Studies on the Effect of Deforestation on Organic Carbon, Nitrogen and the Potash Status of some Forest soils of Kerala

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Received for publication August 8, 1966

In Kerala forests occupy a total area of about 10,640 sq. km representing approximately 27.5 per cent of the total land surface. Depending on variations in temperature, rainfall and elevation different kinds of forests are fouud, the tropical evergreen and the moist deciduous types predominating. The former type is found at elevations ranging from 240-1050 m with an average rainfall of about 200-350 cm. The other type is found in regions of lower elevation and rainfall, viz., at altitudes of 150-400 m and rainfall 150-200 cm. Much of the forest area is being denuded year after year both in a systematic and haphazard way, primarily to meet the demands of an increasing population, both for cultivation and habitation. The indiscriminate and unscientific ways of deforestation followed by intensive cultivation have given rise to various soil fertility and management problems in areas thus denuded. It has, been reported that the growth of trees in teak plantations raised after deforestation is adversely affected by an accelerated process of laterisation. Other changes that may take place in the soil as a result of deforestation are in the organic matter, nitrogen and potash status of soils, as these are subject to loss by drainage and erosion. The investigations of Trimble and Tripp (1949), Shibata *et al* (1951) and Dryness and Youngberg (1957) indicate that denudation results in the destruction of organic matter in soils. However, the studies carried out by Hatch (1957) in Australia revealed that controlled burning at temperatures below 450° C had no effect on the organic carbon and nitrogen contents of *Eucaliptus* forest soils. There is also evidence to show that deforestation may be followed by an increase in soil humus content and the easily hydrolysable nitrogen (Siviridova, 1960). In Kerala

* **Condensed** from the thesis submitted by J. I. Mitra Chaly in partial fulfilment of the requirements for the M. Sc. (Agri) degree of the University of Kerala. Published by kind permission of the University of Kerala, Trivandrum.

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Thomas (1964) observed that both organic matter and nitrogen had been leached down to greater depths in deforested areas as compared to forest lands. The downward movement of nitrogen was more than that of organic carbon, and he attributed the lower C/N ratio of the subsoils of the deforested lands to the greater penetration nitrogen to the lower horizons. An increase in the availability of the bases has been reported by Fuller (1955) and Nye and Greenland (1964) consequent on denudation. However, Thomas (1964) observed no serious depiction of the plant nutrient elements in the course of two years after deforestation. The present investigation was undertaken with a view to studying systematically the effects of deforestation on the content of organic carbon, nitrogen and potassium in the soils of this State.

Materials and Methods

Soil profiles were collected from two major forest areas, Chalakudi and Palode, representing the moist evergreen and deciduous types of vegetation respectively. From each of these centres four profiles were taken, one from the standing forest and the others from areas denuded for 5, 10 and 15 years. These are referred to as profiles I, II, III, and IV respectively. For the collection of the soil samples pits were dug to a depth of 120 cm in each of the selected sites and soils collected from depths of 0-20, 20-40, 40-80 and 80-120 cm. From each layer 2 kg soil was collected, air-dried, passed through a 2 mm sieve and stored in glass bottles. Organic carbon, nitrogen and total and available potassium in these samples were determined by standard analytical methods.

Results

1. *Organic carbon*

The data relating to the variation in the organic carbon content with depth in the different profiles are given in Table I and presented graphically in Fig. 1. Among the profiles from Chalakudi the highest value for organic carbon is obtained in the surface layer of the soil from the forest area. With increase in the depth of profile and with period of denudation the organic carbon content tends to decrease. The Palode profiles contain generally much higher values of organic carbon, but they too exhibit the tendency for decrease in the level of this element with depth and period of denudation.

2. *Nitrogen*

The variation in the nitrogen content of soils with increasing periods of deforestation in the different profiles is given in Table II and presented graphically in Fig. 2. Among the profiles from Chalakudi the highest amount of this element is present in the surface layer from the forest area. With increase in the period of denudation the nitrogen content of the top layer decreases and reaches a minimum value in the profile exposed for 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.

All the profiles from Palode record relatively higher values for nitrogen. In these soils also the level of this element decreases with increase in the period of deforestation. An examination of the nitrogen content of the top layers reveals that

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 defore-station)	Profile III (10 years after defore-station)	Profile IV (15 years after defore-station)
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

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 defore-station)	Profile III (10 years after defore-station)	Profile IV (15 years after defore-station)
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

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

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

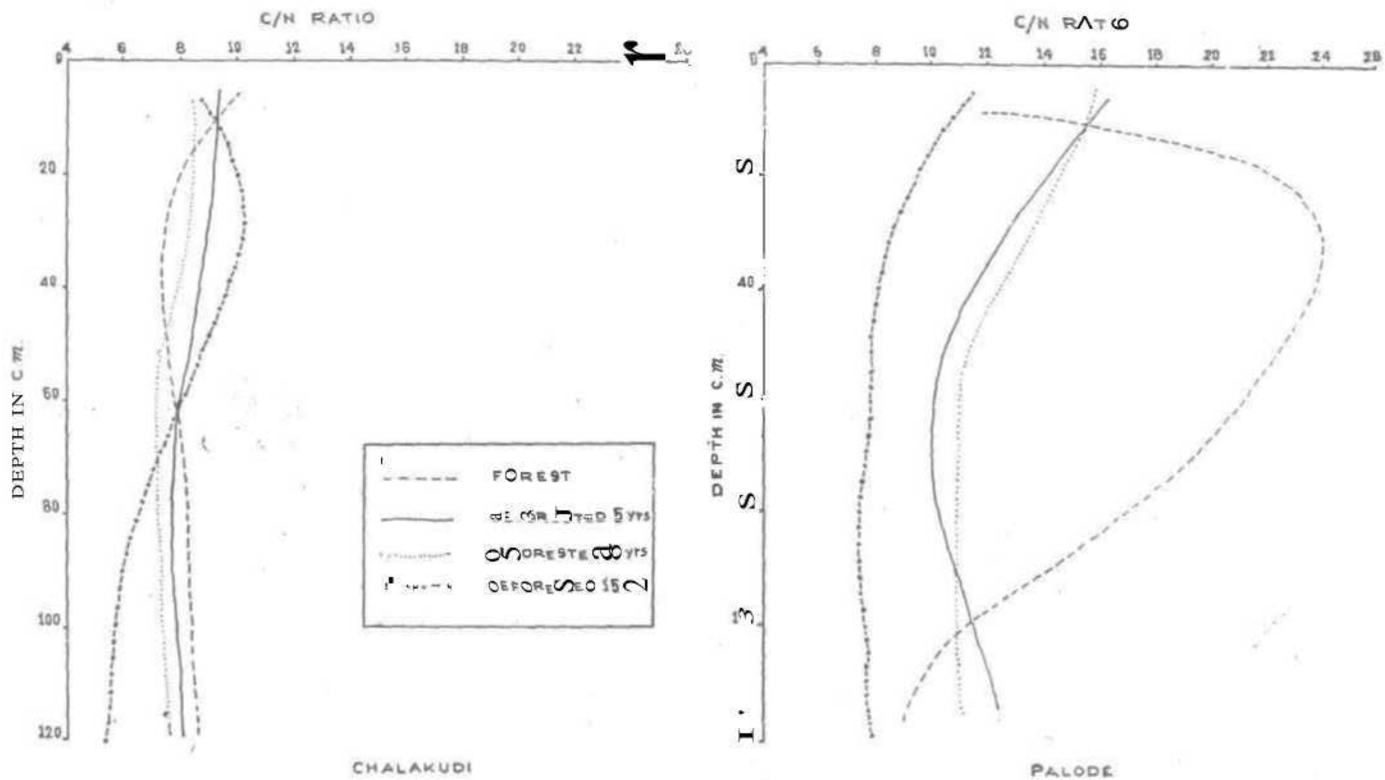

Fig. 3. Variation in the C/N ratio with depth in different profiles.

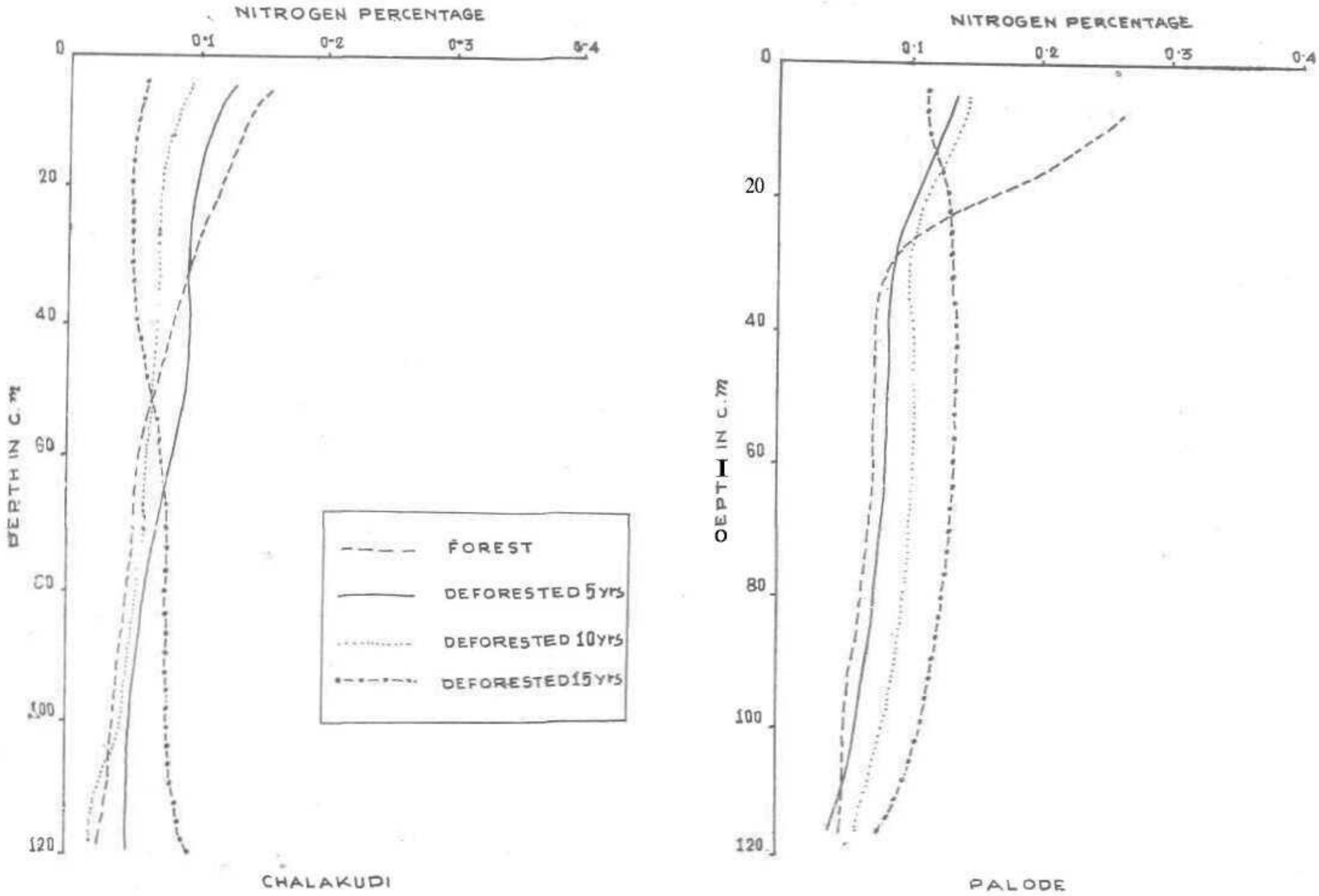

Fig. 2. Variation in the nitrogen content with depth in different profiles.

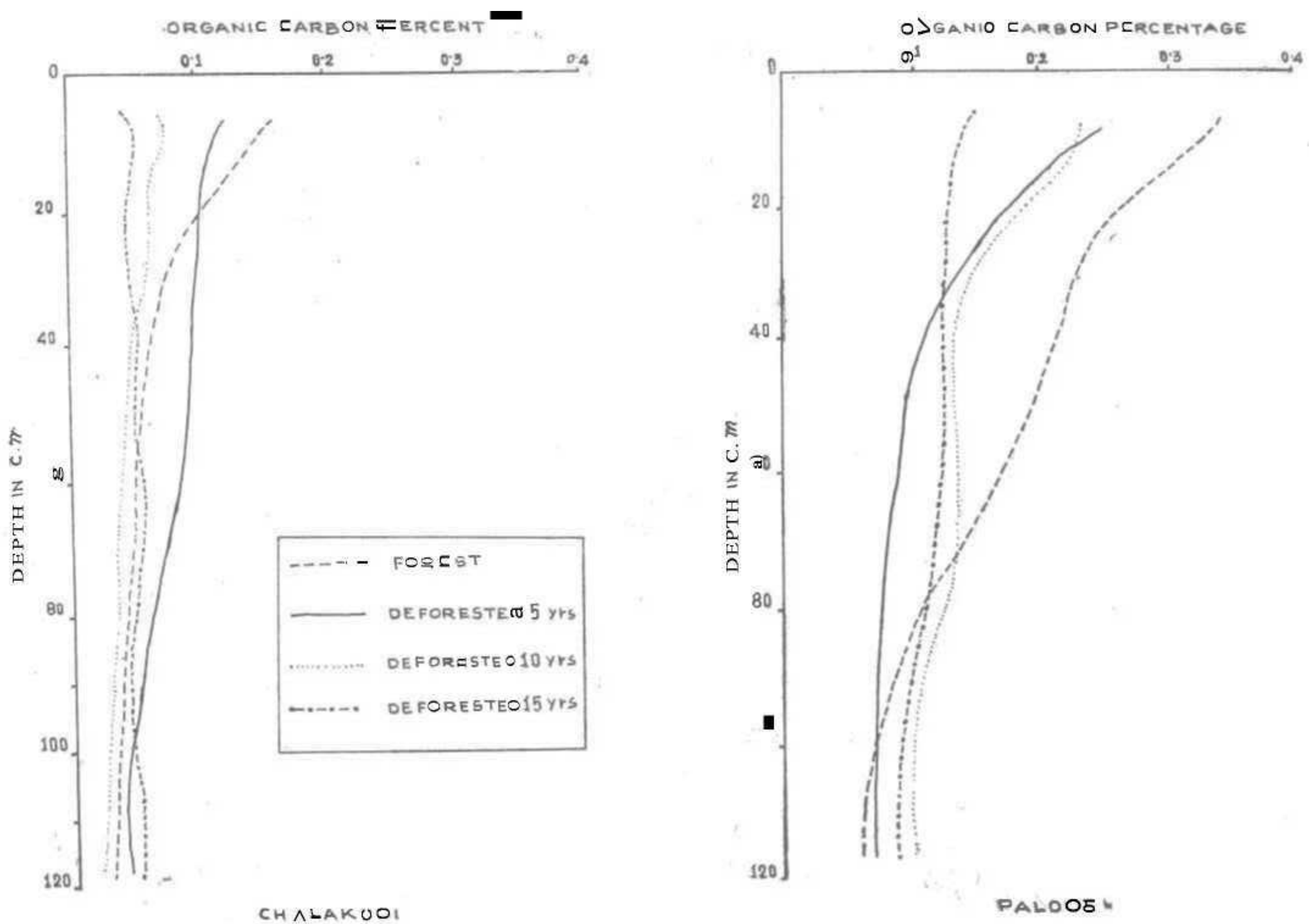

Fig. 1. Variation in the organic carbon oo[redacted]t with depth in different profiles.

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 defore-station)	Profile III (10 years (after defore-station)	Profile IV (15 years (after defore-station)
1. Chalakudi	0-20	0.008	0.016	0013	0.007
	20-40	0.006	0.012	0.010	0.011
	40-80	0.004	0. 09	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

the maximum amount is present in the forest profile which decreases and reaches a minimum value in Profile IV (15 years). The variation in the nitrogen content with increase in the period of denudation does not show any regular trend in the lower layers.

3. *C/N ratio*

The C/N ratios of the different profiles are presented in Table III and their variation presented graphically in Fig. 3. This ratio generally shows a tendency to decrease with depth in the profiles from Chalakudi. A decrease is also observed with increase in the period of deforestation. In the top layer the highest value for the C/N ratio (9.47) is seen in the forest profile and lowest (8.62) in profile III (10 years of denudation). The forest and deforested soils of Palode reveal a regular decrease in the C/N ratio with increase in the period of deforestation in all the layers except the top. A general tendency for decrease in the values of the C/N ratio down the profile is also noted, the exception being only in the case of the second and third layers of profile I. The highest C/N ratio (15.81) in the top layer is in profile II (5 years after deforestation) and the lowest (11.25) in profile IV (15 years after deforestation).

4. *Total potassium*

The distribution of total K_2O in the different profiles is given in Table IV. From the data it is seen that the potash status of Palode soils is considerably higher than that of Chalakudi soils. A general tendency for an increasing potash status down the profile is also observed. When the total K_2O content of the top layers of all the profiles from Chalakudi is considered the maximum value is found in profile II

(5 years) which gets appreciably reduced with increase in the period of deforestation, reaching a minimum in profile IV (15 years). The Palode soils have recorded considerably higher values for total K_2O in all the profiles studied. The highest value for the surface layer is in profile II and the lowest in profile IV. 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.

5. *Exchangeable potassium*

Data relating to the exchangeable K_2O content of the profiles are given in Table V. The highest level of exchangeable K_2O in the top layers of Chalakudi soils is found in profile II (5 years of deforestation) and the lowest in profile IV (15 years of deforestation). This constitutent shows a tendency to decrease with increase in the period of denudation. In the Palode soils also the maximum value for exchangeable K_2O in the surface layer is found in profile II and the lowest in profile IV. With increase in the period of deforestation the level of exchangeable K_2O tends to decrease.

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 forests, viz., the tropical 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 theirf distribution down the profile in both the soils. As might be expected, the level o 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 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 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

(Satyanarayana *et al*, 1946 ; Yadav, 1963). The differences in the state of decomposition of organic matter in different layers and the preferential eluviation of mineralised form of nitrogen over corbon would explain this wide variation in the C/N ratio. According to Russel (1961) nitrogen, which moves down to the lower soil horizons in the form of ammonium ions tends to accumulate there by adsorption on the clay complex, which would explain the lower values of the C/N ratio in the lower layers of the 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 illuviation of this element into the lower horizons.

Deforestation is found to influence very markedly the distribution of carbon, nitrogen and potash in the profiles studied. The organic matter content is reduced considerably in the course 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 constitutent are rapidly depleted by the enhanced action of atmospheric air and water. As the period after deforestation extends to ten and fifteen years the organic matter 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 the leaching down of organic matter.

The effect of deforestation on the potash status of 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 considered 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 amounts of this element in the surface layer. Much of this element dissolved by water is, nevertheless, recovered in the lower horizons 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 the present 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 effect resulting therefrom and hence the necessity for proceeding cautiously with the programme of deforestation.

Summary and Conclusions

A study was made of the effect of deforestation on the contents of organic carbon,

nitrogen, C/N ratio and the total and exchangeable potassium of the soils of two major forest areas of Kerala, viz., Chalakudi and Palode, which represent the tropical evergreen and moist deciduous types of vegetation respectively. Four profiles were studied from each of these centres, one from the standing forest and others from areas denuded for 5, 10 and 15 years. The main findings were 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 (7.38-24.50) and tended to decrease with depth, indicating a preferential down, ward 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 layers. An increase in the potash content of the lower horizons 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.

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