STUDIES ON THE EFFECT OF DEFORESTATION ON ORGANIC CARBON, NITROGEN AND POTASH STATUS OF SOME FOREST SOILS OF KERALA

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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 J. I. Mithra Chaly 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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INTRODUCTION

INTRODUCTION

The State of Kerala, situated at the end of the Indian Peninsula is blessed with an abundance of forest wealth. It has been estimated that 27.5 per cent of the total land surface of this State is under forests, covering an area of about 10,640 sq. km. Trees of considerable commercial importance are found in abundance in these forests which contribute considerably to the economy of this State.

The State is favourably located with regard to rainfall, temperature and other climatic factors, conducive to a luxuriant growth of vegetation. The forests are confined to the eastern half of the State and include the mountains of the Western Ghats and the rolling plains. They merge with the forests of adjoining Madras and Mysore States. The entire forest area is Criscrossed with rivers and streams.

The climatic condition existing in different parts of Kerala are diverse and have a profound influence on the development of the vegetation. Depending on the variations in temperature, rainfall and elevation, different kinds of forests are found, the tropical evergreen and moist deciduous types predominating.

Tropical evergreen forests are found at elevation ranging from 240 to 1050 m; with an average rainfall of 350 cm.

They also occur in areas of rainfall as low as 200 cm. These forests represent the most luxuriant type of vegetation in Kerala with characteristic green leaves throughout the year. The leaves are found to last for more than one year.

The important species of trees obtaining in these forests are Artocarpus hirsuta, Artocarpus integrifolia, and Dysoxylon malabaricum.

Moist deciduous types of forests are met with in regions of lower rainfall and elevation. They are found to thrive well at elevations of 150 to 400 m. and in regions having a rainfall of 150-200 cm. The trees usually shed their leaves every year. These types of forests contain a larger number of trees of considerable economic importance as compared to the evergreens. Important species like Dalbergia latifolia and Tectona grandis are found in these forests in great abundance.

Much of the forest area is being deforested year after year both in a systematic and haphazard way. This is because of the increasing demand of the growing population for newer and better land both for the cultivation of crops of economic importance as well as to grow food crops for their sustenance.

Such indiscriminate and unscientific ways of deforestation followed by intensive cultivation have given rise to various soil fertility and management problems in the areas thus denuded. For instance, it has been reported that the growth of trees in pure plantations raised after deforestation is adversely affected which might be considered as a consequence of denudation. The process of laterisation in soils is in soils is said to be hastened by deforestation.Other changes that may take place in the soil as a result of deforestation are in the nitrogen and potash status of the soil as these elements are liable to be lost in drainage. Further more, the effect of the intense climatic factors of these regions, viz., heavy rainfall and high temperature, become severe after deforestation and profoundly affect the denuded soils. Both erosion and percolation are accelerated with consequent changes in the soil characteristics. It is presumed that all these changes have a cumulative effect on the denuded forest soils. The burning of the stumps immediately after deforestation which is a common practice in this State, will also lead to appreciable changes in the soil,especially the surface layers.

It is very desirable that we have a precise knowledge of the effect of deforestation of soil properties to enable us to adopt suitable management practices in the deforested areas. However, a review of literature reveals that very little work has been done on the forest soils of the tropics and subtropics, much less on the effects of deforestation on soil characteristics. Hence, the present investigation was undertaken with a view to studying the effects of deforestation on the content of organic carbon, nitrogen and potassium in forest soils as these are the constituents liable to be affected most by denudation.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

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

According to Romell (1930) a forest soil is a natural or slightly modified natural product whereas an agricultural soil is an artificial product.

Hilgard (1892) was of the opinion that forest soils are frequently younger than agricultural soils.

Forests, their growth, development and influence on soil properties

Villeneuve (1946) suggested that temperature and precipitation are important factors that determine the development of forests, as well as, their composition.

According to Coile (1952) the climate of a place, as defined indirectly by the latitude and longitude, is correlated with the growth of forests, independent of other factors.

Waheed Khan and Yadav (1962) also are of opinion that the physical and chemical nature of the soil, as well as, numerous other factors that effect the growth of forest vegetation come only after climate as a factor influencing the development and distribution of vegetation.

Concurring views are also held by Chandrasekharan (1962) according to him differences in temperature and precipitation at different altitudes are responsible for the variation in the forest vegetation found in this State.

Burger (1926) is of opinion that the quality of a soil is to a large extent a function of the forest stand it supports.

Haig (1929) found that the site index of red pine in Conneticut increased as the percentage of finer fractions increased in the 'A' horizion.

Hicock et.al. (1931) found some correlation between site index and individual soil attributes. The relationship was more marked in the case of nitrogen and less so in the case of soil pH.

In Central Europe Braun-Blanquet (1934) found a close correlation between the natural evolution of vegetation and that of the soil.

Blanck meister (1938) expressed the opinion that the influence of specific forest stand on the soil is greatest in regions climatically favourable for the development of that type of vegetation. Soil properties are profoundly influenced by the vegetation while the vegetation is also to some extent determined by the soil characteristics.

Donahue (1939) reported that poor internal drainage is largely responsible for the poor growth and even failure on coniferous plantations.

In New York Heiberg (1941) found that forest trees grew higher when planted on mull soils than on moor type humus.

Studies on the relationship between soil type and site quality of forests carried out by Diebold (1935) in East Central and South Central New York revealed that well-drained soils with an alkaline influence in the sub soil regions were best suited for natural hardwoods while shallow soils and those with poor internal drainage were suitable only for poor quality local hardwoods.

In the case of aspen, Stokeler (1948) found soil texture to be an important factor affecting site quality.

Livingston (1949) reported than in Colorado forests and grass lands occur side by side; forest lands on coarse textured soils with a conglomerate substrate and the grass lands in the contiguous areas with fine textured soils.

According to Aaltonen (1950) there is good correlation between the forest type and soil texture and profile characteristics.

Bhatia (1954) found good correlation between the growth of teak and soil fertility factors like pH exchangeable calcium, magnesium and phosphorus but not with nitrogen, organic matter and the C/N ratio.

Thomas (1954) stated that soil may be the determining factor in the formation and development of tropical forests. Forests are the cause rather than the effect of fertility in tropical soils.

Thomas (1964) in his studies on the forest soils of Kerala has reported that higher acidity and more clay are obtained in soils of moist deciduous forests while soils supporting ever green vegetation are generally higher in organic matter and nitrogen.

Carbon, Nitrogen and C/N ratio

Mosier and Gustafson (1917) reported that the average organic matter content of forest soils of Illinois was 1.93.

Alway and McMiller (1933) observed greater accumulation of organic matter content in mineral soils of fine texture than in those of coarse texture.

Heyward and Barnette (1936) found the C/N ratio in the various horizions of long leaf pine soils to be 101 for litter, 47 for the "F" layer and 33 for the A horizion.

Satyanarayana et.al. (1946) made a comparative study of Indian soils with special reference to the C/N ratio. They observed the general level of carbon and nitrogen to be low in many of the soils, the C/N ratios lying between 5 and 25. They found no correlation between climate and the nitrogen content. High amounts of carbon and nitrogen which decreased with depth were observed on the surface soils of the perhumid zone.

Aaltonen (1949) found no significant difference in the depths of humus layers under pine, spruce and birch.

Wilson (1949) found no significant differences in the humus content of the soils under the different forest vegetations. In the "B" horizion under beach, birch and sugar mapple, the humus content was higher than in the same horizion under softwoods, suggesting more favourable conditions for the downward movement of water under the northern hardwoods.

Duchaufour (1950) obtained the lowest C/N ratio in the "A" horizions of well aerated soils with in a pH range of 5-7. In the case of podsols organic matter content tended to decrease with the C/N ratio, probably as a result of illuviation.

Puri and Gupta (1957) reported significant correlation between the organic matter content and nitrogen as well as between nitrogen and calcium content of humus in Kulu valley. An increase in nitrogen and calcium content was noticed when the organic matter was increased. The amounts of organic matter and nitrogen decreased considerably in the lower layer of the soil.

Zaitzev (1956) showed that the nitrogen reserve in the top soil was much higher under oak than under spruce.

Allison (1957) working on the various virgin soils of U.S.A. reported that the percentage of nitrogen varied from 0.15-0.30 in the Chernozems of Eastern Dakotas and Kansas, from 0.10-0.25 in the Prairie soils of central states and from 0.05-0.20 in the Brown forest soils of the north east.

Solovev (1960) observed that forests tended to increase the humus content of the soil and the content of humic acid in the humus.

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

Studies on forest soils of India by Yadav and Pathak (1963) revealed that the percentage of nitrogen varied between 0.013 and 0.427 in the forest soils of Uttar Pradesh. Organic matter was found to very from 0.172-8.130 per cent. The C/N ratio ranged between 1.5 and 25.4. No relation was observed between the depth of the profiles and the C/N ratio.

In his study of the forest soils of Kerala Thomas (1964) found that the C/N ratio of these soils varied between 2.8 and 20.7. Both the carbon and nitrogen contents tended to decrease with depth down the profile.

Total and available potash

Feher and Frank (1936) observed seasonal variations in the amount of citric acid soluble potash in the soil. It was found to be lowest during summer and highest in autumn.

Solovev (1960) was of opinion that the nutrient content of the soils under forest is comparatively higher. He reported that forests increased the amount of nutrients especially that of phosphorus and potassium.

Thomas (1964) showed that in the forest soils of Kerala the potash content varied from 0.18-0.37 per cent in the top soil. Available potash was reported to vary between 0.15 and 0.27 per cent. No characteristic variations down the profile was observed.

Effects of deforestation on soil characteristics

1. General.

Both beneficial, as well as, adverse effects due to deforestation have been reported in liter ature.

Wittich (1930) working in North East Germany observed that the pore space of sandy soils increased as a result of clearcutting of forests.

Ehrenburg (1922) showed that erosion brought about as a result of the removal of the forest canopy and burning resulted in the loss of ash material and the fertile top soil.

In his studies in tropical soils Rawitscher (1946) concluded that deforestation led to an increase in leaching and removal of essential nutrients resulting in the reduction of crop yields.

Trimble and Tripp (1949) studied the effect of fire and cutting on forest soils of lodge-pole pine forests on Northern Rocky mountains of U.S.A. They found that after burning, the soil became impervious resulting in sheet erosion. They also observed that the cutting down of timber caused ground disturbance leading to erosion hazards.

Chevalier (1949) observed ferruginous concretions forming a pan at shallow depths in areas where the forests were denuded. Erosion led to the removed of the top soils with consequent exposure of the ferruginous pan.

Burgy and Scott (1952) found that burning increased the larger particle size distribution in the forest soils. They also observed that the ash remaining on the top soil did not hinder its permeability.

Duchaufour (1953) studied the effect of denudation on the structure of forest soils. He observed that it led to leaching and podsolization in permeable sandy soils and to the formation of gley horizion in more compact areas. He suggested that forest soils should be exposed to the sun for as short a time as possible.

Investigation by McDonald (1955) on the effect of clearfelling, showed no appreciable changes in the physical condition of the soil. He also found no difference in the moisture content of the soils of the denuded and forest areas either during the wet or dry periods.

Suarez (1957) showed that burning practiced as an agronomic operation, reduced surface run off, but increased erosion, as there was no surface cover. But Biswell and Shultz (1957) reported no evidence of surface run off and erosion following prescribed burning in pine forests even on lands that were slightly sloping. They maintained that the decomposed debris remaining on the surface after controlled burning prevented run off by favouring percolation.

2. <u>Organic carbon, Nitrogen and C/N ratio</u>

Trimble (1949) found that clear felling led to humus destruction. It also facilitated opening up of the soil leading to the oxidation of the soil humus. He observed that the entire organic matter disappeared in 30 years after deforestation.

Shibata *et.al*. (1951) showed that in the cleared areas the organic matter decomposed more readily. They reported that the total nitrogen was higher in the lower layers of the deforested area as compared to the forest lands. They concluded that any desirable results of deforestation would last for only a short time and would disappear completely in a matter of years.

Riquier (1953) reported that the clearing of forests completely destroyed the organic matter in the soil and prevented its accumulation. He showed that the improvement in physical properties were only of a temporary nature.

Studies by Fuller (1953) showed that part of the soil nitrogen was lost as a result of burning after deforestation while other nutrients were converted to more available forms.

He also observed that controlled burning increased the availability of exchangeable bases, while a decrease in organic matter and C/N ratio was noted, especially in the surface layers.

Dryness and Youngberg (1957) showed that logging and slash burning resulted in the loss of organic matter content form the soil.

Studies made on the effect of burning in the Eucalyptus forest soils of Western Australia by Hatch (1957) revealed that controlled burning, keeping the temperature always below 450°C., had no effect on the organic carbon, nitrogen and exchangeable cations.

Coltharp (1960) found an increase in the soil humus content and a decrease in undecomposed organic matter as a result of deforestation.

Siviridova (1960) showed that clear felling and denuding of forests considerably increased the soil humus content and easily hydrolysable nitrogen.

Thomas (1964) observed that both organic matter and nitrogen had been leached down to greater depths is deforested areas as compared to forest lands. The downward movement of nitrogen in the soil was more than that of organic carbon. He attributed the lower C/N ratio of the subsoils of the deforested land to the greater penetration of nitrogen to the lower horizions.

Nye and Greenland (1964) observed that the loss of organic matter was very rapid during the first year after deforestation and burning.

3. <u>Total and exchangeable potassium.</u>

Literature relating the effect of deforestation on the potash status of soils is rather meagre.

Ehrenburg (1922) found that clearfelling followed by burning increased the potash content of soils. He also found that plant nutrients were leached down to the lower horizons from where they were subsequently lost in drainage.

Rawitscher (1946) observed that the essential bases were lost due to increased leaching consequent on the deforestation of tropical soils.

Fuller (1955) showed that controlled burning increased the exchangeable bases.

Maran (1955) reported that clearfelling of old coniferous plantation led to an increased availability of potash.

In his studies on forest soils of Kerala, Thomas (1964) observed no serious depletion of the plant nutrient elements in the course of two years after deforestation.

Nye and Greenland (1964) studied the effect of deforestation and burning on the nutrient status of forest soils. They observed that following burning all the potash was accounted for by a rise in the exchangeable potash in the soil. A marked loss of potash was noted during the second year. The loss was reported to be more under shifting cultivation than under ordinary practices. Kowal and Tinker, as quoted by Nye and Greenland (1964) found surprisingly small losses of potash between one and eleven years after clearfelling a forest and cropping it to exhaustion. According to them burning causes remarkable changes in the quantities of exchangeable cations like calcium, magnesium and potash.

MATERIALS AND METHODS

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1. Profile sites.

Soil profiles were collected from two major forest areas, Chalakudi and Palode, representing the moist evergreen and deciduous type of vegetation respectively. From each of these centres four profiles were collected one from the standing forest and the others from areas denuded for 5, 10 and 15 years. The details of profiles collected are as follows.

A. Chalakudi. (Moist evergreen forest).

Profile I	Forest area
Profile II	Deforested area--5 years after denudation
Profile III	Deforested area--10 years after denudation
Profile IV	Deforested area--15 years after denudation

B. Palode. (Moist deciduous vegetation)

Profile I	Forest area
Profile II	Deforested area--5 years after denudation
Profile III	Deforested area--10 years after denudation
Profile IV	Deforestation--15 years after denudation

The profile sites are indicated in figure and relevant climatic data are furnished in appendix.

2. Collection and preparation of soil sample.

Pits were dug to a depth of 120 cm. in each of the selected sites and the profiles differentiated into four layers as follows:

Layer.	Depth. (cm.)
1	0-20
2	20-40
3	40-80
4	80-120

From each layer 2 Kg. of soil was collected, bagged and brought to the laboratory. In the laboratory the samples were airdried, ground in a procelain mortar, sieved through a 2 mm. seive and stored in glass bottles.

3. Chemical analysis.

i) Organic carbon.

The organic carbon was estimated by the wet digestion method of Walkley and Black (1934).

1 g. of the soil sample finely ground to pass through a 0.5 mm. sieve was transferred into a 500 ml. Erlenmeyer flask.

To this was added IN. potassium dichromate solution, followed by 20 ml. of concentrated sulphuric acid. The contents of the flask were shaken for a minute and kept aside on an asbestos pad for exactly half an hour. 200 ml. of distilled water was then added followed by 10 ml. of phosphoric acid and 1 ml. of diphenylamine. This was then titrated against 0.5N ferrous sulphate solution, and from the values obtained the organic carbon content was calculated.

ii) Nitrogen.

The nitrogen in the soil sample was estimated by the Kjeldahl method as described by Jackson 1958.

iii) Potassium.

Total potassium was estimated in the hydrochloric acid extract of the soil.

20 g. of the sample was digested with 200 ml. of constant boiling hydrochloric acid for six hours, filtered and made upto 500 ml. 50 ml. of this extract was pipetted out into a silica dish and evaporated to dryness on a waterbath. The residue was ignited to dryness to dehydrate the silica and extracted with hot water. 50 ml. of the clear extract was treated with 20 ml. of sodium cobaltinitrate and kept overnight. The precipitate was filtered through a sintered crucible, washed with 95% alcohol and dried in an air oven at

105°C. to constant weight. From the weight of the precipitate the K_2O content of the soil was calculated.

<u>Exchangeable potassium.</u>

The exchangeable potassium was determined after extraction with IN. NH_4OAc and precipitation with sodium cobaltinitrate as described by Jackson (1958).

RESULTS

RESULTS

From the work carried out on the effect of deforestation on the soils of Chalakudi and Palode which are representative of moist ever green and moist deciduous forests of Kerala, and where extensive deforestation has been carried out for various purposes, interesting results have been obtained which are generally in agreement with the findings of other workers in this field.

A. Organic carbon.

The data relating to the organic carbon content of the different profiles are given in table I and presented graphically in figure 1. It may be noted that among the profiles from Chalakudy the highest level of organic carbon (1.32 per cent) is obtained in the top layer of the soils from the forest area, which steadily decreases with increased period of deforestation and reaches a value of 0.46 per cent in Profile IV (15 years after deforestation). The carbon content decreases regularly with depth in all the profiles except Profile IV in which there is slight accumulation in the second and third layers. When the distribution of carbon in the second layer of the different profiles is considered the highest amount (0.97 per cent) is found in Profile II (5 years) and the lowest (0.52 per cent) in Profile IV (15 years). Similarly the highest amount (0.64 per cent)

TABLE I.

Effect of deforestation on the organic carbon content of soils

(Expressed as per cent on oven dry basis)

Locality	Depth (cm)	Profile I (forest area)	Profile II (5 years after deforestation)	Profile III (10 years after deforestation)	Profile IV (15 years after deforestation)
I. Chalakudi	0-20	1.32	1.11	0.69	0.46
	20-40	0.73	0.97	0.58	0.52
	40-80	0.48	0.64	0.44	0.56
	80-120	0.33	0.46	0.30	0.47
II. Palode	0.20	3.28	2.27	2.22	1.35
	20-40	2.20	1.17	1.37	1.25
	40-80	1.72	0.93	1.27	1.22
	80-120	0.72	0.68	1.01	0.94

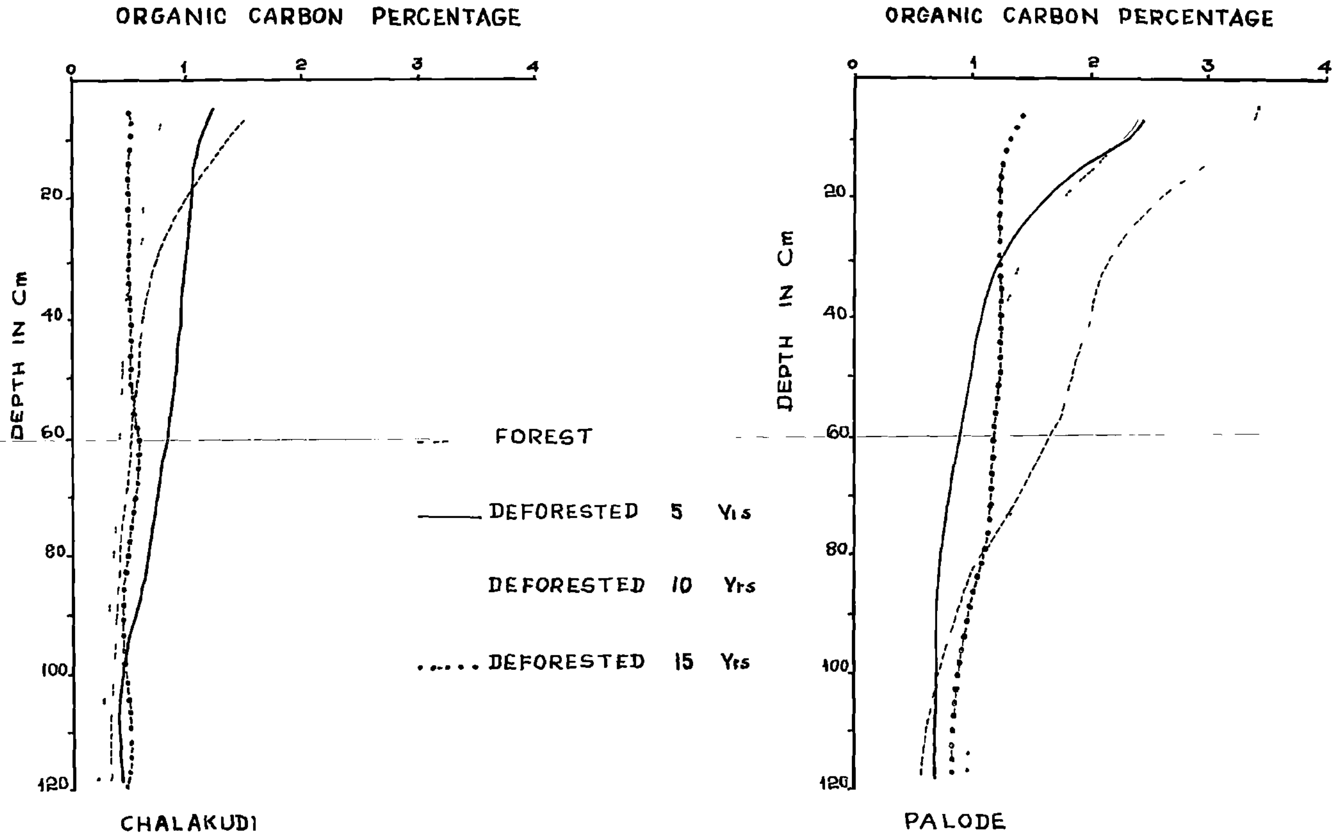

FIG 1. EFFECT OF DEFORESTATION ON THE ORGANIC CARBON CONTENT OF SOIL

of organic carbon in the third layer is also observed in Profile II (5 years) and lowest in Profile III (10 years). In the fourth layer the largest amount (0.47 per cent) of carbon is obtained in Profile IV and the lowest (0.30 per cent) in Profile III.

The level of carbon in the profiles from Palode is generally much higher than that of Chalakudi profiles. It decreases steadily with increased period of deforestation in the surface layers and varies from 3.285 per cent in Profile I (forest area) to 1.35 per cent in Profile IV (15 years). This trend is maintained in the second layer as well, the organic carbon content decreasing from 2.20 per cent in the second layer of Profile I to 1.25 per cent in the same layer of Profile IV. In the third layer the highest amount of carbon (1.72 per cent) is found in the forest profile and the lowest amount in Profile II (5 years). The highest amount of organic carbon (0.10 per cent) in the fourth layer is obtained in Profile III (10 years) and the lowest in Profile II. In all the profiles from Palode the organic carbon content decreases steadily with depth.

B. Nitrogen.

The variation in the nitrogen content of soils with increasing periods of deforestation is given in table II

TABLE II.

Effect of deforestation on the Nitrogen content of soils

(Expressed as per cent on oven dry basis)

Locality	Depth (cm.)	Profile I (Forest area)	Profile II (5 years after deforestation)	Profile III (10 years after deforestation)	Profile IV (15 years after deforestation)
I. Chalakudi	0-20	0.14	0.12	0.08	0.05
	20-40	0.10	0.11	0.07	0.05
	40-80	0.06	0.08	0.06	0.07
	80-120	0.04	0.06	0.04	0.08
II. Palode	0-20	0.25	0.14	0.14	0.12
	20-40	0.09	0.09	0.10	0.14
	40-80	0.08	0.09	0.11	0.14
	80-120	0.06	0.06	0.09	0.12

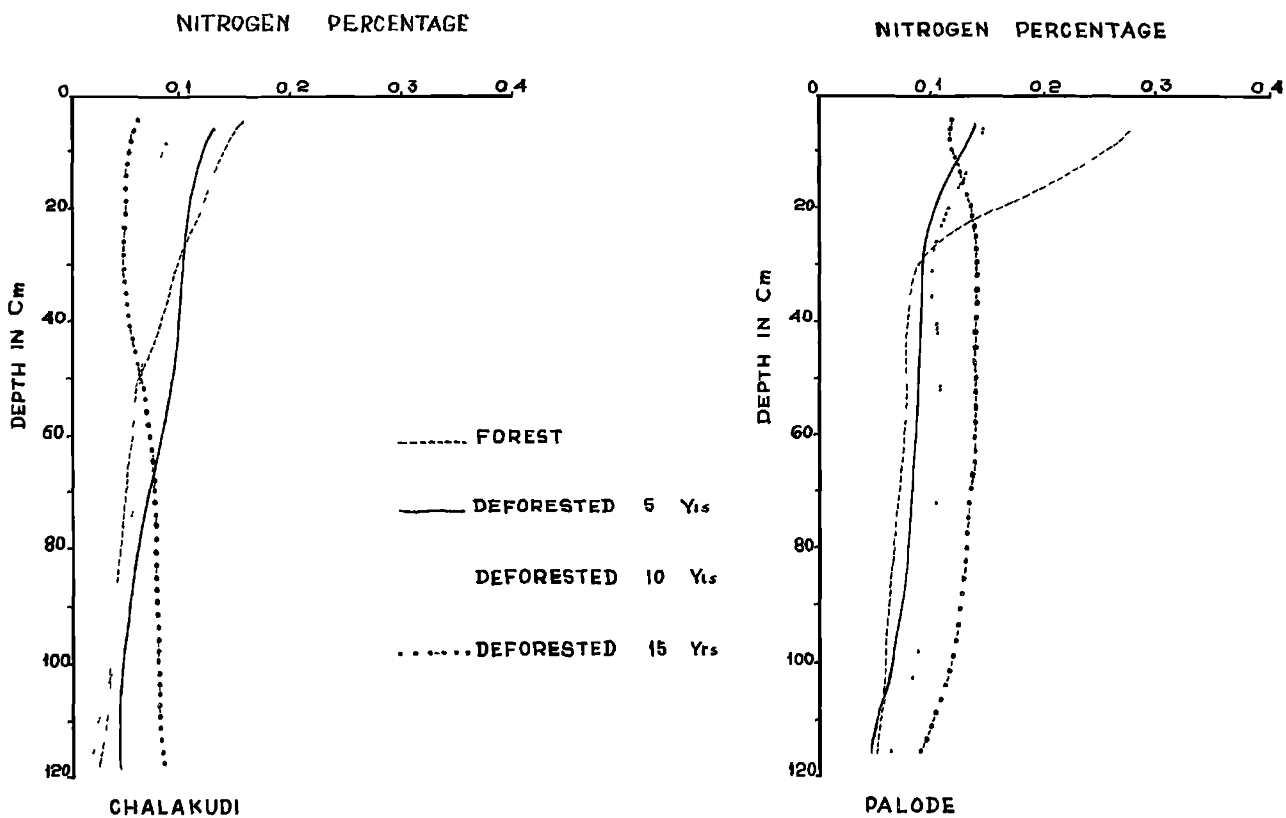

FIG 2. EFFECT OF DEFORESTATION ON THE NITROGEN CONTENT OF SOILS

and presented graphically in figure 2. The highest amount of nitrogen (0.14 per cent) present in the top layer of the Chalakudi forest profile steadily decreases with increase in the period of deforestation and reaches a value of 0.05 per cent in Profile IV (15 years). It is also seen that the nitrogen content decreases regularly with depth in all the profiles except Profile IV where an accumulation of this element is seen in the third and fourth layers. An examination of the second layer shows the highest amount of nitrogen (0.11 per cent) in Profile II (5 years) and the lowest (0.05 per cent) in Profile IV. A more or less similar trend is observed for the third layer also, the highest amount (0.08 per cent) being present in Profile II and the lowest (0.06 per cent) in Profile III (10 years). In the case of the fourth layer the maximum amount of nitrogen (0.08 per cent) is found in Profile IV and the lowest (0.04 per cent) in Profile III and I.

All the profiles studied in Palode record considerably higher values for nitrogen. This is true of all the profiles and all the layers. The nitrogen content is found to decrease with depth down the profile except in the case of the second and third layers of Profile IV, where the values are slightly higher. The nitrogen content is also found to decrease with increase in the period of deforestation.

An examination of the nitrogen content of the top layers of all the profiles reveals that the maximum amount (0.25 per cent) is present in the forest profile, which decreases and reaches a minimum value of 0.12 per cent in Profile IV (15 years). In the second layer the maximum value (0.14 per cent) is obtained in Profile IV and lowest (0.09 per cent) in Profiles I and II. The same trend is being maintained in the third layer also, the highest nitrogen content (0.14 per cent) being found in Profile IV and lowest (0.08 per cent) in Profile I. The fourth layer also exhibits the same pattern of nitrogen distribution. The maximum nitrogen content (0.12 per cent) is in Profile IV and the lowest in Profiles I and II.

C. <u>C/N ratio.</u>

The C/N ratios of the different profiles are presented in table III and their variation represented graphically in figure 3. The C/N ratio generally shows a tendency to decrease down the profile in the soils of Chalakudi. A decrease is also observed with increase in the period of deforestation. In the top layer the highest value for C/N ratio (9.47) is seen in the forest profile and the lowest (8.62) in Profile III. But an examination of the second layer reveals no defenite pattern in the variation of this

TABLE III.

Effect of deforestation on the C/N ratio of soils.

Locality	Depth (cm.)	Profile I (Forest area)	Profile II (5 years after deforestation)	Profile III (10 years after deforestation)	Profile IV (15 years after deforestation)
I. Chalakudi	0-20	9.47	9.32	8.62	9.20
	20-40	7.38	8.83	8.28	10.40
	40-80	8.00	8.10	7.40	8.30
	80-120	8.25	7.70	7.50	5.89
II. Palode	0-20	12.90	15.87	15.81	11.25
	20-40	24.50	13.00	13.70	8.88
	40-80	21.56	10.33	11.55	8.01
	80-120	12.00	11.46	11.10	7.85

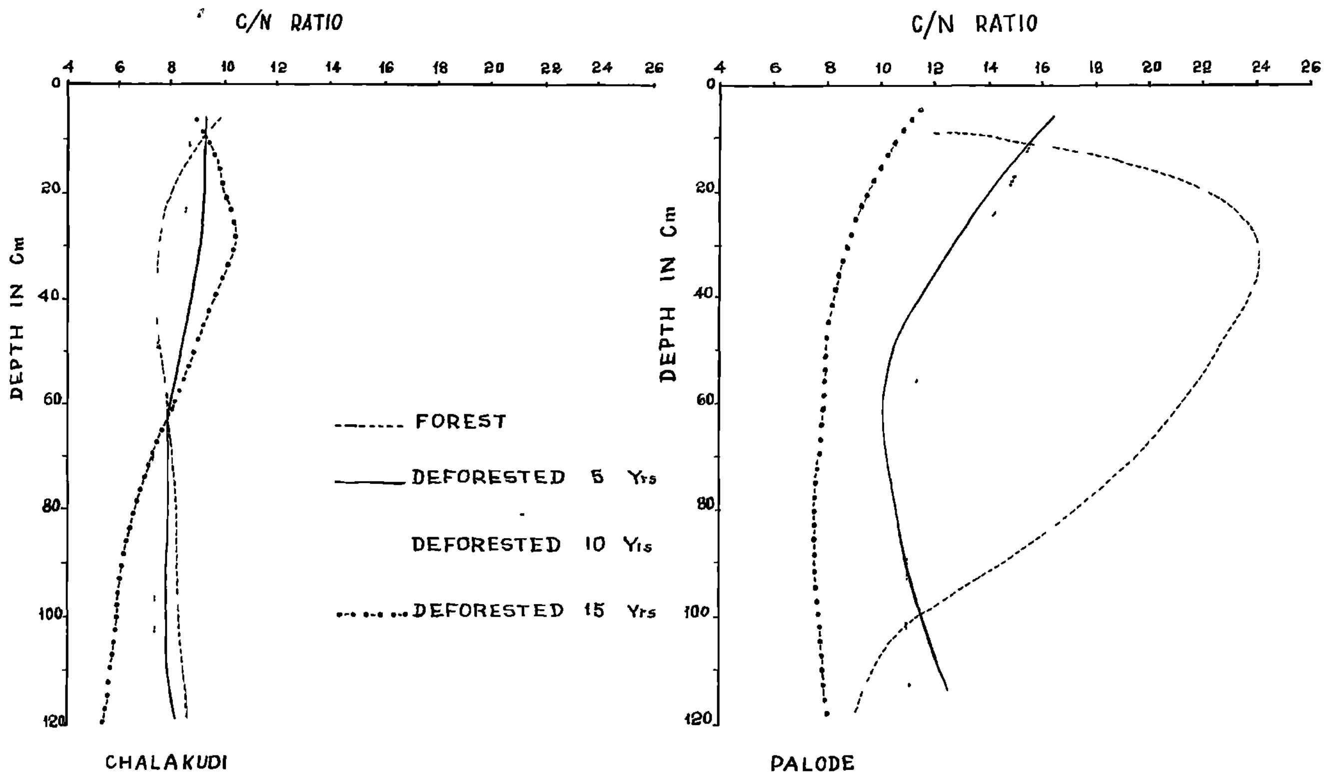

FIG 3 EFFECT OF DEFORESTATION ON THE C/N RATIO OF SOILS

ratio with increase in the period of deforestation. The lowest value (7.38) is obtained in Profile I, which increases in Profile II, decreases in Profile III and again increases in Profile IV. The highest value (10.4) is obtained in the profile denuded for 15 years. In all the profiles the C/N ratio of the second layer is lower than that of the top layer except in the case of Profile IV. When the C/N ratios of the third layer are examined, it is seen that the values are lower than that of the second layer in all the profiles. The highest value (8.30) is in Profile IV and lowest in Profile III. In the fourth layer the highest value for C/N ratio (8.25) is in the forest profile and the lowest in Profile IV (5.8). The reduction in C/N ratio with increase in the period of deforestation is steady and regular.

An examination of the forest and deforested soils of Palode, reveals a regular decrease in the C/N ratio with increasing periods of deforestation in all the layers except the top. A general tendency for decrease in the values of C/N ratio down the profile is also noticed, the exception being only in the case of the second and third layers of Profiles I. It is seen from the table that the maximum C/N ratio (15.81) in the top layer is in Profile II and the lowest (11.25) in Profile IV. The C/N ratio in the second layer is generally lower than in the first layer except in the forest soil where there is an increase in the second and third layers. The highest C/N ratio (24.50) is in the forest profile and the lowest (8.88) in Profile IV. A similar pattern is observed for the third layer also, the highest value (21.56) being in the forest profile and the lowest (8.01) in the profile denuded for 15 years. In the fourth layer the values are generally lower than those of the third layer except in Profile II. The C/N ratio in this layer decreases regularly with increase in the period of deforestation and varies from 12.00 in the forest profile to 7.85 in Profile IV.

Total Potash.

The distribution of total K_2O in the different profiles is given in table IV and presented graphically in figure 4-5. From the data presented it can be seen that the potash status of the Palode soils is considerably higher than that of Chalakudi soils. A general tendency to have an increased K_2O status down the profile is also observed. When the total K_2O content of the top layer of all the profiles at Chalakudi is considered, the maximum value (0.15 per cent) is found in Profile II, which gets appreciably reduced with increase in the period of deforestation reaching a minimum of 0.05 per cent in Profile IV. In the case of the second layer

TABLE IV.

Effect of deforestation on the total Potash content of soils.

(Expressed as per cent on oven dry basis)

Locality	Depth (cm.)	Profile I (forest area)	Profile II (5 years after deforestation)	Profile III (10 years after deforestation)	Profile IV (15 years after deforestation)
I. Chalakudi	0-20	0.10	0.15	0.08	0.05
	20-40	0.12	0.13	0.15	0.12
	40-80	0.11	0.09	0.11	0.19
	80-120	0.08	0.05	0.07	0.09
II. Palode	0-20	0.17	0.13	0.10	0.09
	20-40	0.18	0.09	0.12	0.10
	40-80	0.15	0.23	0.24	0.26
	80-120	0.13	0.09	0.13	0.15

the maximum K_2O content (0.15 per cent) is in Profile II and the lowest (0.12 per cent) in Profiles I and IV. In the third layer the highest value (0.19 per cent) is found in Profile IV and the lowest (0.09 per cent) in Profile II. The highest value (0.09 per cent) for total K_2O in the fourth layer is in Profile IV and the lowest in Profile II.

The Palode soils record considerably higher values for total K_2O in all the profiles studied. The highest value (0.23 per cent) for the surface layer is in Profile II and lowest in Profile IV (0.09 per cent). It is noteworthy that the K_2O content of the surface layers of the profiles from Chalakudi and Palode denuded for 5 years contain appreciably more K_2O than the corresponding layers of the forest profiles. In the case of the second layer the K_2O content is found to be generally higher than that of the first layer. The total K_2O content is maximum in the forest profile (0.18 per cent) and lowest in Profile II (0.09 per cent) Considerably higher values are obtained for the third layers. It is found to vary between 0.26 per cent in Profile IV and 0.15 per cent in the forest profile. This trend is maintained in the fourth layer also. The highest amount of K_2O (0.15 per cent) is noticed in Profile IV and the lowest (0.09 per cent) in Profile II in the fourth layer.

Exchangeable K_2O.

Data relating to exchangeable K_2O content of the profiles are given in table V and presented graphically in figure 5.When the exchangeable K_2O content of the top layer is examined, the highest amount (0.016per cent) is found in Profile II and the lowest (0.007 per cent) in Profile IV. This constituent shows a tendency to decrease with increase in the period of deforestation. The values obtained for exchangeable K_2O in the second layer are generally lower than those of the first layer, except in Profile IV where there is a slight increase. The highest value (0.012per cent) is obtained for Profile II and the lowest (0.006 per cent) for Profile I. This trend is being maintained in the third layer as well, the highest value obtained being in Profile IV. The lowest value in Profile I (0.004 per cent) gradually increases with increase in the period of deforestation, reaching the maximum value of 0.015per cent in Profile IV. In Profiles I and II the exchangeable K_2O of the third layer is lower than that of the second layer but higher values are obtained for Profiles III and IV. In all the profiles except Profile IV the exchangeable K_2O content is lowest in the fourth layer. The highest value (0.013per cent) is observed in Profile IV and lowest (0.004 per cent) in Profile I. The values are found to increase with increase

TABLE V.

Effect of deforestation on the Exchangeable Potash content of soils.

(Expressed as per cent on oven dry basis)

Locality	Depth (cm.)	Profile I (forest area)	Profile II (5 years after deforestation)	Profile III (10 years after deforestation)	Profile IV (15 years after deforestation)
I. Chalakudi	0-20	0.008	0.016	0.013	0.007
	20-40	0.006	0.012	0.010	0.011
	40-80	0.004	0.009	0.014	0.015
	80-120	0.004	0.007	0.009	0.013
II. Palode	0-20	0.009	0.018	0.016	0.009
	20-40	0.007	0.020	0.019	0.014
	40-80	0.007	0.012	0.014	0.020
	80-120	0.005	0.009	0.011	0.015

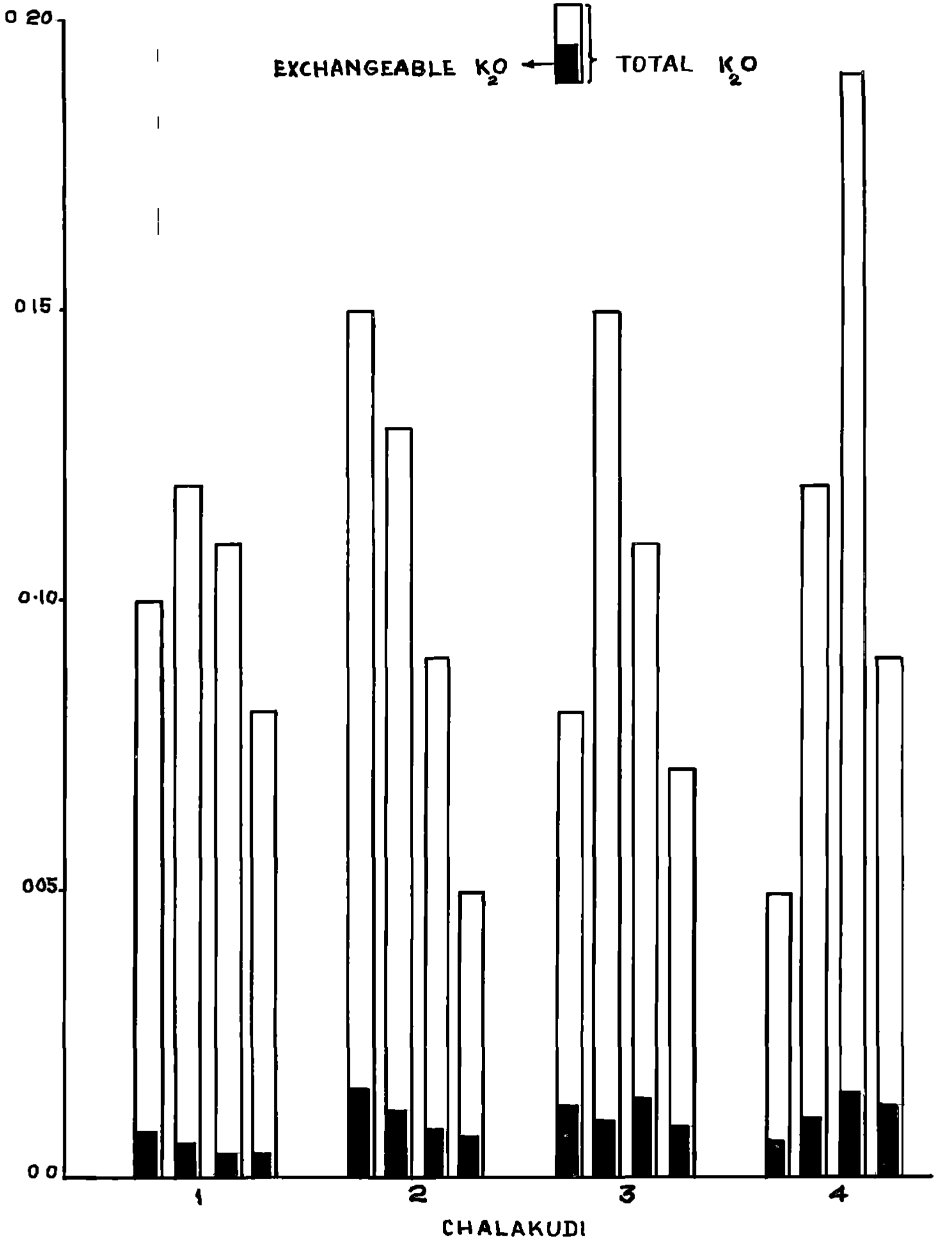

FIG 4 EFFECT OF DEFORESTATION ON THE TOTAL AND EXCHANGEABLE K_2O CONTENT OF SOILS

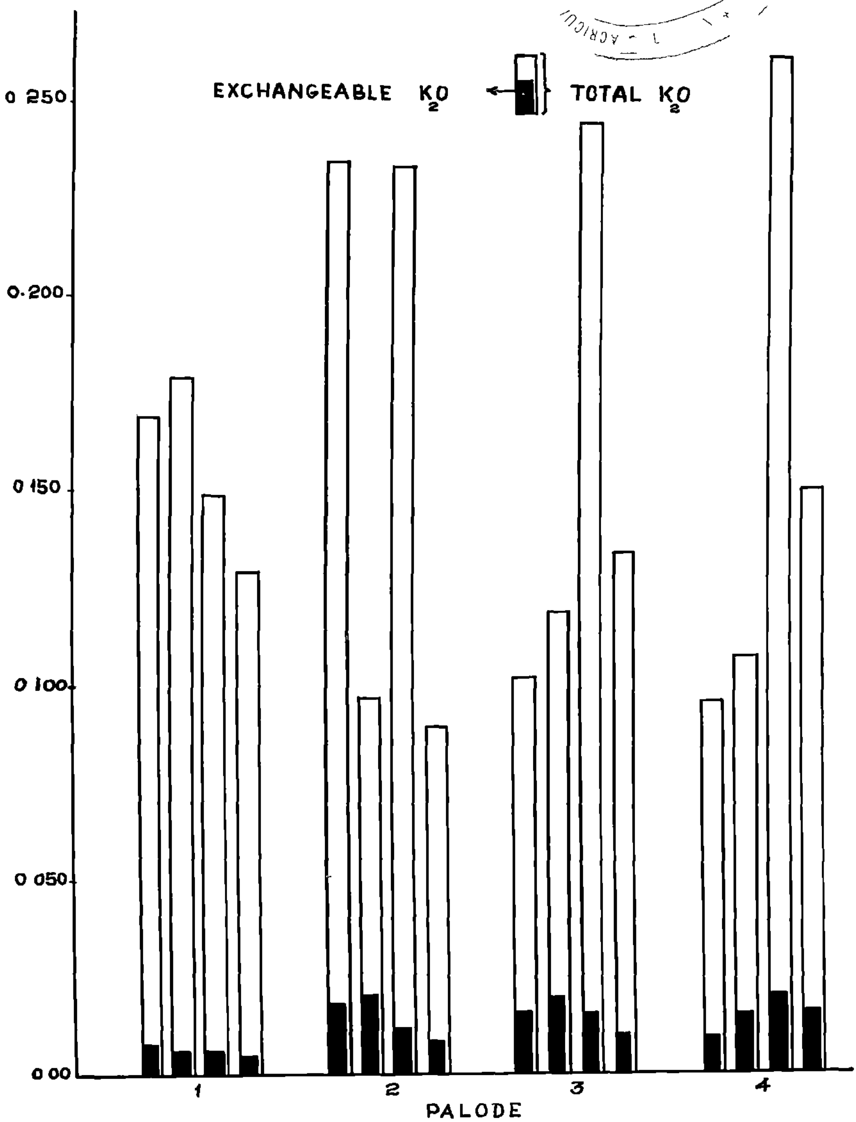

FIG 5 EFFECT OF DEFORESTATION ON THE TOTAL AND EXCHANGEABLE K_2O CONTENT OF SOILS.

in the period of deforestation. In the top layer of the Palode profiles the maximum value for exchangeable K_2O is in Profile II (0.01 per cent) and lowest (0.009 per cent) in Profile IV. A tendency for this constituent to decrease with increase in the period of deforestation is also observed. The exchangeable K_2O content is found to be higher in the second layer of all the profiles except Profile I, where it shows a slight decrease, compared to the top layer. The highest value is obtained in Profile II (0.02 per cent) and the lowest in Profile I (0.007 per cent). In the third layer, the exchangeable K_2O content is observed to the s till lower in all profiles except IV where an increase in its content is noted. The highest value is obtained in Profile IV (0.02 per cent) and the lowest in Profile I (0.007 per cent). The exchangeable K_2O, content is found to increase with increase in the period of deforestation. The amount of exchangeable K_2O in the fourth layer is seen to be lowest in all the profiles except IV in which it is higher than in the first two layers. The lowest value in Profile I (0.005 per cent) shows gradual increase with increasing periods of deforestation and reaches the maximum value (0.1 per cent) in Profile IV.

DISCUSSION

DISCUSSION

The results of the present investigation reveal significant differences in the carbon, nitrogen and potash status of soils developed under two major types of tropical forest soils, viz., the moist evergreen and the moist deciduous. Palode soils which have developed under a deciduous type of vegetation contain substantially higher amounts of these elements as compared to the soils of Chalakudi formed under evergreen vegetation. Though it is not known how far factors like the composition of the parent material have contributed to the difference in the potash status of the two soils, the higher carbon and nitrogen contents of Palode soils may be attributed to the frequent addition of forest litter in the form of fallen leaves in the deciduous forests of this area. The nutrient cycle involving the removal of plant food elements from the lower layers of the soil by roots and their deposition on the surface through leaves should also be rather active in the Palode profiles which would explain the higher amounts of potash in these soils.

In spite of the general difference in the level of organic matter and potash in the Chalakudi and Palode soils there is considerable similarity in the nature of their distribution down the profiles in both the soils.

As might be expected the level of carbon and nitrogen is highest in the surface layers and it decreases rapidly with depth in all the profiles. However, the downward decrease is more gradual in the Palode profiles than in the Chalakudi soils. This would indicate better incorporation of organic matter into the lower layers of the soils developed under a deciduous vegetation than in the soils formed under the influence of an evergreen vegetation. Though the limited amount of data obtained in the present study and do not permit assigning an explanation for this phenomenon, it may, however, be indicated that conditions are more favourable in the deciduous forests for accelerated percolation and enhanced incorporation of organic matter into the lower layers.

The C/N ratio varies between wide limits (7.38-24.5) in these soils which is in agreement with the findings of other workers. (Satyanarayanan <u>et</u>.<u>al</u>. 1946, Yadav and Pathak 1963). The differences in the state of decomposition of organic matter in different layers and the preferential eluviation of mineralised form of nitrogen over carbon would explain this wide variation in C/N ratio. According to Russel (1961) nitrogen which moves down to the lower soil horizions in the form of ammonium ions tends to accumulate there by adsorption in the clay complex which would explain the lower values of C/N ratio in the lower layers of forest profiles.

Nothing very remarkable is observed in the distribution of total and exchangeable potash in the two forest profiles. There is a tendency for the potash content to be low in the surface layer, which might be attributed to the illuvation of this element into the lower horiz ons.

Deforestation is found to influence very markedly the distribution of carbon, nitrogen and potash in the Chalakudi and Palode profiles. The organic matter content is considerably reduced in the c ourse of five years after denudation. This is not only because the denuded forest soils have been deprived of further additions of organic matter in the form of fallen leaves but also because the reserves of this constituent have been rapidly depleted by the enhanced action of atmospheric air and water. As the period after deforestation extends to ten and fifteen years, the organic carbon content in the surface layers is substantially reduced. There is, however, a tendency for the level of carbon in the lower layers to increase with increased period of denudation, which might be attributed to the enhanced percolation of water and leaching down of organic matter.

The effect of deforestation of the potash status of the soils is interesting. The soils denuded for five years contain substantially higher amounts of both total and exchangeable potash. The influence of denudation in increasing the potash content of the soil is prima facie inexplicable, but the situation becomes clear when it is remembered that deforestation is invariably followed by burning of the tree stumps. This practice leads to the addition of substantial amounts of potash to the top soil in the form of ash which results in higher values for both total and exchangeable K_2O. However, appreciable amounts of this potassium are easily lost by percolation and drainage and consequently the soils examined after ten and fifteen years again contain reduced amount of this element in the surface layer. Much of this element dissolved by water is, nevertheless, recovered in the lower horiz ons by illuviation, but a considerable portion is also lost by drainage and erosion.

The data obtained in the present study indicate a general deterioration of the surface soils as a result of deforestation, especially in respect of their organic matter and potash contents. Denudation of tropical forests is reported to hasten the process of laterisation but this problem has not been investigated in this work. There is little doubt that as the soil is denuded by deforestation the action of climatic factors like rainfall and temperature becomes very intense resulting in accelerated erosion and enhanced leaching. It would appear that the adverse effects of deforestation far outweigh any beneficial effects resulting therefrom and hence the necessity for proceeding cautiously with the programme of deforestation.

SUMMARY AND CONCLUSIONS

SUMMARY AND CONCLUSION

A study was made of the effects of deforestation on the content of organic carbon, nitrogen, C/N ratio and the total and exchangeablepotassium of the soils of two major forest areas of Kerala, viz., Chalakudi and Palode, which represent the moist ever green and moist deciduous type of vegetation respectively. Four profiles were studied from each of the centres, one from the standing forest and others from areas denuded for 5, 10 and 15 years. The main findings are as follows.

1. The levels of organic carbon, nitrogen and total and available potassium in the soil profiles from Palode were considerably higher than those of the profiles from Chalakudi.

2. Both organic carbon and nitrogen decreased steadily with depth in all the profiles. The downward incorporation of organic matter was more in Palode soils than in the soils from Chalakudi.

3. The C/N ratio varied within wide limits (7.38-24.5) and tended to decrease with depth indicating a preferential downward movement of nitrogen over carbon.

4. The organic matter in the surface layer was reduced substantially with increase in the period of denudation. The level of this constituent tended to increase in the lower layers after deforestation, presumably due to enhanced leaching.

5. Soils denuded for five years contained higher amounts of total and exchangeable potassium than the forest soils. This might be attributed to the addition of this element in the form of ash as a result of burning of the tree stumps.

6. In the profiles denuded for 10 and 15 years there was considerable reduction in the amounts of total and exchangeable potassium in the surface layer. An increase in the potash content of the lower horizions of these soils showed that there was enhanced downward movement of this element consequent on denudation.

The effects of denudation on the organic carbon, nitrogen and total and exchangeable potassium of soils as revealed by the present study indicate the necessity of proceeding cautiously with the schemes of deforestation and afforestation.

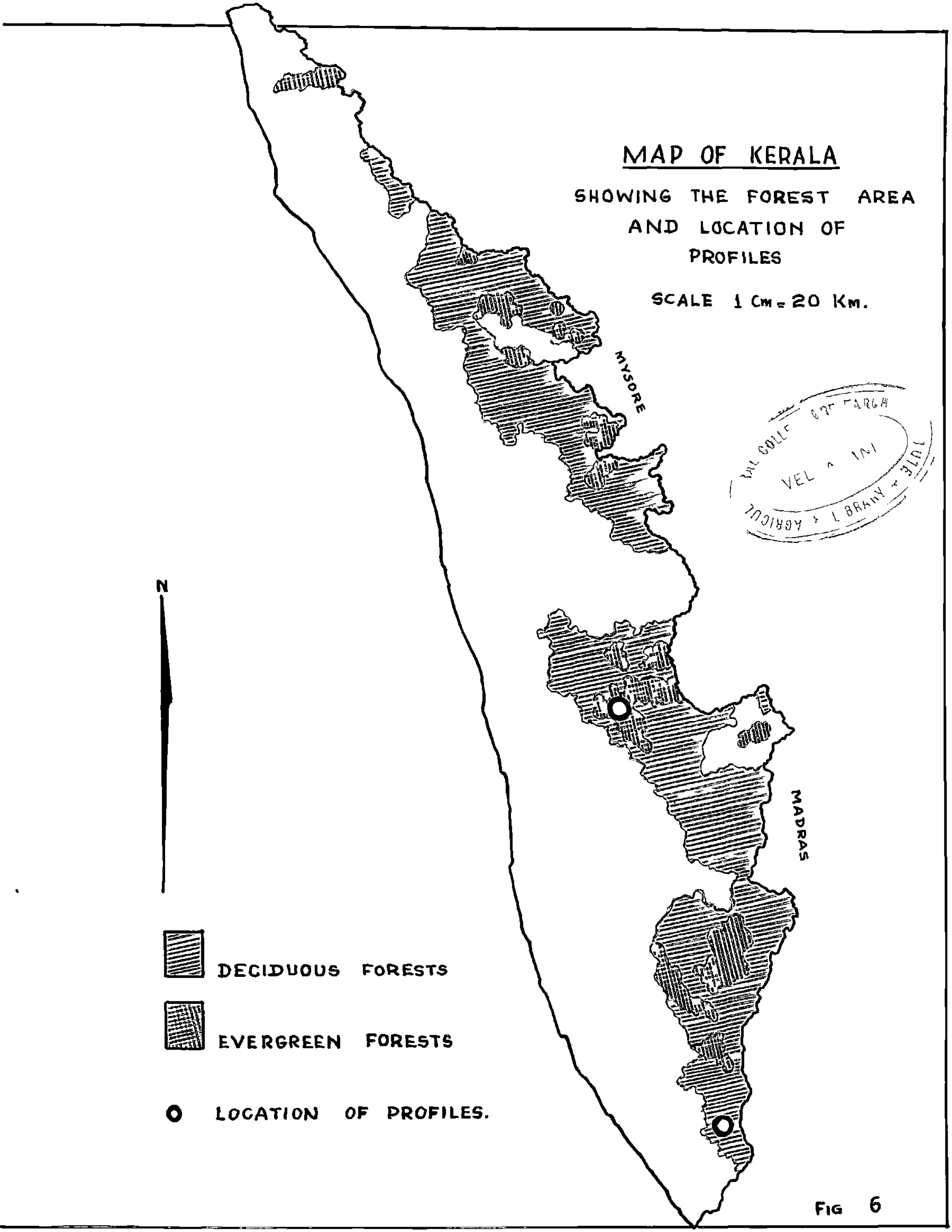
MAP OF KERALA
SHOWING THE FOREST AREA AND LOCATION OF PROFILES
SCALE 1 Cm = 20 Km.
N
MYSORE
MADRAS
DECIDUOUS FORESTS
EVERGREEN FORESTS
LOCATION OF PROFILES.

FIG 6

A P P E N D I X

I

PARTICULARS OF PROFILE SITES

State:	...	Kerala
District:	...	Trichur
Locality:	...	Chalakudi
Elevation:	...	345 Mt.
Rainfall:	...	2685.7 mm.
Relief:	...	Undulating.
Vegetation:	...	Moist evergreen.

II

PARTICULARS OF PROFILE SITES

State:	..	Kerala
District:	..	Trivandrum
Locality:	..	Palode
Elevation:	..	285 Mt.
Rainfall:	..	2004 mm.
Relief:	..	Undulating
Vegetation:	..	Moist deciduous.

III

Average monthly rainfall in mm. in the regions from where the soil samples were collected.

Month.	Chalakudi	Palode
January	5.4	16.6
February	16.5	33.9
March	49.8	37.6
April	30.7	172.2
May	160.8	310.1
June	560.0	342.5
July	706.8	266.9
August	600.7	112.4
September	172.7	147.0
October	246.6	305.1
November	63.2	206.1
December	44.5	53.7
ANNUAL	2658.7	2004.1

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