and Agarwal (1960) and Yadav and Pathak (1963). The content of available phosphorus is low in all the profiles which may be attributed to a low rate of release of this nutrient from soil minerals. This may also be the result of relatively high amounts of organic matter in these soils, because as reported by Shrikhande and Yadav (1954) and Yadav and Pathak (1963) phosphorus availability decreases in the presence of organic matter. The very low level of available potassium despite comparatively high amounts of total K_2O indicates the presence of unweathered potassium bearing minerals in these soils.

The calcium content is highest in the surface soils which decreases with depth in all the profiles which points to the accumulation of this element in the top soil through leaf fall. Due to the relatively high content of calcium in their litter, many hardwoods favour accumulation of this element in the surface soil to a greater extent (Alway 1933). The magnesium content is highest in the second horizons of the profiles. This conforms with the observations of Lutuz and Chandler (1957) who found that magnesium may accumulate in the B horizons of forest soils.

The cation exchange capacity is found to be mainly governed by the orgnic matter and clay contents of these soils. In view of the very low values obtained for cation exchange capacity, the main type of clay present in these soils appears to be kaolinite.

EFFECTS OF DEFORESTATION ON SOIL CHARACTERISTICS

There is considerable differences of opinion with regard to the effects of clearfelling of trees in natural forests and raising of plantations,on the physical and chemical characteristics of soils. Muller (1887), Shibata et al (1951) McDonald (1955), Biswell and Schultz (1957) and Siviridova (1960) held the view that clearfelling has no harmful effects on soil characteristics. Ehrenberg (1922), Albert (1944), Rawitscher (1946), Trimble (1949), Chevalier (1949) and Riquier (1953) considered the clearfelling of natural forests and raising of pure crops as positively detrimental because of the resultant hazards, such as, soil erosion, depletion of nutrients etc. that may alter the natural equilibrium of the soil. Wiedeman (1934), on the other hand, concluded that the effects of clearcutting of forests cannot be generalized for all situations. In some cases an unfavourable effect and in others, a favourable influence is obtained.

The results of the present investigation go to show that while no serious depletion in plant nutrients has taken place in the soil, its physical condition has been markedly altered as a result of deforestation and subsequent planting with teak seedlings. As seen from the morphological features of the two profiles recorded in Chapter 3, there is considerable evidence that soil erosion has taken place in the deforested land on a large scale. The favourable structure of the forest soil has been almost completely destroyed in the deforested land, probably due to the deflocculation of soil aggregates caused by excessive insolation and by the mechanical disturbances such as, removal of stumps and logging of wood brought about by deforestation. Trimble (1949) has reported that timber cutting from forests caused considerable ground disturbances which led to erosion and humus destruction.

The clay content of the forest soil is highest in the second horizon, but in the deforested land it increased steadily down the profile and at a depth of about 150 cm. attained a maximum value which was three times that of the surface horizon. This indicates that clay has been translocated to the subsoil in the cleared land at a more rapid rate than in natural forest under normal conditions. Such rapid eluviation of the clay can only be attributed to the excessive mechanical disturbances to the soil caused by deforestation. The accumulation of clay has resulted in the formation of a clayey soil horizon which, as pointed out by Pearson and Marsh (1935), inhibits the growth and regeneration of trees.

The pH values of the soils indicate that the surface soil of the deforested land is less acid. This may be due to the incorporation of large amounts of ash in the soil during the burning operations connected with deforestation and also the subsequent leaching of soluble salts present in the ash. This finding conforms with the observations of Riquier (1953), Fuller (1955), Maran (1955) and Tarrant (1956) who found that clearfelling of forests and burning of soil raises the pH value.

Unlike in the forest profile, the loss on ignition of the soil from the cleared land remained uniform with depth. This indicates that organic matter has been leached to the lower layers. The data on organic matter presented in table XI substantiate this view. A similar condition is witnessed in the case of nitrogen also. In the deforested land, this nutrient has been leached to the lower horizor in relatively larger amounts. The low carbon-nitrogen ratic of the subsoils of the deforested land may also be attributed to the greater leaching of nitrogen to these horizons.

A higher cation exchange capacity is recorded for the subsoils of the cleared land than for the natural forest which may be ascribed to the greater content of clay and organic matter in these horizons.

The total and available P_2O_5 contents are appreciably higher in the cleared land than in the forest profile. This result is in agreement with the findings of Tarrant (1956), Chirikov and Solovev (1960) and Sivirividova (1960) who noted that clearfelling of natural forest and burning of soil increases the total and available phosphorus contents of soils.

The chemical composition and cation exchange capacity of the clays from the two profiles reveal that the chemical constitution of the clay has not been altered to any marked extent as a result of the operations undertaken during deforestation. This finding has however to be viewed with some reservation as the present study was limited only to two profiles. Moreover, this investigation was carried out after a period of only two years of deforestation during which time no significant change in the chemical constitution of the clay could have taken place. A study extending over a longer period and covering a larger area is therefore warranted. Only such an investigation can help in determining more precisely the nature of the soil transformations brought about by deforestation and its effects on soil fertility.

SUMMARY AND CONCLUSIONS

S U M M A R Y   A N D   C O N C L U S I O N S

A study has been made of the forest soils of Kerala State to determine their morphological features, physico-chemical characters and fertility status. Five typical profiles representing the three important vegetational types in this State viz., tropical evergreen, moist deciduous and shola forests, located at different altitudes and of different topography were examined. The data reveal that these soils are the product of long, continued, severe leaching under a hot humid climate. There is close similarity in many of the important soil characteristics of the profiles studied.

The soils, in general, are brown to red in colour, moderately deep, acid in reaction, rather heavy in texture and non-calcareous in nature. They have a high content of organic matter, nitrogen, phosphorus and potassium but are low in available P_2O_5 and K_2O.

The soils of the various forest communities studied show slight differences in certain characterstics which is a consequence of local site features. Higher acidity and more clay are found in soils of the moist deciduous forests. The soils supporting evergreen and shola forests are generally higher in organic matter and nitrogen. The accumulation of iron and aluminium is also found to be greater in these profiles.

Studies undertaken to determine the effects of deforestation on soil characteristics indicate that no pronounced changes are brought about as a result of deforestation. The nutrient capital of the soil has not been depleted to any noticeable extent after two years of deforestation. Marked changes, however, are noted in the physical condition of the soil. The favourable structure of the natural forest soil has been adversely affected by deforestation and the soil exposed to severe erosion.

The analysis of the clay fraction of the soils reveals that the chemical constitution of the clay has not been altered to any significant extent as a result of deforestation.

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* Originals not seen.