IMPACT OF EUCALYPTUS AND ACACIA PLANTATIONS ON SOIL PROPERTIES IN DIFFERENT PEDOGENIC ENVIRONMENTS IN KERALA

BY

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THESIS

submitted in partial fulfilment of the

requirement for the degree

MASTER OF SCIENCE IN AGRICULTURE

Faculty of Agriculture

Kerala Agricultural University

DEPARTMENT OF SOIL SCIENCE AND AGRICULTURAL CHEMISTRY

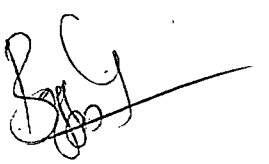
COLLEGE OF AGRICULTURE

VELLAYANI - TRIVANDRUM

1989

DECLARATION

I hereby declare that this thesis entitled "Impact of Eucalyptus and Acacia plantations on soil properties in different pedogenic environments in Kerala" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.



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ACKNOWLEDGEMENT

The author wishes to acknowledge and express his heartfelt gratitude and indebtedness to

Dr.Thomas Varghese, Professor of Soil Science and Agricultural Chemistry and Chairman of the Advisory Committee for suggesting the problem and for his sustained enthusiastic interest, unstinted help, inspiring guidance and constructive criticisms in the conduct of the present investigations and preparation of the thesis.

The author also expresses his deep sense of gratitude to:

Sri.K.Babukutty, Associate Professor of Soil Science and Agricultural Chemistry for his keen interest evinced in this work and for offering constructive criticisms;

Dr.N.Saifudeen, Associate Professor of Soil Science and Agricultural Chemistry,N.A.R.P(SR), Vellayani for his critical suggestions all through these investigations and for providing the necessary facilities to analyse the samples in the Central Analytical Laboratory, N.A.R.P.(SR),Vellayani;

Dr.Lekha Sreekantan, Assistant Professor of Agronomy, College of Agriculture, Vellayani for her interest in this work and for helpful criticisms;

Sri.M.Sivarajan, Principal Chief Conservator of Forests and Sri.S.Chand Bhasha, Chief Conservator of Forests(Social Forestry and Projects), Kerala for permitting to collect soil and plant samples from different locations;

Sri.P.T.Mathew, Deputy Director of Soil Survey, Directora of Soil Conservation, Trivandrum for his keen interest in this work and for his valuable suggestions for taking profile pits and describing profile morphology;

CERTIFICATE

Certified that this thesis, entitled "Impact of Eucalyptus and Acacia plantations on soil properties in different pedogenic environments in Kerala" is a record of research work done independently by Shri G. BYJU under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to him.

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23/9/85

Sri P.K.Uthaman, an Environmentalist; Sri.N.Badusha, Secretary, Wynad Prakriti Samrakshana Samiti and other members of Wynad Prakriti Samrakshana Samiti for their valuable help in the collection of samples from Wynad forest;

Sri.M.K.Ravikrishnan, P.G.Student of Agronomy for his help in taking photographs and drawing the diagrams;

Sri.Sam Mathew; Sri.S.Prem Kumar; Ms Susan John, K and Ms Jaya V; P.G. students of Soil Science & Agricultural Chemistry for their help and co-operation throughout the course of investigation;

And to his parents, brother and sister for their consistent prayers, unfailing inspiration and sincere encouragement at every stage of his study.

Finally the author likes to place on record the valuable co-operation rendered by the field staff of the Department of Forests, Kerala and also the Adivasi labourer of Wynad and Kottoor in the collection of profile samples from difficult forest areas.

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INTRODUCTION

INTRODUCTION

The fertility of soil undisturbed by man is its capacity to support the climax population of plants and animals above ground, and the associated flora and fauna below ground. In a natural forest ecosystem this equilibrium once attained, will continue to be the same unless it is subject to the intervention of man or through natural calamities. However, in agriculture and social forestry we destroy the natural association of plants and animals that make soil their home and remove a portion of the products of plant growth, as yield of grain, fruits, fodder timber or roots.

The inevitable result of this intervention with the natural ecosystem is to diminish natural fertility, because portions of absorbed plant nutrients and the organic compounds synthesised with the aid of solar energy, carbon dioxide and water are removed. In an undisturbed biotic environment these would be returned to the soil by means of organic recycling and the soil fertility is maintained or even enriched.

Under the joint crisis of unsatisfied basic needs and ecological instability, the rebuilding of India's forest wealth has, in recent years, become one of the major issues in land-use policy and has provided a new paradigm

for development through social forestry; the strategy being to regenerate forest resources through the participation of the community in the protection and management of forests for ecological rehabilitation and basic needs satisfaction.

The programme of National Social Forestry is aimed at building the forest stocks in two ways. Firstly, it is expected to provide resources to satisfy the basic needs of the population through the creation and regeneration of tree wealth within human settlements. Secondly, it serves as a mechanism for reducing the pressures which are at present destroying the reserved forests.

Under the National Social Forestry Programme which is being implemented in a massive way, two exotic tree species viz. Eucalyptus and Acacia have been introduced since early seventees in many states of India. Out of the 600 species of Eucalyptus which are natives of Australia, only a dozen species are extensively planted in India.

In Kerala, Eucalyptus tereticornis forms the chief species in the plains and E. grandis is the predominant one planted in higher elevations. It is estimated that 40,000 ha in Kerala have been planted with Eucalyptus spp; the major portion falling in the forest lands of the Western Ghat region.

Out of the 1200 existing species of Acacia, many are indigenous to India. The predominant one that has been chosen under social forestry is Acacia auriculiformis which is endemic to Australia.

Eucalyptus tereticornis and Acacia auriculiformis have many qualities which qualify them for inclusion under the National Social Forestry Programme. These fast growing tree species have the unique capability of surviving and regulating their growth to prevailing growth factors and are found to survive from hostile atmosphere of 200 mm rainfall in desert zone to highly wetland ecosystem of 4000 mm and from seashore to 3000 m altitude. Both the species are not browsed and hence can survive without protection from grazing animals and also come up without irrigation in rural environment in all soil types.

The cardinal objectives of National Social Forestry programme in India proclaim to popularise trees which will yield food, fuel, fodder and timber to alleviate the problems of the rural poor and give a boost to rural economy and will go a long way in protecting the soil and water resources and building up a better lush green environment in the rural landscape.

In this context, it becomes highly relevant to examine how far the above objectives can be achieved by planting extensive areas of our garden lands and forest areas with the exotic species of Eucalyptus tereticornis and Acacia auriculiformis. Environmentalists in India and abroad have questioned the feasibility of bringing fertile lands under these exotic species which they claim to have deleterious impact on soil properties, hydrological parameters, biotic associations and long-term socio-economic consequences. It is also argued that these exotic species are prone to the production of allelochemicals which have an inhibitory effect on the undergrowth in the plantations.

However, the arguments put forward in favour of and against the planting of Eucalyptus and Acacia in Kerala's environment do not have a sound scientific basis due to lack of sufficient research data base. Hence, with a view to acquire factual information on the impact of these plantations, the present study is envisaged with its major thrust on their impact on soil properties under different pedogenic environments in Kerala State.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Impact of Eucalyptus and Acacia plantations on soil properties is a subject of controversy among soil scientists. The question of Eucalyptus and Acacia plantations is one that arouses strong feelings, both for and against; and the arguments used by both the opponents and the supporters of Eucalyptus and Acacia have often been based more on prejudice than on a balanced consideration of facts. Excellent research results are available in literature on certain aspects of the impact of Eucalyptus and Acacia plantations on soil properties.

1. Impact of Eucalyptus plantations on soil properties.

1.1. Physical characteristics and Water Relationships.

A number of research results are available on the effect of Eucalyptus on soil physical properties and moisture relationships. Investigations carried out in Israel have shown that interception of rainfall by a 7-year old plantation of Eucalyptus camaldulensis as compared to an open area range from 14.3 to 14.9 per cent; the figures for throughfall and stemflow causing moisture recharge being 80.1 to 82.4 per cent and 3.4 to 5.0 per cent respectively (Heth and Karschon, 1963).

Studies in relation to the recharge of soils and aquifers have been made by Karschon and Heth (1967) in the Central coastal plain of Israel. A comparison was made

between a plantation of E. camaldulensis (11 m high) and open ground; both sites were level. The Eucalyptus made use of all the water available to it. During the wet season evapotranspiration was proportional to evaporation from a pan of open water, but was sharply curtailed in the dry season. It is presumed that if the trees had access to groundwater, they would have continued to transpire at a high rate.

Studies of Dabral (1970) on the potential evapotranspiration of different forest species in the juvenile stage have shown highest water consumption by E. citriodora (5526 mm of water per seedling) though biomass per litre of water consumed was also the highest. The annual transpiration rate of E. globulus (Thomas et al. 1972) was reported to be about 3475 t ha^{-1} corresponding to 34.75 cm of rainfall.

The hydrological cycle associated with trees has been given by Anon(1978) as:

$$P = ETR + R + D + S \quad \text{where,}$$

P = Precipitation

ETR = Evapotranspiration

R = Run-off

D = Infiltration and percolation

S = Change in Soil Moisture

Species naturally occurring in an ecosystem have evapotranspiration rates which maintain the hydrological

cycle and water balance. Their morphology and physiology are adapted to the most effective utilisation of the available precipitation.

Bara Temes (1981) in a study on the effects of Eucalyptus on physical and chemical composition of soil indicated that Eucalyptus silviculture had not led to soil degradation or depletion of nutrient reserves.

The hydrological impact of Eucalyptus on water resources has been systematically studied by the hydrological division of the CSIRO in Australia (Sharma, 1984). A long-term experiment established that during years with precipitation less than 1000 mm, deficits in soil moisture and groundwater were created by Eucalyptus. A permanent water deficit was avoided by significantly high rainfall of 1477 mm in one of the five years studied.

In a study on the physical properties of soils in relation to Eucalyptus growth in Kondazhi and Muthanga areas of Kerala, Alexander and Thomas (1985) concluded that gravel, sand and water holding capacity were the characteristics which stand out among the physical properties and these factors influence the height growth of Eucalyptus.

Dabral and Raturi (1985) in a study on the water consumption by Eucalyptus hybrid in U.P., India observed significant depletion of stored soil water and the consumption was highest during rains and lowest during the summer. It was estimated that, for above-ground biomass, 167 mm of

water were required to produce 1 kg dry weight.

A study was undertaken by Samra et al (1985) of the variable growth rate of E. tereticornis plantations in Tarai Central division, U.P., India in a contiguous area with identical climate and rainfall but with varying soil conditions. Best growth was observed in those areas with high moisture content, near absence of gravel and pebbles and high clay content.

The native occurrence of E. tereticornis is along the well watered eastern coast of Australia with good rainfall. In its native habitat in Australia, E. tereticornis is not found to occur in the dry regions of Central Australi mainland. This provides an indication that Eucalyptus hybrid is suitable only for the humid and semi-humid zones (Shiva, Vandana and Bandyopadhyay, 1985).

Francis et al.(1986) in a study on hydrological investigations on blue gum (E. globulus) revealed no adverse effect of blue gum on hydrological cycle in Nilgiris. They also observed no adverse effect on local groundwater and soil moisture regime and water quality.

Gupta (1986) observed that the role of Eucalyptus on soil and water conservation is inferior to the indigenous species, though for meeting the shot-term needs of fuel and as an industrial raw material it could find a suitable place in the production forestry programme.

Ramachandran and Kumari (1986) in a study on the use of Eucalyptus for prevention of slumping of over burden soil along valleys in Idukki reservoir area, Kerala suggested that increase in soil moisture content and rise in the groundwater table cause slope instability and they recommended planting of Eucalyptus with a high capacity for water intake.

Soil water extraction by a mixed Eucalyptus forest in South-east Australia was studied by Talsma and Gardner (1986). Eucalyptus trees growing on deep soils, with a water table at about 8 m depth showed no apparent drought effects during dry period when gross precipitation was only 388 mm. At the end of the drought, soil water to 4 m depth was depleted to a soil water potential of -0.5 M Pa and under these conditions unsaturated flow from the water table to the lower rootzone was calculated to be 0.17 mm day^{-1}.

Reynolds *et al.*(1988) in a study on the water table under Eucalyptus hybrid monoculture by resistivity method demonstrated little direct abstraction by the trees from water table deeper than 1.5 m.

1.2 Chemical characteristics

In pristine ecosystems, most of the nutrients are bound inliving and dead biomass present at the sites in tight cycles. The balance in the natural climax forest is disturbed when

the forest is removed and the soil exposed to the influence of environmental factors. Following clearence and subsequent cultivation, a loss of 9 per cent organic matter per annum was observed by Kowal and Tinker (1959).

Investigations of Hart (1961) have shown that due to deforestation there was a decrease in organic carbon and nitrogen content of soils. Weert and Linselink (1972) also agreed with the observations of Hart (1961). Yadav et al. (1973) examined a 5-year old plantation of Eucalyptus sp. at Asarori, U.P., India. They reported a movement downwards of calcium and of the finer soil particles, a fall in pH, magnesium, total phosphorus, potassium and available phosphorus and a rise in available potassium.

Significant decrease in organic matter content as compared to that occurring under natural sal has been observed when Eucalyptus was raised in natural sal zone (Singhal et al. 1975). In Kerala, Thomas (1964) had reported leaching of organic cabon and nitrogen to greater depths in deforested areas compared to forest.

In a study on the properties of soils under Eucalyptus in the Munnar, Vazhachal, Trichur and Wynad forest divisions of Kerala, Alexander et al. (1981) reported relatively higher levels of organic carbon and cation exchange capacity indicating the generally high fertility of soils under Eucalyptus.

A study on the litter production and nutrient return in Eucalyptus hybrid plantations of 5, 7 and 10 years old was done by George (1982). Total litter production was respectively 3377, 3801 and 6207 kg ha^{-1} (1133-1167 trees ha^{-1}). Most of the nutrients were released through leaf litter and the least through bark.

Balagopalan and Alexander (1983) reported that soils of Eucalyptus plantations at Kadassery, Kerala had a relatively lower content of organic carbon than that of natural forests. Return of nutrients by leaf litter of blue gum plantations in Nilgiris was investigated by Venkataraman *et al.* (1983) and reported that *E. globulus* add annually 1935 kg of litter ha^{-1}. They have also reported that leaf litter of shola contained a higher percentage of nutrients especially nitrogen, phosphorus, calcium and organic matter than that of Eucalyptus.

A comparison of the soil profiles under *E. camaldulensis* and *Shorea robusta* monocultures with natural sal area of Doon Valley was made by Jha and Pande (1984). The area under study had a tropical monsoon climate with a long winter period and a humid monsoon of about 4 months with soil type of typic paleudalfs. Neither of the monocultures had higher values than natural sal for organic matter accumulation, total nitrogen and phosphorus or available nitrogen, phosphorus and potassium. At 14 year, Eucalyptus had a higher organic matter accumulation. They concluded that Eucalyptus monoculture in natural sal areas causes no damage to soil fertility and is superior to sal monoculture.

Nutrient cycle in E. tereticornis plantations was studied by Singh (1984) and observed that Eucalyptus hybrid requires 217 kg nitrogen, 100 kg phosphorus and 1594 kg calcium ha^{-1} $year^{-1}$. He concluded that planting of Eucalyptus hybrid creates nutrient deficits because compared to its high uptake of nutrients, Eucalyptus returns a very small quantity of nutrient to the soil through leaf litter. Its annual return in leaf litter is only 35 kg nitrogen, 14 kg phosphorus and 335 kg calcium ha^{-1} $year^{-1}$. Nutrient status in a Eucalyptus hybrid monoculture was also studied by Kushalappa (1985) who also obtained similar results.

A study was undertaken to find out the distribution of organic carbon and different forms of nitrogen in soils under a natural forest and an adjacent Eucalyptus plantation at Arippa, Kerala by Balagopalan and Jose (1986). They observed that plantation activities enhanced erodibility, decreased organic carbon, total as well as different forms of nitrogen and cation exchange capacity of soils.

Banerjee et al.(1986) studied the characteristics of soils under E.tereticornis in South Bengal and found that the lateritic soils were acidic and poor in organic matter. Clay translocation is common in most profiles. Silica decreased down the profile and alumina content was greater than iron oxide content. Contents of total bases (Calcium, magnesium and potassium) were very low.

Kushalappa (1987), in a study on nutrient status under Mysore gum (E. tereticornis) plantation of ten years near Bangalore reported that there was a general improvement in soil structure and nutrient status.

Poore and Fries (1987) reported that Eucalyptus planted on nitrogen rich peat has been shown to take up large quantities of nitrogen and could be used for reducing eutrophication. The cropping of Eucalyptus on short rotation especially if the whole biomass is taken leads to the rapid depletion of the reserve of nutrients in the soil.

1.3. Biological and Biochemical characteristics.

Del Moral and Muller (1964) were the first to scientifically study allelopathy in Eucalyptus plantations and to analyse this factor as responsible for the absence of herbaceous annuals.

Moral et al.(1978) made a detailed investigation on the suppression of coastal hea th vegetation by E.baxteri. They observed that E. baxteri produced a zone of suppression beneath its canopy when growing on humus podsol soil in coastal hea th. Foliar leachates of E. baxteri were found to be inhibitory in bioassays and contained gentisic and ellagic acids. Litter leachates were also inhibitory in bioassays and contained gentisic, gallic, sinapic, caffeic and ellagic acids. Both leachates also contained several unknown phenolic aglycones,

numerous glycosides and terpenoids. They concluded that the suppression zone was associated with the allelopathic ability of E. baxteri, and was maintained either through the direct transfer of foliar leachates to leaves of suppressed species, through root absorption of foliar and litter leachates, or as a consequence of mycorrhizal inhibition by such leachates.

Kale and Krishnamurthy (1981) had reported that the scanty leaf litter of Eucalyptus was not effectively transformed into decomposed organic matter because of the toxicity of Eucalyptus to soil organisms constituting decomposer-food chains. The earthworms Lanopito mauriti, responsible for decomposition of leaf-litter were found in most dryland agricultural fields of Karnataka. They were, however absent in Eucalyptus plantations. They had attributed this to the presence of chemical repellants in the leaves.

A study was conducted by Rao and Reddy (1984) on the inhibitory effect of Eucalyptus hybrid leaf extracts on the germination of certain food crops. Investigations revealed that the reduction of seed germination due to Eucalyptus was not due to soil moisture, nutrient contents and shading. On the other hand, leaf extracts, decaying leaves and soil collected under Eucalyptus canopies inhibited seed germination and seedling growth of associated species.

Prasad et al.(1985) studied the compatibility of field crops viz. sorghum, greengram and blackgram in kharif season and safflower and taramira in rabi season with E. tereticornis. The results indicated that E. tereticornis tree-line had an adverse effect on yield upto 10 m distance in kharif crops and upto 20 m distance in rabi crops, by competing for soil moisture and providing shade.

Not only is Eucalyptus toxic to the germination of other plants, it is also toxic to soil organisms responsible for building soil fertility and improving soil structure (Shiva, Vandana and Bandyopadhyay, 1985). They also observed that in the semi-arid zones Eucalyptus excludes other plant associates through its high water-nutrient demands and its allelopathic effects. The large nutrient deficits created by Eucalyptus as an exotic species therefore cannot be compensated by the nutrient returns from other species.

Ground flora studies were carried out Eucalyptus hybrid plantations of different ages by Bhaskar and Dasappa (1986). In Eucalyptus plantation, ground flora is found to be more during earlier years of growth whereas it decreased significantly as the plants grew more than 6 years old. The ground flora virtually disappeared in the coppice plantations. In Eucalyptus, profusely branched surface root system seem to hinder the growth of other plant species by competing for water and nutrients.

Gupta (1986) observed that in low rainfall regions at Jodhpur, Eucalyptus roots form a network of feeder roots, just below the soil surface to absorb all the available moisture and does not allow any other plants to grow under it. He attributed it to the growth inhibiting alkaloids present in the leaf of Eucalyptus which remain concentrated in the top soil layers and does not get leached or washed due to low rainfall. In the subhumid climate these alkaloids have a fair chance to get washed off or leached down to lower soil layers thus allowing profuse undergrowth.

2. Impact of Acacia Plantations on Soil properties.

Acacia suriculiformis is a new inotroduction from Australia under the National Social Forestry Programme (Banerjee, 1973) and only little work has been done on the impact of Acacia plantations on soil characteristics.

2.1 Physical characteristics and Water Relationships.

According to Nzindukiyimana and Sabasajya (1977), Acacia decurrens has been used effectively at high altitudes in Rwanda to stabilise hills from erosion.

The ability to withstand a lowering of water table was investigated for Acacia aneura var. latifolia, Casuarina cristata. Eucalyptus clelandii and Eucalyptus latifolia by Shea et al.(1979). The study was undertaken in view of a uranium mining operation at Yeelirrie, Australia which requirec

lowering of water table to extract ore. They observed that A. aneura had a high pressure potential and stomatal resistance indicating that it is a drought evader and not using stored water. This species is likely to survive a lowering of the water table.

Acacia mearnsii and A. dealbata and other bipinnates are favoured in New Zealand for control of gully and hillside erosion (Anon. 1984, Sheppard, 1986). Although potentially weedy, Troup (1921) reported that A. dealbata, because of its ability to root sucker, was almost unrivalled as a means of stabilising eroded hill slopes in India. By contrast, A. decurrens in Indonesia was reported to suppress weed growth to such an extent that soil erosion became a serious problem when this species was planted on steep slopes (Werff, 1953).

Webb et al. (1984) suggested that A. auriculiformis plantations require annual mean precipitation in the range 1300-1700 mm. Trials at lower rainfall sites would be more risky, especially in areas affected by any continuing sub-Sahellan drought.

Skelton (1987) observed that A. auriculiformis required higher soil moisture levels but was longer lived than A. crassicarpa. He noted that it is scarce in savannas but it is found as a codominant in dry evergreen forest, on river banks with A. crassicarpa and on the edge of the seasonally flooded grass plains. It probably tolerates flooding better than the other species provided the water is not stagnant.

2.2 Chemical characteristics

Acacia auriculiformis will grow in a wide range of deep or shallow soils including sand dunes, mica schist, clay, limestone, podsols, laterite and lateritic soils. These problem soils are often poor in nutrients, but the plant produces profuse bundles of nodules and can often survive on land very low in nitrogen and organic matter where Eucalyptus and other species fail (Anon. 1980). Australian acacias grow well on diverse soil types in their native habitat (Turnbull, 1986) and are known to perform extremely well on non-saline soils of some Third World Countries (Boland and Turnbull, 1981).

The relationship between vegetation and soil properties in part of the eastern wheat belt of western Austr alia was investigated by Snowball and Robson (1985). Soils supporting wodjil vegetation (*Acacia beauverdiana*, *Acacia signata* and *Allocasuarina corniculata*) had a very low pH in the 4.3 to 5.0 cm surface soil layer, a very low level of mineralisable nitrogen and a low chloride content compared to soils supporting *Eucalyptus* spp. All soils were low in exchangeable potassium and bicarbonate-extractable phosphorus.

Gupta *et al.* (1986) studied the salt tolerance in some tree species at seedling stage and concluded that *Acacia nilotica* could be grown at salinity values upto 5 mmhos cm^{-1} with less than 50 per cent growth reduction. *A nilotica*

survived upto 15 mmhos cm^{-1} but A. auriculiformis was highly sensitive and did not survive values more than 2.5 mmhos cm^{-1}.

The suitability of Australian acacias in the people's Republic of China was tested by Pan Zhigang and Yang Minquan (1987). They observed that Acacia auriculiformis grew in a variety of soils with a PH range of 4.0 to 6.5. It was also suitable in thin eroded gravelly soils, and on coastal sandy soil where salinity was high.

2.3. Biological and Biochemical characteristics.

A study was conducted on the allelopathic effect of Acacia auriculiformis, A. villosa and Albizia falcataria on seedlings of Tamarindus indica by Setiadi and Samingan (1978) in Indonesia and reported that the leaf extracts of A. auriculiformis had an allelopathic effect on the germination of other plants.

According to Lawrie (1981), the rate of nitrogen fixation by Acacia was extremely low and were found to be less than 2 kg ha^{-1} $year^{-1}$. The variation in the amount of nitrogen fixed was attributed to be due to differences in nodule number rather than specific activity. She suggested that the best approximation of the significance of nitrogen fixation by particular legumes to the ecosystem is an estimate of host abundance and nodule number as recorded by Beadle(1964

Acacias had responded to inoculation with VA mycorrhizal fungi in pot experiments (Cornet and Diem,1982) They found that in a pot experiment with a phosphorus-deficient soil that had been sterilised to kill the native population of mycorrhizal fungi, inoculation of Acacia raddiana and A. holosericea with the VA mycorrhizal fungus Glomus mosseae increased shoot weights by 170 per cent and 850 per cent respectively, and nodule weight by 10 to 12 fold.

The root nodule bacteria in Acacias were investigated by Roughley (1987) and he found that the root nodule bacteria which nodulated Acacias belonged either to the genus Rhizobium or Bradyrhizobium.

The importance of mycorrhizal fungi in the nutrition of Acacias was studied by Reddell and Warren (1987). They found that Acacias were capable of forming both ecto- and VA mycorrhizas. Net works of fungal hyphae extended from the mycorrhizal roots into the surrounding soil. These mycorrhizas were found to be important for the uptake of nutrients that are immobile in soils (Phosphorus, Zinc, Copper and Ammonium).

Since not much research results are available on varied aspects of the impact of Acacia plantations on soil properties, there is much scope for research on the environmental effects of Acacia monoculture plantations under varied geo-climatic and pedogenic environments with special reference to Kerala.

MATERIALS AND METHODS

MATERIALS AND METHODS

To study the impact of Eucalyptus and Acacia plantations on soil properties in different pedogenic environments in Kerala, four specific geoclimatic locations were selected. The locations were selected in such a way so as to represent environments of reserve forests, cultivated lands, barren lands, Eucalyptus plantations and Acacia plantations. Utmost care was taken to locate adjacent plots of different vegetation from a uniform terrain. The locations were as follows:

Pedogenic environment	Location
1. Highland forest region with high precipitation	Wynad
2. Highland forest region with medium precipitation	Kottoor
3. Coastal sandy tract with high precipitation	Nileswar
4. Coastal sandy tract with medium precipitation	Kazhakkoottam.

Major geoclimatic parameters and soil type of these locations are given in Table 1.

Profile pits were dug in the four locations as follows:

Location	Profile No.	Name
1. Wynad	1	Wynad Reserve forest
	2	Wynad Barren land
	3	Wynad Eucalyptus

Table 1. Geoclimatic parameters and soil type of the different locations

Parameters	Wynad	Kottoor	Nileswar	Kazhakkoottam
Latitude (N)	11/40	8/20	12/10	8/24
Longitude (E)	76/22	77/7	75/30	77/15
Elevation (M)	800	300	8	8
Topography	Undulating	Undulating	Plain	Plain
Temperature (^{o}C)				
Mean Mini:	19.1	26.6	22.3	22.9
Mean Max:	29.3	30.2	30.1	30.4
Mean annual	24.2	28.4	26.2	26.6
Precipitation (mm)	3796	2001	3500	2001
No. of rainy days	139.8	104	118	102
Soil type	Forest loam (Udic tropustolls/ Udic tropustalfs)	Forest loam (Udic tropustolls| Udic tropustalfs)	Sandy loam (Quartzi Psamments)	Sandy loam (Quartzi Psammer

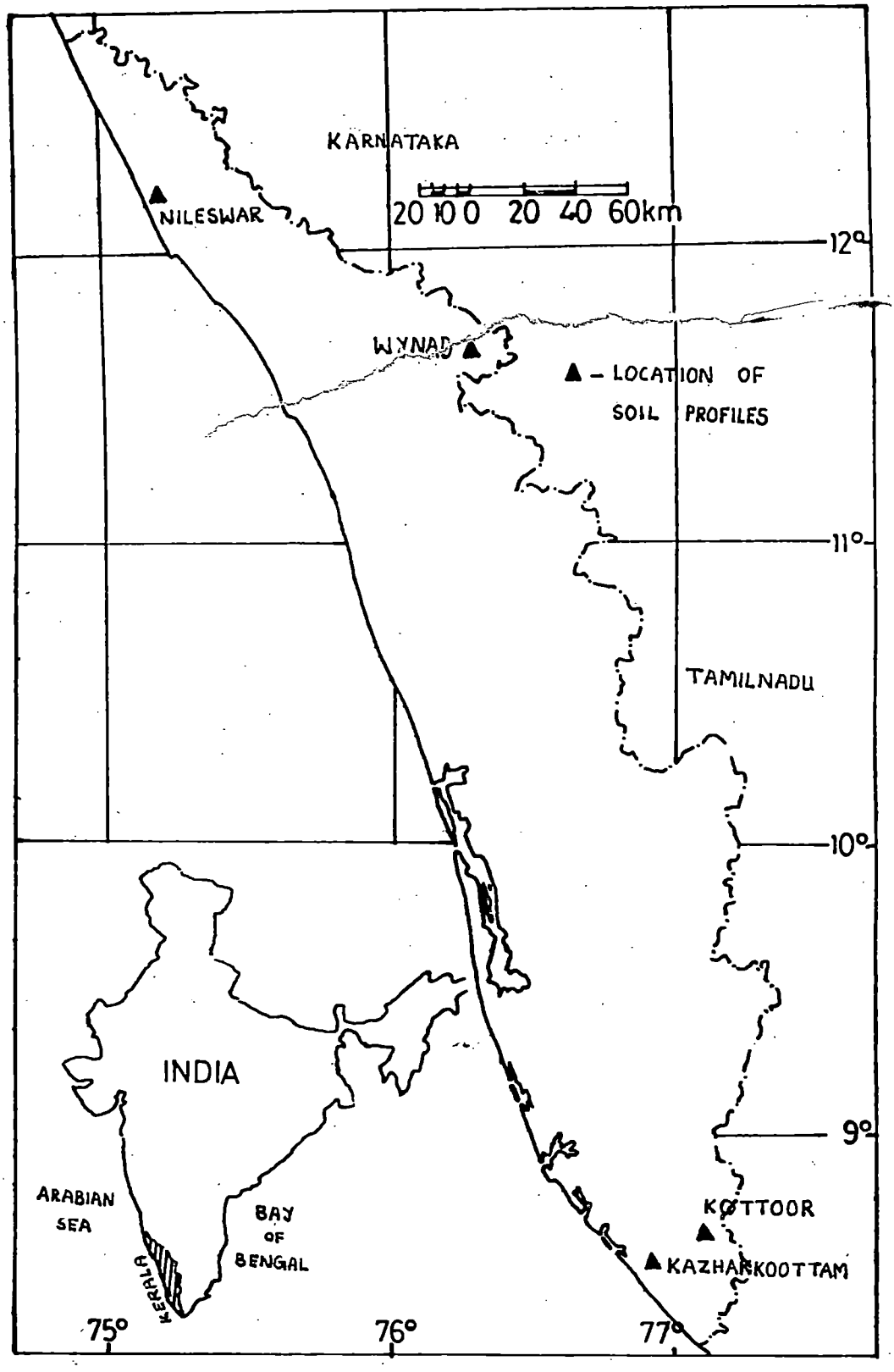

PLATE-1

MAP SHOWING LOCATIONS OF SOIL PROFILES

Location	Profile No.	Name
2. Kottoor	4	Kottoor Reserve forest
	5	Kottoor Barren land
	6	Kottoor Eucalyptus
3. Nileswar	7	Nileswar cultivated land
	8	Nileswar Barren land
	9	Nileswar Acacia
4. Kazhakkoottam	10	Kazhakkoottam Cultivated land
	11	Kazhakkoottam Barren land
	12	Kazhakkoottam Eucalyptus
	13	Kazhakkoottam Acacia.

The profile pits were dug to a depth of 2 m and site characteristics and pedon descriptions were recorded as per the guidelines suggested by FAO (1970). A total of 63 soil samples from individual horizons of the thirteen different profiles were collected for detailed laboratory investigations. Soil samples were also collected from depths of 0-50, 50-100 and 100-150 cm to assess the variations in soil fertility parameters. Four surface samples from each location were also taken for microbiological investigations. Leaf samples were collected to determine the chlorophyll content, chlorophyll-a and -b values and manurial value of leaves.

Laboratory Investigations:

A. Soil Analysis

The air dried soil samples were sieved through a 2 mm I.S. sieve and the weight of the gravel was recorded. The sieved soil samples were stored in air tight containers after proper labelling. The sieved materials were subjected to physical, chemical and microbiological investigations.

1. Physical characteristics

The field moisture content of the soil samples was determined by Gravimetric method (Black, 1965). The mechanical composition of the soil samples was determined by International Pipette method (Jackson, 1973). The single value physical constants viz. bulk density, particle density, water holding capacity, porosity and volumeexpansion were determined following the procedures described by Piper (1950). After the granulo-metric composition was determined the textural classification of soils was done by reference to the textural diagram (Soil Survey Staff, 1951). The quotient silt/clay (L/A value) was also calculated since it is suggested as an index of laterisation.

The modified Yoder's method (1936) of wet sieving suggested by Dakshinamurti and Gupta (1968) was followed to estimate the proportion of water stable aggregates in the

different soil samples. The water dispersible clay content which was suggested as an index of laterisation was estimated following the procedure suggested by Soil Conservation Service of U.S.D.A.(Anon. 1972).

2. Chemical characteristics

Chemical analysis of the soil samples for pH, electrical conductivity (E.C), organic carbon and organic matter, total contents of nitrogen, phosphorus, potassium, calcium, magnesium, iron, aluminium and cation exchange capacity was done by adopting standard procedures described by Jackson (1973).

Available nitrogen content of the different soil samples was determined according to the procedure given by Subbiah and Asija (1956). Available phosphorus was determined by chlorostannous reduced phosphomolybdic blue colour method (Bray and Kurtz, 1945). Available potassium and base saturation were determined according to the standard procedures given by Jackson (1973).

Fractionation of free oxides of iron to estimate the contents of amorphous and crystalline forms was done following the selective dissolution procedure described by Mehra and Jackson (1960) modified by Mc Keague and Day (1966). From the values of oxalate extractable and dithionite extractable iron, the active iron ratio (Fe_o/Fe_d) was calculated which

was also used as an index for differentiating various samples of soils with regard to the extent of laterisation.

3. Microbiological characteristics

The total microflora population in the surface soil and the nitrifying properties of the surface soil were estimated following the procedures given by Black (1965).

B. Plant Analysis

From each location, the height and diameter at breast height (DBH) of 50 trees were measured to make a correlation between age and biomass accumulation. Leaf samples were analysed to determine the chlorophyll content and manurial value.

Total chlorophyll content, chlorophyll-a and -b values were estimated following the procedure described by Witham et al.(1971). Contents of nitrogen, phosphorus, potassium, calcium, magnesium and crude fibre were determined according to the standard procedures given by Piper (1950).

Plate - II Wynad Eucalyptus plantation (17 year old) a general view.

Plate - III Kottoor Eucalyptus plantation (8 year old) - a general view.

PLATE II

PLATE III

Plate - IV Nileswar Acacia plantation (7 year old) devoid of undergrowth.

PLATE IV

PLATE V

Plate - VI Kazhakkoottam Acacia plantation (7 year old) devoid of undergrowth

Plate - VII Pedon : Wynad Reserve Forest - Udic Tropustolls

PLATE VI

PLATE VII

Plate - VIII Pedon : Wynad Barrenland - Udic tropustalfs

Plate - IX Pedon : Wynad Eucaluptus - Udic tropustalfs

PLATE VIII

PLATE IX

Plate - X Pedon : Kottoor Reserve Forest - Udic tropustolls

Plate - XI Pedon : Kottoor Barrenland - Udic tropustalfs

PLATE X

PLATE XI

Plate - XII Pedon : Kottoor Eucaluptus - Udic tropustalfs

Plate - XIII Pedon : Nileswar Cultivated land - Quartzi Psamments

PLATE XII

PLATE XIII

Plate - XIV Pedon : Nileswar Barrenland - Quartzi Psamments

Plate - XV Pedon : Nileswar Acacia - Quartzi Psamments

PLATE XIV

PLATE XV

Plate - XVI Pedon : Kazhakkoottam Cultivated land - Quartzi Psamments

Plate - XVII Pedon : Kazhakkoottam Barrenland - Quartzi Psamments

PLATE XVI

PLATE XVII

Plate - XVIII Pedon : Kazhakkoottam Eucalyptus
Quartzi Psamments

Plate - XIX Pedon : Kazhakkoottam Acacia - Quartzi Psamments

PLATE XVIII

PLATE XIX

RESULTS

RESULTS

1. Profile morphology

Table 2 presents the detailed morphological descriptions of the thirteen soil profiles from four geoclimatic locations in Kerala.

Profile 1. Wynad Reserve forest

A. Information on the site.

1. Soil name	:	Forest loam
2. Higher order category	:	Mollisols
3. Date	:	4th November 1988
4. Location	:	Wynad Reserve forest under the Muthanga forest range. Approx: N.La.11/40 and E.Lo.76/22
5. Elevation	:	800 m
6. Land form		
a) Physiographic position	:	Almost flat, summit of a reserve forest.
b) Surrounding land form	:	Undulating
c) Microtopography	:	Natural forest
7. Slope	:	Sloping : 12%
8. Vegetation	:	Natural forest vegetation.

9. Climate : Humid tropical. High rainfall during June, July and August which accounts for 75% of the total. Mean annual rainfall of 3796 mm with 139.8 rainy days in a year.

Moisture regime: Udic tropustic

Temperature: Max: 29.3°C

Mini: 19.1°C

Mean: 24.2°C

Temperature regime: Hyperthermic

B. General information on the soil

1. Parent material : Not visible. Probably crystalline gneisses.
2. Drainage : Class 3; Moderately well drained.
3. Moisture condition : Moist throughout the profile (Pedon examination: One week after rain)
4. Depth of groundwater : Unknown.
5. Stoniness and rock outcrops. : Fairly stony, no bedrock exposure.
6. Evidence of erosion : None/very slow
7. Presence of salt/alkali : None
8. Human influence : Reserve forest with natural vegetation. Only slight human influence.

C. Profile description

Horizon	Depth	Description
A	0 - 36 cm	Very dusky red, 2.5YR 2.5/2 moist and dusky red, 2.5YR 3/2 dry; clayey; strong, medium, angular blocky; medium, many pores; roots medium, many; gradual, smooth boundary; pH 6.1
AB	36 - 57 cm	Dark reddish brown, 2.5YR 3/4 moist and reddish brown, 2.5YR 4/4 dry; clayey; moderate, medium, angular blocky; medium, common pores; roots medium, many; clear, smooth boundary; pH 6.0
BA	57 - 84 cm	Dark red, 2.5YR 3/6 moist and red, 2.5 YR 4/6 dry; clayey; moderate, medium angular blocky; coarse, common pores; roots medium, common; clear, smooth boundary; pH 6.0
B	84 -127 cm	Red, 10R 4/6 moist and red, 10R 4/8 dry; clayey; strong, coarse angular blocky; coarse, common pores; roots medium, few; diffused, smooth boundary; pH 5.7
BC	127 - 200 cm	Dark red, 10R 3/6 moist and red, 10R 5/6 dry; clayey; strong, coarse, angular blocky; coarse, few pores; roots fine, few; clear, smooth boundary; pH 5.8

Profile 2. Wynad Barrenland

A. Information on the site

1. Soil name	:	Forest loam
2. Higher order category	:	Alfisols.
3. Date	:	4th November 1988
4. Location	:	Barren land, 100 m. away from the reserve forest. Approx. N.La.11/40 and E. Lo. 76/22.
5. Elevation	:	800 m
6. Land form		
a) Physiographic position	:	Almost flat, summit of a hill.
b) Surrounding land form	:	Undulating
c) Microtopography	:	Deforested and kept as barren
7. Slope	:	Gently sloping; 5%
8. Vegetation	:	None
9. Climate	:	Humid tropical. High rainfall during June, July and August which accounts for 75% of the total. Mean annual rainfall of 3796 mm with 139.8 rainy days in a year.

Moisture regime: Udic tropustic.

Temperature: Max : 29.3°C

Mini : 19.1°C

Mean : 24.2°C

Temperature regime: Hyperthermic.

B. General Information on the soil.

1. Parent material : Not visible. Probably crystalline gneisses.
2. Drainage : Class 3: Moderately well drained
3. Moisture condition in profile. : Moist below 30 cm (Pedon examination: one week after rain
4. Depth of groundwater : 40 m
5. Stoniness and rock outcrops. : Fairly stony; no bedrock exposure.
6. Evidence of erosion : Slightly eroded
7. Presence of salt/alkali : None
8. Human influence : Only slight human influence.

C. Profile description

Horizon	Depth	Description
A	0-30 cm	Dark reddish brown, 5YR 3/2 moist and dark reddish grey, 5YR 4/2 dry; clayey; moderate; medium, granular; medium, many pores; roots none; clear, smooth boundary; pH 6.1
AB	30-55 cm	Dark reddish brown, 5YR 3/3 moist and reddish brown 5 YR 4/3 dry; clayey; moderate, medium granular; medium, common pores; roots none; diffused, smooth boundary; pH 6.2
BA	55-89 cm	Dark red, 2.5YR 3/6 moist and red, 2.5YR 4/8 dry; clayey; strong, coarse, angular blocky; medium, many pores; roots, none; diffused, wavy boundary; pH 6.2

B	89-138 cm	Dark red, 2.5YR 3/6 moist and red, 2.5YR 4/8 dry; clayey; strong, coarse, angular blocky; coarse, common pores; roots none; diffused, smooth boundary pH 6.5
BC	138-200 cm	Red, 2.5YR 4/6 moist and red, 2.5YR 5/8 dry; clayey; strong, coarse, angular blocky; coarse, common pores; roots none; clear, smooth boundary; pH 6.5

Profile 3 Wynad Eucalyptus

A. Information on the site

1. Soil name : Forest loam
2. Higher order category : Alfisols.
3. Date : 4th November 1988
4. Location : Eucalyptus plantation under Muthanga forest range, Wynad.Approx. N.La.11/4 and E.Lo. 76/22.
5. Elevation : 800 m
6. Land form
   a) Physiographic position : Almost flat, summit of plateau.
   b) Surrounding land form : Undulating
   c) Microtopography : Deforested and planted with Eucalyptus tereticornis (17 year old plantation)
7. Slope : Gently sloping; 5%
8. Vegetation : Monoculture plantation of Eucalyptus.

9. Climate : Humid tropical. High rainfall during June, July and August which accounts for 75% of the total.
Mean annual rainfall of 3796 mm with 139.8 rainy days in a year.
Moisture regime: Udic tropustic
Temperature: Max : 29.3°C
Mini : 19.1°C
Mean : 24.2°C
Temperature regime: Hyperthermic.

B. General information on the soil.

1. Parent material : Not visible. Probably crystalline gneisses.
2. Drainage : Class 3: Moderate well drained.
3. Moisture condition in profile. : Moist below 30 cm.
(Pedon examination: One week after rain)
4. Depth of groundwater : 45 m
5. Stoniness and rock outcrops. : Fairly stony; no bedrock exposure.
6. Evidence of erosion : Slightly eroded
7. Presence of salt/alkali : None
8. Human influence : Only slight human influence.

c. Profile description

Horizon	Depth	Description
A	0 - 29 cm	Very dark grey, 5YR 3/1 moist and dark grey, 5 YR 4/1 dry; clayey; moderate, medium, angular blocky; medium, common pores; roots medium, common; gradual, smooth boundary; pH 5.2

AB	29-45 cm	Dark reddish brown, 5YR 3/4 moist and reddish brown, 5YR 5/4 dry; clayey; moderate, medium, granular; medium, common pores; roots medium, many; clear, smooth boundary; pH 5.5
BA	45-56 cm	Dark reddish brown, 5YR 3/3 moist and reddish brown, 5 YR 4/3 dry; clayey; strong, coarse, angular blocky; coarse common pores; roots coarse, few; diffused, smooth boundary; pH 5.1
B	56-110 cm	Dark reddish brown, 5YR 3/3 moist and reddish brown, 5 YR 4/3 dry; clayey; strong, coarse, angular blocky; medium common pores; roots coarse, few; diffused, wavy boundary; pH 5.6
BC	110-200 cm	Red, 2.5YR 4/6 moist and red, 2.5YR 5/6 dry; clayey; strong, coarse angular blocky; coarse, common pores; roots coarse, few; clear, smooth boundary; pH 5.2

Profile 4. Kottoor Reserve Forest

A. Information on the site

1. Soil name : Forest loam
2. Higher order category : Mollisols
3. Date : 8th July 1988
4. Location : Kottoor reserve forest under the Paruthippally forest range.Trivandrum. Approx: N.La. 8/20 and E.Lo.77/7.
5. Elevation : 300 m

6. Land form

a) Physiographic position : Summit of Reserve forest

b) Surrounding landform : Undulating

c) Microtopography : Natural forest

7. Slope : Sloping, 10%

8. Vegetation : Natural forest vegetation

9. Climate : Humid tropical. High rainfall during June-July (South-west monsoon) and October-November (North-east monsoon) concentrated in 7 months, well distributed. Mean annual rainfall of 2001 mm with 104 rainy days in an year.

Moisture regime: Udic tropustic

Temperature: Max : 30.2°C

Mini : 26.6°C

Mean : 28.4°C

Temperature regime: Isohyperthermic.

B. General information on the soil.

1. Parent material : Not visible, apparently underlain by Charnockites.

2. Drainage : Class 3; Moderately well drained.

3. Moisture condition in the profile. : Moist throughout the profile (Pedon examination: 3 days after rain.)

4. Depth of groundwater : Unknown.

5. Stoniness and rock outcrops. : Fairly stony; no bedrock exposure.

6. Evidence of erosion : None/ very slow

7. Presence of salt/ alkali : None

8. Human influence : Reserve forest with natural vegetation. Only slight human influence.

C. Profile description

Horizon	Depth	Description
A	0-17 cm	Very dark grey, 10YR 3/1 moist and dark grey, 10YR 4/1 dry; clayloam; moderate, medium, angular blocky; medium, common pores; roots medium, common; diffused, smooth boundary; pH 5.2
AB	17-45 cm	Very dark grey, 10YR 3/1 moist and grey 10YR 5/1 dry; clayey; moderate, medium, angular blocky; medium, many pores; root medium,few; clear, smooth boundary; pH 5.0
B	45-83 cm	Dark yellowish brown, 10YR 4/4 moist and yellowish brown, 10YR 5/4 dry; clayey; strong, coarse, angular blocky; coarse common pores, roots coarse, few; diffused, smooth boundary; pH 4.8
BC	83-200 cm	Yellowish brown, 10YR 5/4 moist and pale brown, 10YR 6/3 dry; clayey; strong, coarse, angular blocky; coarse, common pores; roots coarse, few, clear, smooth boundary; pH 4.5

Profile 5. Kottoor Barren land

A. Information on the site

1. Soil name : Forest loam
2. Higher order category : Alfisols
3. Date : 8th July 1988
4. Location : Barren land under Paruthippally forest range; close to the natural forest. Approx. N.La.8/20 and E.Lo. 77/7.
5. Elevation : 300 m
6. Land form
   a) Physiographic position : Summit of a hillock
   b) Surrounding landform : Undulating
   c) Microtopography : Deforested and kept as barren.
7. Slope : Almost flat; 2%
8. Vegetation : None
9. Climate : Humid tropical. High rainfall during June-July (South-west monsoon) and October-November (North-east monsoon) concentrated in 7 months, well distributed. Mean annual rainfall of 2001 mm with 104 rainy days in an year.

   Moisture regime : Udic tropustic.

   Temperature : Max : 30.2°C
   Mini : 26.6°C
   Mean : 28.4°C

   Temperature regime: Isohyperthermic

B. General information on the soil

1. Parent material	: Not visible, apparently underlain by charnockites.
2. Drainage	: Class 3; Moderately well drained.
3. Moisture condition in profile	: Moist below 20 cm (Pedon examination : 3 days after rain).
4. Depth of groundwater	: 50 m
5. Stoniness and rock outcrops	: Fairly stony; no bedrock exposure.
6. Evidence of erosion	: Moderate
7. Presence of salt/alkali	: None
8. Human influence	: Barren land and only very slight human influence.

C. Profile description

Horizon	Depth	Description
A	0-8 cm	Dark brown, 10YR 4/3 moist and pale brown, 10 YR 6/3 dry; clayey; moderate medium, granular; medium, many pores; roots none; clear, smooth boundary; pH 5.0
AB	8-21 cm	Dark yellowish brown, 10YR 4/4 moist and yellowish brown, 10YR 5/6 dry; clayey; strong, coarse, granular; coarse, common pores; roots none; diffused, smooth boundary; pH 4.4

BA	21-37 cm	Yellowish brown, 10YR 5/6 moist and brownish yellow, 10YR 6/6 dry; clayey; strong, fine, angular blocky medium, many pores; roots none; diffused, wavy boundary; pH 4.7
B	37-81 cm	Yellowish brown, 10YR 5/6 moist and brownish yellow, 10YR 6/6 dry; clayey; strong, coarse, angular blocky; coarse, common pores, roots none; diffused, smooth boundary; pH 4.4
BC	81-200 cm	Yellowish brown, 10YR 5/8 moist and brownish yellow, 10YR 6/6 dry; clayey; strong, coarse, angular blocky; coarse, common pores; roots none; clear, smooth boundary; pH 4.1

Profile 6. Kottoor Eucalyptus

A. Information on the site.

1. Soil name : Forest loam
2. Higher order category : Alfisols
3. Date : 8th July 1988
4. Location : Eucalyptus monoculture plantation under the Paruthippally forest range; on the summit of hillock. Approx. N.La. 8/20 and E.Lo.77/7.
5. Elevation : 300 m
6. Land form
   a) Physiographic position : Summit of Eucalyptus tereticornis plantation.
   b) Surrounding landform : Undulating.
   c) Microtopography : Deforested and planted with Eucalyptus tereticornis(2

7. Slope : Sloping; 12%

8. Vegetation : Monoculture plantation of Eucalyptus.

9. Climate : Humid tropical. High rainfall during June-July (South-west monsoon) and October-November(North-east monsoon) concentrated in 7 months, well distributed. Mean annual rainfall of 2001 mm with 104 rainy days in an year.
Moisture regime:Udic tropustic.
Temperature: Max : 30.2°C
Mini : 26.6°C
Mean : 28.4°C
Temperature regime: Isohyperthermic.

B. General information on the soil.

1. Parent material : Not visible, apparently underlain by charnockites.

2. Drainage : Class 3; Moderately well drained.

3. Moisture condition in profile : Moist below 20 cm (Pedon examination : 3 days after rain)

4. Depth of groundwater : 50 m

5. Stoniness and rock outcrops : Fairly stony; no bedrock exposure.

6. Evidence of erosion : Moderate

7. Presence of salt/alkali : None

8. Human influence : Eucalyptus monoculture plantation of 8 years old was subjected to taungya cultivation. Now only slight human influence.

C. Profile description

Horizon	Depth	Description
A	0-16 cm	Dark reddish brown, 5YR 2.5/2 moist and dark reddish grey; 5YR 4/2 dry; Clayey; moderate, medium, angular blocky; medium common pores; roots medium, common; diffused, smooth boundary; pH 4.6
AB	16-34 cm	Dark reddish brown, 5 YR 2.5/2 moist and reddish brown, 5YR 4/3 dry; clayey; moderate, medium, granular; medium, common pores; roots medium, common; clear, smooth boundary; pH 4.4
BA	34-51 cm	Dark reddish brown, 5YR 3/4 moist and yellowish red 5YR 5/6 dry; clayey; strong, coarse, granular; coarse, common pores; roots medium, common; diffused smooth boundary; pH 4.4
B	51-95 cm	Reddish yellow, 5YR 6/8 moist and reddish yellow, 5 YR 7/8 dry; clayey; strong, coarse, angular blocky; coarse, common pores; roots medium, few; diffused smooth boundary; pH 4.9
BC	95-200 cm	Reddish yellow, 5YR 7/8 moist and reddish yellow,5YR 7/6 dry; clayey; strong, coarse, angular blocky; coarse, few pores; roots fine, few; clear, smooth boundary; pH 4.7

Profile 7. Nileshwar cultivated land

A. Information on the site

1. Soil name : Sandy loam
2. Higher order category : Entisols
3. Date : 27th October 1988
4. Location : Cultivated land. Approx. N.La.12/10 and E.Lo. 75/30.
5. Elevation : 8 m
6. Land form
   a) Physiographic position : Plain
   b) Surrounding landform : Flat
   c) Microtopography : Artificial
7. Slope : Flat; 1%
8. Vegetation : Coconut and Pepper
9. Climate : Humid tropical. High rainfall during June, July and August. Mean annual rainfall of 3500 mm with 118 rainy days in an year.
   Moisture regime: Udic tropustic
   Temperature: Max : 30.1°C
   Mini.: 22.3°C
   Mean : 26.2°C
   Temperature regime: Hyperthermic

B. General information on the soil

1. Parent material : Recent marine deposits (Littoral sand)
2. Drainage : Class 4; well drained

3. Moisture condition in profile. : Moist throughout the profile (Pedon examination: 4 days after rain)

4. Depth of groundwater : 4.6 m

5. Stoniness and rockoutcrops : None

6. Evidence of erosion : None/very slow

7. Presence of salt/alkali : None

8. Human influence : Cultivated land. Subjected to various management practices.

C. Profile description

Horizon	Depth	Description
Ap	0 - 24 cm	Dark yellowish brown, 10YR 4/4 and brown, 10YR 5/3 dry; sandyloam; weak, fine, granular; very fine, many pores; roots many, medium; diffused wavy boundary; pH 5.1
C_1	24-40 cm	Dark yellowish brown, 10YR 4/4 moist and brown; 10YR 5/3 dry; sandyloam; singlegrain; fine, many pores; roots medium, few; diffused, wavy boundary; pH 5.2
C_2	40-61 cm	Yellowish brown, 10YR 5/4 moist and pale brown, 10YR 6/3 dry; sandyloam; single grain; fine, common pores; roots medium, few; diffused wavy boundary; pH 5.4

C_3	61-85 cm	Yellowish brown, 10YR 5/4 moist and pale brown, 10YR 6/3 dry; sandyloam; single grain; fine, many pores; roots fine, few; diffused, wavy boundary; pH 5.2
C_4	85-200 cm	Light yellowish brown, 2.5 Y 6/4 moist and pale yellow, 2.5Y 7/4 dry; sandy loam; single grain; fine, common pores; roots medium, few; diffused, wavy boundary; pH 4.9

Profile 8 Nileswar Barrenland

A. Information on the site

1. Soil name : Sandyloam
2. Higher order category : Entisols.
3. Date : 27th October 1988
4. Location : Barrenland, very near to cultivated land. Approx. N.La.12/10 and E.Lo.75/30
5. Elevation : 8 m
6. Land form
   a) Physiographic position: Plain
   b) Surrounding land form : Flat
   c) Microtopography : Barrenland.
7. Slope : Flat; 1%
8. Vegetation : No vegetation
9. Climate : Humid tropical. High rainfall during June, July and August.Mean annual rainfall of 3500 mm with 118 rainy days in an year.

Moisture regime: Udic tropustic

Temperature : Max : 30.1°C

Mini. : 22.3°C

Mean : 26.2°C

Temperature regime: Hyperthermic.

B. General information on the soil.

1. Parent material : Recent marine deposits (Littoral sand)
2. Drainage : Class 4; well drained
3. Moisture condition in profile. : Moist below 15 cm (Pedon examination : 4 days after rain)
4. Depth of groundwater : 4.6 m
5. Stoniness and rock outcrops. : None
6. Evidence of erosion : None/very slow
7. Presence of salt/alkali : None
8. Human influence : Only very slight human influence.

C. Profile description

Horizon	Depth	Description
A	0 - 18 cm	Brown, 7.5YR 5/4 moist and reddish yellow, 7.5YR 6/6 dry; sandy loam; singlegrain; fine, common pores; roots none; diffused wavy boundary; pH 4.7
C_1	18-35 cm	Yellowish brown,10YR 5/4 moist and palebrown,10YR 6/3 dry; sandyloam; singlegrain; fine; many pores; roots none; diffused wavy boundary; pH 5.2

C_2	35-75 cm	Pale yellow, 2.5Y 7/4 moist and pale yellow, 2.5Y 7/4 dry; sandyloam; singlegrain; fine, common pores; roots none; diffused, wavy boundary; pH 4.3
C_3	75-200 cm	Pale yellow, 2.5Y 7/4 moist and pale yellow, 2.5Y 7/4 dry; sandyloam; single grain; fine, many pores, roots none; diffused, wavy boundary; pH 4.3

Profile 9 Nileswar Acacia

A. Information on the site

1. Soil name	:	Sandyloam
2. Higher order category	:	Entisols
3. Date	:	27th October 1988
4. Location	:	Social forestry plantation of Acacia auriculiformis near the railway station, Nileswar. Approx: N.La.12/10 and E.Lo. 75/30.
5. Elevation	:	8 m
6. Landform		
a) Physiographic position.	:	Plain
b) Surrounding landform	:	Flat
c) Microtopography	:	Artificial, planted with Acacia.
7. Slope	:	Flat; 1%
8. Vegetation	:	Monoculture plantation of Acacia auriculiformis (1982 plantation)

9. Climate : Humid tropical. High rainfall during June, July and August. Mean annual rainfall of 3500 mm with 118 rainy days in an year. Moisture regime: Udic tropustic.

Temperature: Max. : 30.1°C
Mini.: 22.3°C
Mean : 26.2°C

Temperature regime: Hyperthermic

B. General information on the soil

1. Parent material : Recent marine deposits (Littoral sand)
2. Drainage : Class 4; well drained
3. Moisture condition in profile. : Moist below 30 cm (Pedon examination: 4 days after rain)
4. Depth of groundwater : 5 m
5. Stoniness and rock outcrops. : None
6. Evidence of erosion : None/very slow
7. Presence of salt/alkali. : None
8. Human influence : Only slight human influence.

C. Profile description

Horizon	Depth	Description
A	0 - 16 cm	Dark brown, 7.5YR 4/4 moist and brown, 7.5YR 5/4 dry; sandyloam; weak, fine, granular; very fine, many pores; roots fine, many; clear, smooth boundary; pH 4.1

C_1	16-38 cm	Yellowish brown, 10YR 5/4 moist and brown, 10YR 5/3 dry; sandyloam; singlegrain; fine, common pores; roots fine, many; clear smooth boundary; pH 4.6
C_2	38-60 cm	Yellowish brown,10YR 5/4 moist and pale brown, 10YR 6/3 dry; sandyloam; singlegrain; fine, common pores; roots fine, many; clear smooth boundary; pH 3.9
C_3	60-79 cm	Pale yellow, 2.5Y 7/4 moist and pale yellow, 2.5Y 8/4 dry; sandyloam; singlegrain; fine, common pores; roots fine, many; diffused, smooth boundary; pH 4.1
C_4	79-200 cm	Pale yellow, 2.5Y 7/4 moist and pale yellow, 2.5Y 8/4 dry; sandyloam; single grain; fine, common pores; roots coarse, few; diffused, smooth boundary; pH 3.7

Profile 10. Kazhakkoottam cultivated land

A. Information on the site

1. Soil name	:	Sandyloam
2. Higher order category	:	Entisols
3. Date	:	19th March 1988
4. Location	:	Cultivated land; coconut garden near the railway station, Kazhakkoottam. Approx: N.La. 8/24 and E.Lo.77/15.
5. Elevation	:	8 m

6. Landform

a) Physiographic position : Plain

b) Surrounding landform : Flat

c) Microtopography : Artificial

7. Slope : Flat; 1%

8. Vegetation : Coconut garden

9. Climate : Humid tropical. High rainfall during June-July(South-west monsoon) and October-November (North-east monsoon) Total annual rainfall is 2001 mm with 102 rainy days in an year.

Moisture regime : Udic tropustic

Temperature: Max. : 30.4°C

Mini. : 22.9°C

Mean : 26.6°C

Temperature regime: Hyperthermic

B. General information on the soil

1. Parent material : Recent marine deposits (Littoral sand)

2. Drainage : Class 4; well drained

3. Moisture condition in profile. : Moist throughout the profile (Pedon examination : 3 days after rain)

4. Depth of groundwater : 3.4 m

5. Stoniness and rock outcrops. : None

6. Evidence of erosion : None/very slow

7. Presence of salt/alkali : None

8. Human influence : Coconut garden. Subjected to management practices.

C. Profile description

Horizon	Depth	Description
Ap	0 - 17 cm	Dark brown, 7.5YR 4/4 moist and light brown, 7.5YR 6/4 dry; sandyloam; weak, fine, granular; very fine, many pores; roots medium, many; diffused, wavy boundary; pH 5.1
C_1	17 - 38 cm	Reddish brown, 5YR 4/4 moist and reddish brown, 5 YR 5/3 dry; sandyloam; singlegrain; fine, common pores; roots medium, few; diffused, wavy boundary; pH 4.7
C_2	38 - 68cm	Yellowish red, 5YR 4/6 moist and reddish yellow, 5YR 6/6 dry; sandyloam; singlegrain; fine, common pores; roots medium, few; diffused, wavy boundary; pH 4.7
C_3	68 - 88 cm	Yellowish red, 5YR 4/6 moist and reddish yellow 5 YR 6/8 dry; loamy sand; singlegrain; fine, many pores; roots medium, few; diffused, wavy boundary; pH 4.6
C_4	88 - 200 cm	Yellowish red, 5YR 5/8 moist and reddish yellow, 5 YR 7/8 dry; loamysand; singlegrain; fine, common pores; roots medium, few; diffused, wavy boundary; pH 4.6

Profile 11. Kazhakkoottam Barren land

A. Information on the site

1. Soil name : Sandyloam
2. Higher order category : Entisols
3. Date : 19th March 1988
4. Location : Barrenland near the Railway station, Kazhakkoottam. Approx: N.La. 8/24 and E.Lo.77/15.
5. Elevation : 8 m
6. Landform
   a) Physiographic position : Plain
   b) Surrounding landform : Flat
   c) Microtopography : Natural
7. Slope : Flat; 1%
8. Vegetation : No vegetation
9. Climate : Humid tropical. High rainfall during June-July (Southwest monsoon) and October-November (North-east monsoon) Total annual rainfall is 2001 mm with 102 rainy days in an year.

   Moisture regime: Udic tropustic

   Temperature: Max : 30.4°C
   Mini : 22.9°C
   Mean: 26.6°C

   Temperature regime: Hyperthermic.

B. General information on the soil

1. Parent material	: Recent marine deposits (Littoral sand)
2. Drainage	: Class 4; Well drained
3. Moisture condition in profile	: Moist throughout the profile. (Pedon examination : 3 days after rain)
4. Depth of groundwater	: 3.4 m
5. Stoniness and rock outcrops	: None
6. Evidence of erosion	: None/ Very slow
7. Presence of salt/alkali	: None
8. Human influence	: Barren land, only slight human influence.

C. Profile description

Horizon	Depth	Description
A	0 - 13 cm	Brown 7.5 YR 5/4 moist and light brown, 7.5YR 6/4 dry; sandyloam; Singlegrain; fine, common pores; roots none; diffused wavy boundary; pH 4.8
C_1	13 - 49cm	Strong brown, 7.5YR 5/8 moist and reddish yellow, 7.5YR 7/8 dry; sandyloam; singlegrain; fine, many pores; roots none; diffused, wavy boundary; pH 4.6
C_2	49 - 62 cm	Strong brown, 7.5YR 5/8 moist and reddish yellow, 7.5YR 7/8 dry; sandy loam; singlegrain; fine, common pores; roots none; diffused, wavy boundary; pH 4.6

C_3	62 - 80 cm	Yellowish red, 5 YR 4/6 moist and reddish yellow, 5 YR 6/6 dry; loamy sand ; single grain; fine, many pores; roots none; diffused, wavy boundary; pH 4.5
C_4	80 - 200 cm	Yellowish red,5YR 4/6 moist and yellowish red, 5YR 5/6 dry; loamysand; singlegrain; fine, many pores, roots none; diffused, wavy boundary; pH 4.6

Profile 12 Kazhakkoottam Eucalyptus

A. Information on the site

1. Soil name	.. Sandyloam
2. Higher order category	.. Entisols
3. Date	.. 19th March 1988
4. Location	.. Social forestry plantation of Eucalyptus tereticornis near the railway station,Kazhakkoo-ttam. Approx: N.La. 8/24 and E.Lo.77/15.
5. Elevation	.. 8 m
6. Land form	
a) Physiographic position	.. Plain
b) Surrounding landform	.. Flat
c) Microtopography	.. Artificial
7. Slope	.. Flat; 1%
8. Vegetation	.. Monoculture plantation of Eucalyptus tereticornis (1982 plantation)

9. Climate .. Humid tropical. High rainfall during June-July (South-west monsoon) and October-November (North-east monsoon). Total annual rainfall is 2001 mm with 102 rainy days in an year.

Moisture regime: Udic tropustic

Temperature: Max : 30.4°C

Mini : 22.9°C

Mean : 26.6°C

Temperature regime: Hyperthermic

B. General Information on the soil.

1. Parent material .. Recent marine deposits (Littoral sand)

2. Drainage .. Class 4; well drained

3. Moisture condition in profile. .. Moist throughout the profile (Pedon examination : 3 days after rain)

4. Depth of groundwater .. 4.6 m

5. Stoniness and rock outcrops. .. None

6. Evidence of erosion .. None / Very slow

7. Presence of salt/alkali .. None

8. Human influence .. Slight human influence.

C. Profile description

Horizon	Depth	Description
A	0 - 4 cm	Dark brown, 7.5YR 4/4 moist and brown, 7.5YR 5/4 dry; sandyloam; weak, very fine, granular; very fine, many pores; roots very fine, many; diffused, wavy boundary; pH 4.4

C_1	4-17 cm	Reddish brown, 5YR 5/4 moist and reddish brown, 5 YR 6/3 dry; sandyloam; single grain; fine, common pores; roots very fine, common; diffused, wavy boundary; pH 4.5
C_2	17-45 cm	Yellowish red, 5YR 4/6 moist and reddish yellow, 5 YR 6/6 dry; sandyloam; single grain; fine, common pores; roots medium, common; diffused, wavy boundary; pH 4.3
C_3	45-84 cm	Yellowish red, 5YR 4/6 moist and reddish yellow, 5YR 6/6 dry; sandyloam; single grain; fine, common pores; roots medium, few; diffused, wavy boundary; pH 4.3
C_4	84-200 cm	Yellowish red, 5 YR 4/6 moist and reddish yellow, 5 YR 6/6 dry; sandyloam; single grain; fine, common pores; roots medium, few; diffused, wavy boundary; pH 4.4

Profile 13. Kazhakkoottam Acacia

A. Information on the site

1. Soil name : Sandyloam
2. Higher order category : Entisols
3. Date : 19th March 1988
4. Location : Social forestry plantation of *Acacia auriculiformis* near the railway station, Kazhakkoottam. Approx: N.La 8/24 and E.Lo.77/15.
5. Elevation : 8 m

6. Land form

a) Physiographic position : Plain

b) Surrounding land form : Flat

c) Microt opography : Artificial

7. Slope : Flat; 1%

8. Vegetation : Monoculture plantation of Acacia auriculiformis (1982 plantation)

9. Climate : Humid tropical. High rainfall during June-July (South-west monsoon) and October-November(North-east monsoon).Total annual rainfall is 2001 mm with 102 rainy days in an year.

Moisture regime: Udic tropustic

Temperature : Max : 30.4°C

Mini : 22.9°C

Mean : 26.6°C

Temperature regime: Hyperthermic

B. General information on the soil.

1. Parent material : Recent marine deposits (Littoral sand)

2. Drainage : Class 4; well drained

3. Moisture condition in profile: Moist throughout the profile (Pedon examination : 3 days after rain)

4. Depth of groundwater : 4.6 m

5. Stoniness and rock outcrops : None

6. Evidence of erosion : None / very slow

7. Presence of salt/ alkali : None

8. Human influence : Little human influence.

C. Profile description

Horzon	Depth	Description
A	0 - 9 cm	Dark brown, 7.5YR 4/4 moist and brown, 7.5YR 5/2 dry; sandyloam; weak, fine, granular; very fine, many pores; roots fine, many; clear, smooth boundary; pH 4.3
C_1	9-33 cm	Yellowish red, 5YR 4/6 moist and yellowish red, 5YR 5/8 dry; sandyloam; Singlegrain; fine, common pores; roots very fine, few; diffused, smooth boundary; pH 4.3
C_2	33-64 cm	Yellowish red, 5YR 4/6 moist and yellowish red, 5YR 5/8 dry; sandyloam; Singlegrain; fine, common pores; roots fine, many; diffused smooth boundary; pH 4.2
C_3	64-80 cm	Yellowish red, 5YR 5/8 moist and reddish yellow,5YR 6/8 dry; sandyloam; single grain; fine, common pores; roots fine, many; diffused, smooth boundary; pH 4.2
C_4	80-200 cm	Yellowish red, 5YR 4/6 moist and yellowish red, 5YR 5/6 dry; sandyloam; singlegrain; fine, common pores; roots coarse, many; diffused, smooth boundary; pH 4.2

2. Soil physical characteristics

Table 3 gives the mechanical composition of the soil profiles. In Wynad reserve forest, the mean values of gravel, coarse sand, fine sand, silt and clay were 32.22, 29.42, 17.05, 12.86 and 39.59 per cent respectively. There was a slight increase in the gravel content in the surface horizon of Wynad barrenland (33.20) and Eucalyptus plantation (32.40) compared to that of reserve forest (29.60). There was not much variation in the case of coarse sand, fine sand and silt. The clay content increased both in the Wynad barrenland and Eucalyptus plantation. Downward movement of clay was marked in the case of Wynad Eucalyptus plantation.

The textural classification of the various horizons from different soil profiles of Wynad have shown that all the horizons were coming under clays. In the case of silt|clay ratio (L|A value), the mean values were similar in Wynad reserve forest and barren land while a decrease in the L|A values was observed in Eucalyptus plantation.

In Kottoor reserve forest, the gravel content varied from 27.5 to 49.9 per cent, coarse sand from 24.8 to 38.45 per cent, fine sand from 14.4 to 20.8 per cent, silt from 9.4 to 16.45 per cent and clay from 31.85 to 43.1 per cent. The mean values were 38.18, 31.48, 17.73, 12.29 and 39.61 per cent respectively. Gravel content increased markedly both in Kottoor barrenland and Eucalyptus plantation compared to reserve forest. The mean values were 51.86 and 49.72 per cent respectively. Not much variation was observed in the case of coarse sand, fine sand and silt. The surface horizon of

Table 3. Mechanical composition of the soil profiles (I.S.S.S. system)

Sample No.	Depth in cm	Gravel %	Coarse sand %	Fine sand %	Silt %	Clay %	Textural class	Silt/ clay ratio
	Profile 1. Wynad Reserve forest.							
1	0-36	29.60	32.40	17.10	10.95	36.55	Clay	0.30
2	36-57	30.50	31.80	16.30	10.20	41.80	Clay	0.24
3	57-84	30.90	29.60	16.75	10.45	39.75	Clay	0.26
4	84-127	33.20	28.20	17.20	15.80	39.65	Clay	0.39
5	127-200	36.90	25.10	17.90	16.90	40.20	Clay	0.42
	Mean	32.22	29.42	17.05	12.86	39.59	Clay	0.32
	Profile 2. Wynad Barrenland.							
6	0-30	33.20	34.90	17.95	9.20	37.80	Clay	0.24
7	30-55	33.80	28.20	17.80	12.60	41.30	Clay	0.31
8	55-89	34.30	26.20	16.30	14.25	41.75	Clay	0.34
9	89-138	34.60	24.75	17.35	16.35	41.20	Clay	0.39
10	138-200	35.80	24.90	17.70	15.90	40.75	Clay	0.39
	Mean	34.34	27.79	17.42	13.66	40.56	Clay	0.33
	Profile 3. Wynad Eucalyptus							
11	0-29	32.40	36.85	19.20	7.35	36.80	Clay	0.19
12	29-45	34.10	29.40	17.15	11.40	43.95	Clay	0.26
13	45-56	34.80	26.60	19.40	12.25	43.20	Clay	0.28
14	56-110	35.60	24.80	18.80	13.75	42.10	Clay	0.32
15	110-200	35.90	24.90	19.75	13.60	42.90	Clay	0.31
	Mean	34.56	28.51	18.86	11.67	41.79	Clay	0.27
	Profile 4. Kottoor Reserve forest							
16	0-17	27.50	38.45	20.80	9.40	31.85	Clay loam	0.29
17	17-45	32.80	33.25	14.40	10.50	42.20	Clay	0.24
18	45-83	42.50	29.50	15.60	12.80	43.10	Clay	0.29
19	83-200	49.90	24.80	20.10	16.45	41.30	Clay	0.39
	Mean	38.18	31.48	17.73	12.29	39.61	Clay	0.31
	Profile 5. Kottoor Barrenland							
20	0-8	38.50	42.80	16.90	7.10	34.50	Clay	0.21
21	8-21	41.80	36.90	12.80	9.50	41.40	Clay	0.22
22	21-37	52.50	33.50	15.10	12.20	39.80	Clay	0.30
23	37-61	56.50	30.20	17.10	13.10	40.70	Clay	0.32
24	61-200	70.00	26.80	19.95	15.40	39.10	Clay	0.39
	Mean	51.86	34.04	16.37	11.46	39.10	Clay	0.29

(contd..)

Table 3.(contd.)

Sample No.	Depth in cm	Gravel %	Coarse sand %	Fine sand %	Silt %	Clay %	Textural class	Silt/ clay ratio
	Profile 6. Kottoor Eucalyptus							
25	0-16	36.80	41.50	18.15	7.10	36.00	Clay	0.19
26	16-34	40.50	35.80	12.50	9.30	44.50	Clay	0.20
27	34-51	51.80	31.50	14.00	10.50	44.90	clay	0.23
28	51-93	55.50	28.80	16.80	12.16	43.20	Clay	0.28
29	93-200	64.00	24.00	19.20	15.35	41.20	Clay	0.37
	Mean	49.72	32.32	16.13	10.88	41.96	Clay	0.25
	Profile 7. Nileswar Cultivated land							
30	0-24	7.70	58.90	18.30	8.70	15.80	Sandyloam	0.55
31	24-40	8.50	56.50	20.70	10.30	14.60	Sandyloam	0.70
32	40-61	8.30	55.70	21.50	10.10	14.30	Sandyloam	0.70
33	61-85	9.50	52.60	23.60	11.50	13.70	Sandyloam	0.83
34	85-200	9.70	51.30	24.40	11.60	14.80	Sandyloam	0.78
	Mean	8.74	55.00	21.70	10.44	14.64	Sandyloam	0.71
	Profile 8. Nileswar Barrenland							
35	0-18	7.80	59.20	17.90	8.40	15.50	Sandyloam	0.54
36	18-35	8.70	57.10	19.70	10.10	13.80	Sandyloam	0.73
37	35-75	8.50	55.90	20.70	9.80	14.20	Sandyloam	0.69
38	75-200	9.60	53.10	22.60	11.20	14.50	Sandyloam	0.77
	Mean	8.65	56.33	20.23	9.88	14.50	Sandyloam	0.68
	Profile 9. Nileswar Acacia.							
39	0-16	9.60	59.90	17.30	7.10	16.50	Sandyloam	0.43
40	16-38	11.50	58.60	19.70	9.60	14.90	Sandyloam	0.64
41	38-60	11.70	56.40	19.40	9.50	15.70	Sandyloam	0.60
42	60-79	12.80	55.20	21.10	11.00	14.40	Sandyloam	0.76
43	79-200	13.10	53.70	21.90	11.10	15.10	Sandyloam	0.73
	Mean	11.74	56.76	19.88	9.66	15.32	Sandyloam	0.63
	Profile 10. Kazhakkoottam Cultivated land							
44	0-17	8.00	65.30	15.30	7.30	12.70	Sandyloam	0.57
45	17-38	10.60	63.70	18.40	8.10	10.65	Sandyloam	0.76
46	38-68	10.90	60.50	21.60	8.90	10.10	Sandyloam	0.88
47	68-88	11.50	59.40	22.80	10.10	7.85	Loamysand	1.28
48	88-200	11.80	59.20	20.10	10.90	9.20	Loamysand	1.18
	Mean	10.56	61.62	19.64	9.06	10.10	Sandyloam	0.89

(contd.)

Table 3 (contd.)

Sample No.	Depth in cm	Gravel %	Coarse sand %	Fine sand %	Silt %	Clay %	Textural class	Silt/ clay ratio
	Profile 11.Kazhakkoottam Barrenland.							
49	0-13	8.20	65.70	15.10	7.20	12.00	Sandyloam	0.60
50	13-44	11.10	64.90	18.20	7.80	10.50	Sandyloam	0.74
51	44-62	10.90	62.30	20.70	8.50	9.90	Sandyloam	0.85
52	62-80	11.60	61.50	21.90	9.70	8.10	Loamysand	1.19
53	80-200	12.00	58.70	20.50	9.90	9.50	Loamysand	1.04
	Mean	10.76	62.62	19.28	8.62	10.00	Sandyloam	0.86
	Profile 12. Kazhakkoottam Eucalyptus							
54	0-4	11.20	68.60	14.10	6.60	12.90	Sandyloam	0.51
55	4-17	13.50	65.70	16.70	7.30	12.20	Sandyloam	0.59
56	17-45	14.60	64.30	18.70	7.10	11.70	Sandyloam	0.60
57	45-84	15.20	61.90	21.40	9.20	10.30	Sandyloam	0.89
58	84-200	15.80	59.40	19.30	10.60	10.40	Sandyloam	1.01
	Mean	14.06	63.98	18.04	8.14	11.50	Sandyloam	0.70
	Profile 13. Kazhakkottam Acacia							
59	0-9	10.40	68.50	13.90	6.50	12.50	Sandyloam	0.52
60	9-33	13.10	66.10	15.70	7.70	12.10	Sandyloam	0.63
61	33-64	14.70	64.20	18.20	7.40	11.50	Sandyloam	0.64
62	64-80	14.90	62.70	20.20	8.90	11.10	Sandyloam	0.80
63	80-200	15.30	60.80	19.40	9.80	11.40	Sandyloam	0.85
	Mean	13.68	64.46	17.48	8.06	11.72	Sandyloam	0.68

Kottoor Eucalyptus plantation and Kottoor barren land showed slight decrease in fine sand and silt. Downward movement of clay was more in the case of soils under Eucalyptus plantation, the clay increase was to the tune of 1.2 times in the subsurface horizon.

Excepting the surface horizon of Kottoor reserve forest, all others came under the textural class clay. The surface horizon of Kottoor reserve forest was found to be clay loam. The L|A value was highest in Kottoor reserve forest (0.24-0.39) with a mean value of 0.31. The quotient was greatly reduced in Kottoor Eucalyptus plantation (0.19-0.37) with a mean value of 0.25. An intermediate range was observed in barren land (0.21-0.39) with a mean value of 0.29.

The gravel content in Nileswar cultivated land was in the range of 7.7 to 9.7 per cent, coarse sand varied from 51.3 to 58.9 per cent, fine sand from 18.3 to 24.4 per cent, silt from 8.7 to 11.6 per cent and clay from 13.7 to 15.8 per cent. The mean values were 8.74, 55.00, 21.70, 10.44 and 14.16 per cent respectively. The contents of the various fractions were similar in Nileswar barren land and Acacia plantation except that there was an increase in gravel content in Nileswar Acacia plantation.

The textural classification of the various soil horizons from different soil profiles of Nileswar have shown that all the horizons were sandyloams. In the case of L|A value, lowest value was observed in Nileswar Acacia plantation (0.43 - 0.76) with a mean value of 0.63. In Nileswar barrenland it varied from 0.54 to 0.77 with a mean value of 0.68 and the value was highest in Nileswar cultivated land (0.55-0.83) with a mean value of 0.71.

In Kazhakkottam cultivated land, gravel content varied from 8.0 to 11.8 per cent, coarse sand from 59.2 to 65.3 per cent, fine sand from 15.3 to 22.8 per cent, silt from 7.3 to 10.9 per cent and clay from 7.85 to 12.7 per cent. The mean values were 10.56, 61.62, 19.64, 9.06 and 10.10 per cent respectively. There was a great increase in gravel content both in Kazhakkottam Eucalyptus and Acacia plantations while it was similar in barrenland. Coarse sand, fine sand and silt fractions showed not much variation in the four profiles. The clay content was higher in the lower horizons of Eucalyptus and Acacia plantations compared to that of cultivated and barrenlands. The lowest horizons of cultivated land, barrenland, Eucalyptus and Acacia plantations contained 9.2, 9.5, 10.4 and 11.4 per cent respectively of clay.

The textural classification of the different horizons showed that most of them come under the class sandyloam. But it was found to loamysand in the lowest two horizons of cultivated and barrenlands. The L|A value was lowest in

Acacia plantation (0.52-0.85) with a mean value of 0.68 and a slightly higher value was observed in Eucalyptus plantation (0.51 - 1.01) with a mean value of 0.70. L|A value was highest in cultivated land (0.57-1.28) with a mean value of 0.89 followed by barrenland (0.60-1.19) with a mean value of 0.86.

Table 4 presents data of single value physical constants of different soil profiles. The parameters were bulk density, particle density, porosity, water holding capacity and volume expansion. In Wynad reserve forest, bulk density varied from 0.88 to 0.91 g $c\bar{c}^{1}$, particle density from 1.59 to 1.63 g $c\bar{c}^{1}$, porosity from 44.1 to 49.8 per cent, water holding capacity from 51.1 to 53.85 per cent and volume expansion from 1.79 to 3.65 per cent. The mean values were 0.89, 1.61, 47.04, 52.42 and 3.16 respectively. There was a slight increase in bulk density in Wynad Eucalyptus plantation (0.88-0.92 g $c\bar{c}^{1}$) with a mean value of 0.90 g $c\bar{c}^{1}$ and in Wynad barrenland (0.92-0.96 g $c\bar{c}^{1}$) with a mean value of 0.93 g $c\bar{c}^{1}$. Particle density did not vary much both in barrenland and Eucalyptus plantation from that of reserve forest.

In the case of porosity, water holding capacity and volume expansion, there was much variation in the profiles. Porosity of Wynad barrenland (41.51 per cent) and Wynad Eucalyptus plantation (40.79 per cent) were much lower than

Table 4. Single value physical constants of soil profiles

Sample No.	Depth in cm	Bulk density g cc^{-1}	Particle density g cc^{-1}	Porosity %	Water holding capacity %	Volume expansion %
	Profile 1. Wynad Reserve forest					
1	0-36	0.90	1.59	44.60	51.20	1.79
2	36-57	0.88	1.62	44.10	53.85	3.60
3	57-84	0.89	1.62	47.20	53.15	3.25
4	84-127	0.88	1.63	49.80	52.80	3.65
5	127-200	0.91	1.63	49.50	51.10	3.51
	Mean	0.89	1.61	47.04	52.42	3.16
	Profile 2. Wynad Barrenland					
6	0-30	0.92	1.52	40.25	39.10	1.95
7	30-55	0.92	1.53	42.15	43.20	1.98
8	55-89	0.93	1.58	41.60	38.95	1.70
9	89-138	0.95	1.59	41.90	40.85	1.68
10	138-200	0.96	1.62	41.65	38.25	1.25
	Mean	0.93	1.56	41.51	40.07	1.73
	Profile 3. Wynad Eucalyptus					
11.	0-29	0.92	1.51	39.85	38.90	1.88
12	29-45	0.90	1.54	41.30	42.85	3.56
13	45-56	0.89	1.58	40.15	39.30	3.38
14	56-110	0.88	1.62	41.60	41.10	3.10
15	110-200	0.90	1.60	41.05	36.60	2.96
	Mean	0.90	1.57	40.79	39.75	2.97
	Profile 4. Kottoor Reserve forest					
16	0-17	0.86	1.47	47.10	50.00	1.86
17	17-45	0.82	1.33	46.62	52.54	3.15
18	45-83	0.88	1.55	50.28	52.17	3.27
19	83-200	0.85	1.49	50.29	54.89	3.41
	Mean	0.85	1.46	48.57	52.40	2.92
	Profile 5. Kottoor Barrenland					
20	0-8	0.91	1.47	43.75	45.26	2.30
21	8-21	0.91	1.51	45.82	46.15	2.56
22	21-37	0.94	1.72	44.71	45.27	2.30
23	37-61	0.97	1.68	49.01	42.34	1.17
24	61-200	0.97	1.61	41.85	40.56	2.90
	Mean	0.94	1.59	45.02	43.91	2.24
	Profile 6. Kottoor Eucalyptus					
25	0-16	0.89	1.42	41.85	44.80	1.93
26	16-34	0.87	1.43	46.30	50.74	3.69
27	34-51	0.92	1.48	43.12	45.42	3.22
28	51-95	0.90	1.55	46.94	48.24	2.19
29	95-200	0.92	1.39	43.60	40.39	2.34
	Mean	0.90	1.45	44.36	45.91	2.67

(contd...)

Table 4 (contd.)

Sample No.	Depth in cm	Bulk density g cc1	Particle density g cc1	Porosity	Water holding capacity	Volume expansio
	Profile 7. Nileswar Cultivated land					
30	0-24	1.25	2.17	37.75	32.25	1.25
31	24-40	1.28	2.06	33.50	29.85	0.71
32	40-61	1.26	2.12	32.10	29.05	0.75
33	61-85	1.29	1.96	34.20	27.85	0.65
34	85-200	1.33	1.99	34.10	26.80	0.69
	Mean	1.28	2.06	34.33	29.16	0.81
	Profile 8. Nileswar Barrenland					
35	0-18	1.32	1.91	33.95	28.90	1.18
36	18-35	1.28	1.92	33.05	27.80	0.58
37	35-75	1.31	2.13	30.65	26.60	0.61
38	75-200	1.32	2.01	31.25	26.10	0.62
	Mean	1.31	1.99	32.22	27.35	0.74
	Profile 9. Nileswar Acacia					
39	0-16	1.21	1.88	34.80	29.36	1.23
40	16-38	1.29	1.90	32.10	27.25	0.69
41	38-60	1.28	1.89	30.60	26.80	0.72
42	60-79	1.31	1.87	33.25	26.55	0.70
43	79-200	1.31	1.87	33.20	25.90	0.65
	Mean	1.28	1.88	32.79	27.12	0.79
	Profile 10. Kazhakkottam cultivated land					
44	0-17	1.27	20.04	36.44	27.68	0.30
45	17-38	1.26	1.94	31.82	24.94	0.45
46	38-68	1.27	1.87	32.62	25.63	0.20
47	68-88	1.27	1.88	33.10	25.41	0.20
48	88-200	1.35	2.02	33.65	24.73	0.30
	Mean	1.28	1.93	33.52	25.67	0.29
	Profile 11. Kazhakkottam Barrenland					
49	0-13	1.30	1.90	33.41	26.41	0.20
50	13-44	1.31	1.94	32.78	24.76	0.10
51	44-62	1.29	1.94	32.78	25.25	0.25
52	62-80	1.33	1.92	31.34	23.65	0.30
53	80-200	1.34	1.91	30.87	22.86	0.46
	Mean	1.30	1.92	32.23	24.58	0.26
	Profile 12. Kazhakkottam Eucalyptus					
54	0-4	1.30	2.01	35.96	27.43	0.55
55	4-17	1.25	1.77	29.60	23.38	0.15
56	17-45	1.29	1.93	33.73	25.49	0.54
57	45-84	1.24	1.76	30.39	24.04	0.58
58	84-200	1.32	1.93	31.82	24.10	0.31
	Mean	1.28	1.88	32.30	24.88	0.42
	Profile 13. Kazhakkottam Acacia					
59	0-9	1.19	1.71	32.30	26.85	1.00
60	9-33	1.32	1.89	31.34	23.52	0.58
61	33-64	1.29	1.80	29.75	23.05	0.66
62	64-80	1.30	1.85	31.03	23.50	0.59
63	80-200	1.30	1.87	31.34	23.75	0.52
	Mean	1.28	1.82	31.15	24.13	0.67

that of reserve forest (47.04 per cent). The surface horizon of Wynad reserve forest had a porosity of 44.6 per cent while in barrenland it was 40.25 per cent and in Eucalyptus plantation it was 39.85 per cent. A great decrease in porosity was also observed in the subsurface horizons of barrenland and Eucalyptus plantation compared to that of reserve forest. Water holding capacity of Wynad barrenland (40.07 per cent) and Eucalyptus plantation (39.75 per cent) was much lower compared to reserve forest (52.42 per cent). This decrease was observed throughout the profile. In the case of volume expansion, the surface horizons did not vary much while there was a decrease in the subsurface horizons of Wynad barrenland and Eucalyptus plantation compared to that of reserve forest. Lowest volume expansion was observed in the subsurface horizon of barren land.

In Kottoor reserve forest, bulk density varied from 0.82 to 0.88 g cc^{-1}, particle density from 1.33 to 1.55 g cc^{-1}, porosity from 46.62 to 50.29 per cent water holding capacity from 50.00 to 54.89 per cent and volume expansion from 1.86 to 3.41 per cent. The mean values were 0.85, 1.46, 48.57, 52.40 and 2.92 respectively. An increase in bulk density was observed both in Kottoor barrenland (0.94 g cc^{-1}) and Eucalyptus plantation (0.90 g cc^{-1}) compared to reserve forest. Particle density of the three profiles did not show much variation.

Porosity, water holding capacity and volume expansion of Kottoor reserve forest were higher than that of barrenland and Eucalyptus plantation.Surface horizon of reserve forest had a porosity of 47.1 per cent while the corresponding values for barrenland and Eucalyptus plantation were 43.75 and 41.85 per cent respectively. Waterholding capacity of reserve forest was observed to be 52.4 per cent while in barren land it was only 43.91 per cent and Eucalyptus plantation had a waterholding capacity of 45.91 per cent. Porosity of reserve forest was 2.92 per cent while that of barrenland was 2.24 per cent and Eucalyptus plantation 2.67 per cent.

Eventhough the mean values of bulk density were observed to be similar in Nileswar cultivated land, barrenland and Acacia plantation, the surface horizon of cultivated land had a value of 1.25 g $c\bar{c}^{1}$ while that of barrenland was 1.32 g $c\bar{c}^{1}$ and Acacia plantation 1.21 g $c\bar{c}^{1}$. Not much variation was observed in the case of particle density.

Porosity of Nileswar cultivated land was 34.33 per cent while that of barrenland was 32.22 per cent and Acacia plantation 32.79 per cent. Surface horizon of cultivated land showed highest value of porosity (37.75 per cent) compared to that of barrenland (33.95 per cent) and Acacia plantation (34.80 per cent). Nileswar cultivated land had a waterholding capacity of 29.16 per cent while that of barrenland was 27.35 per cent and Acacia plantation had

27.12 per cent water holding capacity. Volume expansion was also highest in cultivated land (0.81 per cent) compared to barrenland (0.74 per cent) and Acacia plantation (0.79 per cent).

Bulk density and particle density of the four profiles from Kazhakkottam showed similar mean values. Bot there was a decrease in bulk density in the surface horizon of Acacia plantation (1.19 per cent) compared to that of cultivated land (1.27 per cent), barrenland (1.30 per cent) and Eucalyptus plantation (1.30 per cent).

Not much variation was observed in the case of porosit of the four profiles from Kazhakkoottam.The mean values were 33.52, 32.23, 32.30 and 31.15 per cent respectively for cultivated land, barrenland, Eucalyptus and Acacia plantations. In the case of water holding capacity also, not much variation was observed among the four profiles. The surface horizon of Acacia plantation showed highest value for volume expansion (1.00 per cent) compared to that of cultivated land (0.3 per cent), barrenland (0.2 per cent) and Eucalyptus plantation (0.55 per cent). The mean value was also highest in Acacia plantation (0.67 per cent) followed by Eucalyptus plantation (0.42 per cent) cultivated land (0.29 per cent) and barren land (0.26 per cent).

Soil aggregation analysis was carried out for all the thirteen profiles and the results are present in Tables 5 and 6.

Table 5. Aggregate size distribution in the soil profiles

Sample No.	Depth in cm	Aggregate per cent						
		< 0.1 mm	0.1-0.25 mm	0.25-0.5 mm	0.5-1.0 mm	1.0-2.0 mm	2.0-4.5 mm	4.5-8.0 mm
	Profile 1. Wynad Reserve forest							
1	0-36	7.6	8.1	8.0	7.8	4.2	20.3	44.0
2	36-57	9.6	8.7	8.9	4.9	6.1	18.1	43.7
3	57-84	6.9	9.8	11.4	9.6	8.0	17.7	36.5
4	84-127	6.9	10.8	10.7	8.5	7.7	19.7	35.7
5	127-200	7.1	13.5	13.8	9.6	12.0	21.5	22.5
	Mean	7.6	10.1	10.5	8.0	7.6	19.4	36.4
	Profile 2. Wynad Barrenland							
6	0-30	6.5	7.9	8.1	7.8	4.5	20.7	44.6
7	30-55	9.6	8.5	8.9	4.8	6.3	18.2	43.7
8	55-89	7.1	9.6	11.7	9.7	7.9	17.5	36.5
9	89-138	7.1	10.6	11.0	8.5	7.8	19.6	35.3
10	138-200	7.1	13.4	13.8	9.7	12.0	21.7	22.2
	Mean	7.4	10.0	10.7	8.1	7.7	19.5	36.4
	Profile 3. Wynad Eucalyptus							
11	0-29	6.0	7.6	7.7	7.6	4.8	21.2	45.1
12	29-45	9.1	8.3	8.6	4.6	6.6	18.6	44.2
13	45-56	6.7	9.5	11.4	9.5	8.1	17.9	36.9
14	56-110	6.7	10.5	10.7	8.3	8.0	19.9	35.9
15	110-200	6.7	13.3	13.5	9.5	12.2	22.0	22.8
	Mean	7.0	9.8	10.3	7.9	7.9	19.9	36.9
	Profile 4. Kottoor Reserve forest							
16	0-17	6.0	7.7	7.7	7.6	4.7	21.6	45.2
17	17-45	8.8	8.5	8.6	4.5	7.0	18.4	44.0
18	45-83	6.5	10.5	11.6	9.4	7.8	17.8	36.4
19	83-200	6.3	13.3	13.5	9.6	12.3	22.3	23.1
	Mean	6.9	10.0	10.3	7.7	7.9	20.0	37.1
	Profile 5. Kottoor Barrenland							
20	0-8	5.1	7.4	7.7	7.4	5.1	21.5	45.8
21	8-21	8.3	8.0	8.2	4.4	7.3	19.1	44.6
22	21-37	6.0	9.3	11.3	9.4	8.3	18.0	37.7
23	37-61	6.0	10.5	10.3	8.1	8.3	20.5	36.1
24	61-200	6.0	12.9	13.5	9.5	12.4	22.4	23.3
	Mean	6.2	9.6	10.2	7.7	8.2	20.3	37.5
	Profile 6. Kottoor Eucalyptus							
25	0-16	5.2	7.3	7.5	7.5	5.2	21.7	45.6
26	16-34	8.2	8.1	8.3	4.4	7.2	19.2	44.6
27	34-51	6.1	9.3	11.2	9.4	8.3	18.3	37.4
28	51-95	6.2	10.3	10.5	8.2	8.2	20.3	36.3
29	95-200	6.2	13.1	13.3	9.4	12.4	22.4	23.2
	Mean	6.3	9.6	10.1	7.7	8.2	20.3	37.4
	Profile 7. Nileswar Cultivated land							
30	0-24	8.5	16.2	34.2	29.0	7.8	2.9	1.4
31	24-40	8.1	17.3	35.4	28.2	8.0	2.6	0.4
32	40-61	7.7	19.2	36.8	27.0	6.9	1.4	0.5
33	61-85	7.1	18.8	37.9	29.0	5.4	1.8	0.1
34	85-200	6.9	19.2	37.8	29.6	5.2	0.2	0.1
	Mean	7.6	18.1	36.4	28.5	6.6	1.7	0.5

(contd..)

Table 5 (contd.)

Sample No.	Depth in cm	Aggregate per cent						
		<0.1 mm	0.1-0.25 mm	0.25-0.5 mm	0.5-1.0 mm	1.0-2.0 mm	2.0-4.5 mm	4.5-8.0 mm
	Profile 8. Nileswar Barrenland							
35	0-18	8.0	15.8	34.2	28.8	8.4	3.2	1.6
36	18-35	7.7	17.1	35.3	28.1	8.3	3.0	0.6
37	35-75	7.5	19.0	36.9	27.0	7.3	1.4	0.6
38	75-200	6.9	18.8	37.9	28.8	5.5	2.0	0.1
	Mean	7.5	17.6	36.0	28.1	7.3	2.4	0.7
	Profile 9 Nileswar Acacia							
39	0-16	8.0	15.9	34.1	28.9	8.2	3.3	1.6
40	16-38	7.8	17.1	35.1	28.0	8.4	3.0	0.6
41	38-60	7.3	19.1	36.7	26.9	7.3	1.6	0.6
42	60-79	6.9	18.7	37.8	29.0	5.6	1.9	0.1
43	79-200	6.7	19.0	37.8	29.7	5.4	0.3	0.1
	Mean	7.3	17.9	36.3	28.5	6.9	2.0	0.6
	Profile 10. Kazhakkoottam Cultivated land							
44	0-17	7.9	15.7	33.9	28.7	8.6	3.5	1.7
45	17-38	7.6	16.8	34.8	27.9	8.7	3.3	0.9
46	38-68	7.0	18.9	36.1	26.7	7.6	1.9	0.8
47	68-88	6.5	18.5	37.6	29.0	6.0	2.3	0.1
48	88-200	6.3	18.9	37.4	29.5	6.0	0.8	0.1
	Mean	7.0	17.7	35.9	28.3	7.3	2.3	0.7
	Profile 11. Kazhakkoottam Barrenland.							
49.	0-13	7.3	15.6	33.6	28.9	9.1	3.6	1.9
50	13-44	7.1	16.1	34.6	28.4	9.1	3.4	1.3
51	44-62	6.7	18.3	35.7	26.8	8.1	2.2	1.2
52	62-80	6.1	18.2	37.4	29.3	6.2	2.6	0.2
53	80-200	5.9	18.6	36.8	30.0	6.3	1.2	0.2
	Mean	6.6	17.3	35.6	28.6	7.7	2.6	0.9
	Profile 12. Kazhakkottam Eucalyptus							
54	0-4	7.4	15.5	33.5	29.0	9.1	3.7	1.8
55	4-17	7.0	16.2	34.6	28.5	9.0	3.6	1.1
56	17-45	6.5	18.2	35.9	26.9	8.2	2.2	1.1
57	45-84	6.1	18.1	37.5	29.2	6.4	2.5	0.2
58	84-200	5.8	18.6	37.0	29.9	6.4	1.1	0.2
	Mean	6.5	17.3	35.7	28.7	7.8	2.6	0.8
	Profile 13. Kazhakkottam Acacia.							
59	0-9	7.7	15.6	33.7	28.8	8.8	3.6	1.8
60	9-33	7.3	16.6	34.6	28.2	8.8	3.5	1.0
61	33-64	6.9	18.6	35.8	26.7	7.9	2.2	0.9
62	64-80	6.2	18.4	37.4	29.1	6.3	2.4	0.2
63	80-200	6.0	18.7	37.3	29.6	6.3	1.0	0.1
	Mean	6.8	17.5	35.7	28.4	7.6	2.5	0.8

Table 6. Quantitative index of water stability of soil aggregate of the soil profiles.

Sample No.	Depth in cm	Aggregate >0.25 mm (%)	Mean weight Diameter mm	Aggregate stability(%)
	Profile 1. Wynad Reserve forest			
1	0-36	84.3	3.71	65.25
2	36-57	81.7	3.52	56.66
3	57-84	83.2	3.23	51.36
4	84-127	82.3	3.10	45.30
5	127-200	78.9	2.78	36.55
	Mean	82.0	3.26	51.02
	Profile 2. Wynad Barrenland			
6	0-30	83.8	3.69	63.20
7	30-55	81.5	3.51	53.78
8	55-89	83.3	3.26	52.29
9	89-138	82.2	3.10	44.80
10	138-200	79.4	2.95	38.35
	Profile 3. Wynad Eucalyptus			
11	0-29	86.3	3.86	64.10
12	29-45	82.6	3.71	55.75
13	45-56	83.8	3.43	53.45
14	56-110	82.8	3.16	46.16
15	110-200	80.0	2.91	38.25
	Profile 4. Kottoor Reserve forest			
16	0-17	86.8	3.79	63.15
17	17-45	82.5	3.61	42.25
18	45-83	83.0	2.79	38.20
19	83-200	80.8	2.61	34.33
	Mean	83.2	3.20	44.48
	Profile 5. Kottoor Barrenland			
20	0-8	87.5	3.65	62.77
21	8-21	83.6	3.55	44.15
22	21-37	84.7	3.32	42.80
23	37-61	83.3	2.90	37.88
24	61-200	81.1	2.74	34.61
	Mean	84.0	3.23	44.44
	Profile 6. Kottoor Eucalyptus			
25	0-16	87.5	3.78	62.75
26	16-34	83.7	3.60	42.37
27	34-51	84.6	3.34	41.20
28	51-95	83.5	2.85	39.87
29	95-200	80.7	2.76	36.63
	Mean	84.0	3.26	44.56
	Profile 7. Nileswar Cultivated land.			
30	0-24	75.3	0.65	44.48
31	24-40	74.6	0.62	41.75
32	40-61	72.6	0.58	38.28
33	61-85	74.2	0.54	35.00
34	85-200	72.9	0.51	30.15
	Mean	73.9	0.58	37.93

Table 6 (contd.)

Sample No.	Depth in cm	Aggregate >0.25 mm (%)	Mean weight Diameter	Aggregate stability(%)
	Profile 8. Nileswar Barrenland			
35	0-18	76.2	0.64	44.20
36	18-35	75.3	0.62	41.15
37	35-75	73.2	0.59	34.75
38	75-200	74.3	0.50	29.65
	Mean	74.7	0.58	37.43
	Profile 9. Nileswar Acacia.			
39	0-16	76.1	0.69	46.75
40	16-38	75.1	0.64	42.15
41	38-60	73.1	0.61	38.78
42	60-79	74.4	0.57	34.16
43	79-200	73.3	0.55	30.81
	Mean	74.4	0.61	38.53
	Profile 10. Kazhakkottam Cultivated land			
44	0-17	76.4	0.75	46.71
45	17-38	75.6	0.66	43.19
46	38-68	73.1	0.62	40.28
47	68-88	75.0	0.60	34.25
48	88-200	73.8	0.59	31.81
	Mean	74.7	0.64	39.24
	Profile 11. Kazhakkottam Barrenland			
49	0-13	77.1	0.75	46.85
50	13-44	76.8	0.73	45.05
51	44-62	74.0	0.68	40.28
52	62-80	75.7	0.66	37.75
53	80-200	74.5	0.62	35.38
	Mean	75.6	0.68	41.06
	Profile 12. Kazhakkottam Eucalyptus			
54	0-4	77.1	0.79	45.15
55	4-17	76.8	0.74	44.33
56	17-45	74.3	0.69	42.27
57	45-84	75.8	0.66	37.15
58	84-200	74.6	0.62	36.18
	Mean	75.6	0.70	41.01
	Profile 13. Kazhakkottam Acacia			
59	0-9	76.7	0.78	51.56
60	9-33	76.1	0.70	45.28
61	33-64	73.5	0.67	40.19
62	64-80	75.4	0.63	33.16
63	80-200	74.3	0.60	30.33
	Mean	75.2	0.67	40.10

A perusal of the data in Table 6 will reveal that all the soil profiles from forested areas of Wynad and Kottoor contained macroaggregates (diameter higher than 0.25 mm) in abundance. The proportion of macroaggregates in the Wynad reserve forest, barrenland and Eucalyptus plantation were in the ranges of 78.9 to 84.3, 79.4 to 83.8 and 80.0 to 86.3 per cent respectively. The mean values were 82.0, 82.0 and 83.1 per cent respectively for the above three profiles which speak for their excellent structural condition. The percentage of macroaggregates in the surface horizons of Wynad reserve forest, barrenland and Eucalyptus plantation were 84.3, 83.8 and 86.3 per cent respectively.

Mean weight diameter (MWD) of all the three profiles from Wynad decreased with depth. Highest value was observed in Wynad Eucalyptus plantation (2.19 - 3.86 mm) with a mean value of 3.41 mm followed by Wynad barrenland (2.95-3.69 mm) with a mean value of 3.30 mm and reserve forest had MWD in the range 2.78 to 3.71 mm with a mean value of 3.26 mm.

Not much variation was observed in aggregate stability among the three profiles from Wynad. The mean values were 51.02, 50.48 and 51.54 per cent respectively for Wynad reserve forest, barrenland and Eucalyptus plantation.

Three profiles from Kottoor also had higher content of macroaggregates. The mean values for Kottoor reserve forest, barrenland and Eucalyptus plantation were 83.2, 84.0

and 84.0 per cent respectively. Surface horizons of these three profiles recorded macroaggregate contents of 86.8, 87.5 and 87.5 per cent respectively which show their excellent structural conditions.

MWD of all the three profiles from Kottoor decreased with depth. The values were similar in all the three locations with mean values of 3.20, 3.23 and 3.26 mm respectively for Kottoor reserve forest, barrenland and Eucalyptus plantation.

Aggregate stability showed no variation among the three profiles from Kottoor. The values ranged from 34.33 to 63.15, 34.61 to 62.77 and 36.63 to 62.75 per cent respectively in Kottoor reserve forest, barrenland and Eucalyptus plantation.

The percentage of macroaggregates in the profiles of Nileswar cultivated land, barrenland and Acacia plantation were in the range of 72.6 to 75.3, 73.2 to 76.2 and 73.1 to 76.1 per cent respectively. The mean values were 73.9, 74.7 and 74.4 per cent.

A decrease in MWD was observed with depth in all the three soil profiles from Nileswar. Profile from Acacia Plantation recorded a slightly higher value (0.61 mm) compared to cultivated land (0.58 mm) and barrenland (0.58 mm)

Eventhough the mean values of aggregate stability in the three profiles from Nileswar showed not much variation, the surface horizon of Acacia plantation had a higher

aggregate stability (46.75 per cent) compared to that of cultivated land (44.48 per cent) and barrenland (44.20 per cent).

The percentage of macroaggregates in the profiles of Kazhakkoottam cultivated land, barrenland, Eucalyptus and Acacia plantations were in the range of 73.1 to 76.4, 74.0 to 77.1, 74.3 to 77.1 and 73.5 to 76.7 per cent respectively. The mean values were 74.7, 75.6, 75.6 and 75.2 per cent.

A decrease in MWD was observed with depth in all the four profiles from Kazhakkoottam. The surface horizons of Eucalyptus plantation (0.79 mm) and Acacia plantation (0.78 mm) showed higher MWD compared to cultivated land (0.75 mm) and barrenland (0.75 mm). The mean values were 0.64, 0.68, 0.70 and 0.67 mm respectively for cultivated land, barrenland, Eucalyptus and Acacia plantations.

The mean values of aggregate stability showed not much variation among the four profiles from Kazhakkoottam. But the surface horizon of Acacia plantation recorded a high value of 51.56 per cent compared to that of cultivated land (46.71 per cent), barrenland (46.85 per cent) and Eucalyptus plantation (45.15 per cent).

Table 7 gives the soil moisture content and water dispersible clay content of soil samples of different horizons of the thirteen profiles.

Table 7. Soil moisture content and water dispersible clay of the soil profiles.

Sample No.	Depth in cm	Moisture %	Water dispersible clay %
	Profile 1. Wynad Reserve forest		
1	0-36	19.10	7.9
2	36-57	17.65	7.1
3	57-84	19.76	6.5
4	84-127	22.70	6.2
5	127-200	23.46	5.4
	Mean	20.53	6.6
	Profile 2. Wynad Barrenland		
6	0-30	9.30	6.4
7	30-55	11.11	6.1
8	55-89	17.90	5.9
9	89-138	17.95	5.6
10	138-200	18.34	5.0
	Mean	14.92	5.8
	Profile 3. Wynad Eucalyptus		
11	0-29	8.10	6.1
12	29-45	9.30	5.8
13	45-56	9.89	5.7
14	56-110	9.30	5.2
15	110-200	11.11	4.6
	Mean	9.54	5.4
	Profile 4. Kottoor Reserve forest		
16	0-17	33.33	7.3
17	17-45	33.33	6.4
18	45-83	27.39	4.9
19	83-200	33.33	4.5
	Mean	31.84	5.7
	Profile 5. Kottoor Barrenland		
20	0-8	14.29	5.7
21	8-21	19.05	5.1
22	21-37	17.65	4.6
23	37-61	23.46	4.3
24	61-200	21.21	4.0
	Mean	19.13	4.7
	Profile 6.Kottoor Eucalyptus		
25	0-16	26.50	5.4
26	16-34	22.69	5.2
27	34-51	16.95	4.0
28	51-95	26.58	3.9
29	95-200	29.03	3.7
	Mean	24.35	4.4

(contd..)

Table 7. (contd.)

Sample No.	Depth in cm	Moisture %	Water dispersible clay %
	Profile 7. Nileswar Cultivated land		
30	0-24	4.20	2.6
31	24-40	4.38	2.4
32	40-61	3.62	2.1
33	61-85	3.62	2.0
34	85-200	3.20	1.9
	Mean	3.80	2.2
	Profile 8. Nileswar Barrenland		
35	0-18	3.75	2.4
36	18-35	2.90	2.2
37	35-75	3.65	1.9
38	75-200	4.65	1.7
	Mean	3.73	2.0
	Profile 9. Nileswar Acacia		
39	0-16	4.20	2.4
40	16-38	3.10	2.1
41	38-60	3.10	1.8
42	60-79	3.62	1.7
43	79-200	3.10	1.5
	Mean	3.42	1.9
	Profile 10. Kazhakkottam Cultivated land		
44	0-17	5.82	3.0
45	17-38	5.26	2.8
46	38-68	5.82	2.7
47	68-88	5.26	2.5
48	88-200	5.82	2.1
	Mean	5.59	2.6
	Profile 11. Kazhakkottam Barrenland		
49	0-13	4.17	2.9
50	13-44	5.82	2.7
51	44-62	4.71	2.4
52	62-80	4.71	2.2
53	80-200	4.71	2.0
	Mean	4.82	2.4
	Profile 12. Kazhakkottam Eucalyptus		
54	0-4	4.71	2.4
55	4-17	4.71	2.2
56	17-45	3.09	1.6
57	45-84	3.63	1.2
58	84-200	2.56	1.1
	Mean	3.74	1.7
	Profile 13. Kazhakoottam Acacia		
59	0-9	4.71	2.8
60	-33	4.17	2.6
61	33-64	4.71	2.2
62	64-80	3.63	1.8
63	80-200	2.56	1.4
	Mean	3.95	2.1

Moisture content in the profile from Wynad reserve forest, barrenland and cultivated land increased with depth. Profiles were examined one week after a rain. Highest values were recorded in the horizons of reserve forest (19.10 - 23.46 per cent) with a mean value of 20.53 per cent. Barrenland contained 9.30 to 18.34 per cent moisture with a mean value of 14.92 per cent and drastic depletion of moisture was observed in Eucalyptus plantation which contained 8.10 to 11.11 per cent moisture with a mean value of only 9.54 per cent.

A decrease in water dispersible clay content was observed both in Wynad barrenland (5.8 per cent) and Eucalyptus plantation (5.4 per cent) compared to reserve forest (6.6 per cent) water dispersible clay content decreased with depth in all the three profiles.

Drastic depletion of moisture was also observed in Kottoor Eucalyptus plantation (24.35 per cent) compared to reserve forest (31.84 per cent). Barrenland recorded moisture content of 19.13 per cent. The range values were 27.39 to 33.33, 14.29 to 23.46 and 16.95 to 29.03 per cent respectively in reserve forest, barrenland and Eucalyptus plantation.

Water dispersible clay content of Kottoor Eucalyptus plantation was found to be lowest (4.4 per cent) among the three profiles from Kottoor. Barrenland contained 4.7 per cent and reserve forest 5.7 per cent water dispersible clay.

Eventhough the mean values of the moisture content in soils under Nileswar Acacia plantation was lower (3.42 per cent) compared to that of barrenland (3.73 per cent) and cultivated land (3.80 per cent), the surface horizons of cultivated land and Acacia plantation recorded same percent of moisture (4.2 per cent). Surface horizon of barren land recorded a moisture content of 3.75 per cent.

Water dispersible clay content was highest in Nileswar cultivated land (2.2 per cent) compared to that of barren land (2.0 per cent) and Acacia plantation (1.9 per cent). The values ranged from 1.9 to 2.6, 1.7 to 2.4 and 1.5 to 2.4 per cent respectively in cultivated land, barren land and Acacia plantation.

Lowest moisture percentage was recorded in soils under Eucalyptus plantation (3.74 per cent) among the four profiles from Kazhakkoottam. Acacia plantation contained 3.95 per cent while that of barrenland was 4.82 per cent. Kazhakkoottam cultivated land contained 5.59 per cent moisture. Moisture contents in the lowest horizons of profiles under Eucalyptus (2.56 per cent) and Acacia (2.56 per cent) plantations were found to be very low compared to that of cultivated land (5.82 per cent) and barren land (4.71 per cent).

Water dispersible clay content was least in soils under Eucalyptus plantation (1.7 per cent). Kazhakkoottam Acacia plantation recorded 2.1 per cent water dispersible

clay while that of barrenland was 2.4 per cent and cultivated land 2.6 per cent.

3. Soil chemical characteristics

Table 8 gives the chemical composition of the soil samples of different horizons of thirteen profiles. The chemical parameters were pH, E.C., organic carbon, C.E.C, total N, P_2O_5, K_2O, CaO, MgO, Fe_2O_3 and Al_2O_3 expressed as their percent on oven dry basis.

Soil pH

The pH of the various horizons of different profiles showed an acid reaction in all samples. In all the four locations, monoculture plantations of Eucalyptus and Acacia recorded a lower pH value compared to that of reserve forest or cultivated land. Wynad Eucalyptus recorded a pH of 5.3 when the reserve forest had a pH of 5.9. The barrenland had a pH of 6.3. pH of Kottoor barrenland (4.5) and Eucalyptus plantation (4.6) were lower than that of reserve forest (4.9). In sandy tract of Nileswar, Acacia plantation had the lowest value (4.1) compared to barrenland (4.8) and cultivated land (5.2). Eucalyptus (4.4) and Acacia (4.2) plantations of Kazhakkoottam showed lowering of pH compared to that of cultivated land (4.7) and barrenland (4.6).

Electrical conductivity

Not much variation was observed in the case of electrical conductivity (E.C). The forested profiles from Wynad

Table 8. Chemical composition of the soil profiles

Sample No.	Depth in cm	pH	E.C. $dS\ m^{-1}$	C.E.C. $cmol\ kg^{-1}$	Per cent on ovendry basis							
					Organic carbon	Total N	Total P_2O_5	Total K_2O	Total CaO	Total MgO	Total Fe_2O_3	Total Al_2O_3
	Profile 1. Wynad Reserve forest											
1	0-36	6.1	0.17	17.7	3.28	0.184	0.088	0.479	0.067	0.042	7.93	10.28
2	36-57	6.0	0.16	14.2	1.43	0.104	0.085	0.481	0.069	0.038	10.31	12.07
3	57-84	6.0	0.15	11.3	1.13	0.086	0.078	0.424	0.056	0.039	11.96	13.68
4	84-127	5.7	0.13	5.8	0.71	0.063	0.061	0.368	0.041	0.032	12.34	15.88
5	127-200	5.8	0.14	5.3	0.52	0.053	0.057	0.323	0.063	0.030	12.16	19.91
	Mean	5.9	0.15	10.9	1.41	0.098	0.074	0.415	0.059	0.036	10.94	14.36
	Profile 2. Wynad Barrenland											
6	0-30	6.1	0.19	13.9	1.84	0.146	0.076	0.320	0.061	0.039	8.17	12.95
7	30-55	6.2	0.16	13.0	1.21	0.104	0.067	0.354	0.044	0.036	11.19	14.08
8	55-89	6.2	0.20	10.3	0.72	0.067	0.060	0.356	0.056	0.038	12.69	17.21
9	89-138	6.5	0.19	8.2	0.50	0.051	0.054	0.320	0.062	0.031	12.14	18.87
10	138-200	6.5	0.26	4.8	0.39	0.042	0.051	0.318	0.055	0.029	11.97	21.63
	Mean	6.3	0.20	10.0	0.93	0.082	0.062	0.334	0.056	0.035	11.43	16.95
	Profile 3. Wynad Eucalyptus											
11	0-29	5.2	0.18	16.4	1.95	0.151	0.069	0.315	0.037	0.021	10.76	13.49
12	29-45	5.5	0.19	14.0	1.26	0.103	0.061	0.362	0.059	0.029	12.34	14.96
13	45-56	5.1	0.17	13.2	0.76	0.078	0.054	0.365	0.056	0.033	14.89	17.17
14	56-110	5.6	0.17	10.3	0.50	0.061	0.047	0.312	0.057	0.028	13.78	19.97
15	110-200	5.2	0.16	5.1	0.40	0.053	0.036	0.289	0.067	0.025	13.13	21.64
	Mean	5.3	0.17	11.8	0.97	0.089	0.053	0.329	0.055	0.027	12.98	17.45
	Profile 4. Kottoor Reserve forest											
16	0-17	5.2	0.22	17.1	3.53	0.212	0.089	0.457	0.061	0.032	7.83	10.15
17	17-45	5.0	0.26	15.4	2.83	0.210	0.084	0.459	0.060	0.026	9.61	11.96
18	45-83	4.8	0.16	10.5	0.74	0.090	0.079	0.398	0.037	0.025	11.53	14.68
19	83-200	4.5	0.24	4.8	0.52	0.071	0.063	0.391	0.025	0.023	11.15	18.73
	Mean	4.9	0.22	12.0	1.52	0.146	0.079	0.426	0.046	0.027	10.03	13.88

(contd.)

Sample No.	Depth in cm	pH	E.C. dSm^{-1}	C.E.C. cmol kg^{-1}	Organic carbon	Total N	Total P_2O_5	Total K_2O	Total CaO	Total MgO	Total Fe_2O_3	Total Al_2O_3
					Per cent on ovendry basis							
	Profile 5. Kottoor Barrenland											
20	0-8	5.0	0.25	14.6	1.92	0.157	0.080	0.346	0.033	0.024	8.09	12.1
21	8-21	4.4	0.25	13.5	1.63	0.178	0.078	0.374	0.026	0.027	9.97	14.2
22	21-37	4.7	0.22	11.3	1.21	0.170	0.075	0.388	0.017	0.033	11.61	16.9
23	37-61	4.4	0.29	7.1	0.73	0.104	0.067	0.320	0.025	0.028	11.93	17.8
24	61-200	4.1	0.25	4.6	0.42	0.061	0.061	0.318	0.022	0.026	11.68	19.7
	Mean	4.5	0.25	10.2	1.18	0.134	0.072	0.349	0.025	0.028	10.66	16.2
	Profile 6. Kottoor Eucalyptus											
25	0-16	4.6	0.31	15.5	2.45	0.202	0.077	0.336	0.028	0.023	9.31	12.6
26	16-34	4.4	0.25	13.1	2.02	0.215	0.071	0.372	0.037	0.028	1065	14.4
27	34-51	4.4	0.24	11.6	0.53	0.073	0.068	0.391	0.054	0.034	13.63	17.1
28	51-95	4.9	0.19	7.5	0.50	0.071	0.051	0.315	0.043	0.025	12.91	18.4
29	95-200	4.7	0.17	4.8	0.40	0.058	0.034	0.308	0.027	0.021	12.63	20.2
	Mean	4.6	0.23	10.5	1.18	0.124	0.060	0.344	0.038	0.026	11.83	16.6
	Profile 7. Nileswar cultivated land											
30	0-24	5.1	0.21	3.9	0.33	0.026	0.047	0.036	0.094	0.039	0.81	2.6
31	24-40	5.2	0.34	3.6	0.16	0.014	0.039	0.033	0.087	0.036	0.79	2.9
32	40-61	5.4	0.32	3.4	0.09	0.009	0.034	0.030	0.089	0.035	0.73	3.1
33	61-85	5.2	0.24	3.1	0.06	0.006	0.028	0.028	0.071	0.032	0.65	3.3
34	85-200	4.9	0.35	2.6	0.04	0.005	0.025	0.029	0.079	0.029	0.60	3.4
	Mean	5.2	0.29	3.3	0.14	0.012	0.035	0.031	0.084	0.034	0.72	3.1
	Profile 8 Nileswar Barrenland											
35	0-18	4.7	0.31	4.0	0.29	0.028	0.031	0.028	0.089	0.035	0.83	2.7
36	18-35	5.2	0.22	3.7	0.15	0.015	0.029	0.026	0.074	0.037	0.80	3.1
37	35-75	4.3	0.41	3.3	0.06	0.006	0.026	0.024	0.096	0.033	0.71	3.3
38	75-200	4.9	0.20	2.7	0.04	0.005	0.019	0.027	0.093	0.030	0.63	3.4
	Mean	4.8	0.29	3.4	0.14	0.014	0.026	0.026	0.088	0.034	0.74	3.1
	Profile 9. Nileswar Acacia											
39	0-16	4.1	0.23	4.2	0.53	0.054	0.030	0.028	0.041	0.031	0.97	2.9
40	16-38	4.6	0.28	3.9	0.31	0.034	0.028	0.025	0.067	0.038	0.93	3.2
41	38-60	3.9	0.31	3.7	0.15	0.017	0.024	0.024	0.098	0.039	0.87	3.4
42	60-79	4.1	0.26	2.8	0.10	0.011	0.020	0.026	0.072	0.034	0.73	3.6
43	79-200	3.7	0.19	2.6	0.09	0.010	0.018	0.026	0.061	0.024	0.63	3.8
	Mean	4.1	0.25	3.4	0.24	0.025	0.024	0.026	0.068	0.033	0.83	3.4

(contd.)

Table 8 (contd.)

Sample No.	Depth in cm	pH	E.C. dSm^{-1}	C.E.C. $cmol\ kg^{-1}$	Per cent on ovendry basis							
					Organic carbon	Total N	Total P_2O_5	Total K_2O	Total CaO	Total MgO	Total Fe_2O_3	Total Al_2O_3
	Profile 10. Kazhakkoottam cultivated land											
44	0-17	5.1	0.16	3.2	0.31	0.022	0.060	0.035	0.069	0.061	0.70	2.03
45	17-38	4.7	0.15	3.1	0.19	0.015	0.051	0.031	0.048	0.050	0.68	2.28
46	38-68	4.7	0.14	2.8	0.11	0.011	0.048	0.028	0.049	0.046	0.63	2.39
47	68-88	4.6	0.14	2.7	0.08	0.010	0.021	0.026	0.050	0.049	0.61	2.61
48	88-200	4.6	0.14	2.5	0.07	0.010	0.019	0.026	0.053	0.046	0.58	2.69
	Mean	4.7	0.15	2.9	0.15	0.014	0.040	0.029	0.054	0.051	0.64	2.40
	Profile 11. Kazhakkoottam Barrenland											
49	0-13	4.8	0.15	3.1	0.27	0.021	0.035	0.030	0.067	0.060	0.73	2.35
50	13-44	4.6	0.15	3.0	0.08	0.007	0.031	0.026	0.051	0.053	0.71	2.48
51	44-62	4.6	0.14	2.8	0.07	0.007	0.028	0.025	0.047	0.057	0.68	2.75
52	62-80	4.5	0.14	2.6	0.07	0.007	0.023	0.026	0.056	0.049	0.60	2.88
53	80-200	4.6	0.14	2.3	0.07	0.008	0.020	0.027	0.050	0.043	0.59	3.13
	Mean	4.6	0.14	2.8	0.11	0.010	0.027	0.027	0.054	0.052	0.66	2.72
	Profile 12. Kazhakkoottam Eucalyptus											
54	0-4	4.4	0.15	3.3	0.53	0.056	0.040	0.034	0.021	0.046	0.83	2.39
55	4-17	4.5	0.15	3.2	0.29	0.032	0.031	0.031	0.039	0.048	0.81	2.51
56	17-45	4.3	0.14	2.9	0.26	0.029	0.027	0.029	0.019	0.063	0.78	2.73
57	45-84	4.3	0.14	2.8	0.21	0.026	0.026	0.025	0.039	0.056	0.71	2.91
58	84-200	4.4	0.14	2.5	0.18	0.023	0.019	0.027	0.038	0.053	0.61	3.28
	Mean	4.4	0.14	2.9	0.29	0.033	0.029	0.029	0.031	0.053	0.75	2.76
	Profile 13. Kazhakkoottam Acacia											
59	0-9	4.3	0.20	3.9	0.63	0.058	0.038	0.031	0.053	0.037	0.87	2.48
60	9-33	4.3	0.15	3.1	0.34	0.033	0.027	0.028	0.043	0.051	0.83	2.63
61	33-64	4.2	0.15	2.6	0.27	0.027	0.025	0.025	0.050	0.057	0.76	2.91
62	64-80	4.2	0.14	2.7	0.23	0.024	0.021	0.029	0.089	0.045	0.74	2.98
63	80-200	4.2	0.14	2.4	0.21	0.025	0.018	0.029	0.073	0.043	0.62	3.15
	Mean	4.2	0.16	2.9	0.34	0.033	0.026	0.028	0.062	0.047	0.76	2.83

and Kottoor recorded values ranging from 0.13 to 0.31dS m^{-1}. The sandy profiles of Nileshwar and Kazhakkoottam showed E.C. values ranging from 0.14 to 0.41 dSm^{-1}. The mean values showed not much variation among soil profiles of a particular location.

Organic carbon

A decrease in organic carbon percentage was observed by deforestation and planting with Eucalyptus or keeping it barren. Organic carbon contents of Wynad Eucalyptus plantation (0.97 per cent) and barren land (0.93 per cent) were lower than that of reserve forest (1.41 per cent). Greatest reduction was observed in the surface horizon of Wynad Eucalyptus (1.95) and barrenland (1.84) compared to that of reserve forest (3.28). In Kottoor also, surface horizon of Eucalyptus plantation (2.45 per cent) and barrenland (1.92 per cent) recorded lower value for organic carbon compared to that of reserve forest (3.53 per cent). In the case of sandy tracts of Nileswar and Kazhakkoottam, an increase in organic carbon content was observed in monoculture plantations of Eucalyptus and Acacia compared to cultivated and barrenlands. Surface horizon of Nileswar Acacia plantation contained 0.53 per cent organic carbon whereas barrenland had only 0.29 per cent and cultivated land contained 0.33 per cent. Surface horizons of Kazhakkoottom Eucalyptus (0.53) and Acacia (0.63) plantations had higher organic carbon content compared to barren land (0.27) and cultivated land (0.31).

Cation exchange capacity

A lowering of C.E.C. values was observed in the surface horizons of barrenland and Eucalyptus plantation compared to reserve forest in Wynad and Kottoor. Surface horizon of Wynad reserve forest had a C.E.C. value of 17.7 c mol kg^{-1} while barrenland recorded 13.9 and Eucalyptus plantation 16.4 c mol kg^{-1} Surface horizon of Kottoor reserve forest had a C.E.C. value of 17.1 c mol kg^{-1} whereas barren land had 14.6 and Eucalyptus plantation 15.5 c mol kg^{-1}. In the case of sandy profiles of Nileswar and Kazhakkoottam an increase in C.E.C. was observed in the surface horizons of Eucalyptus and Acacia plantations compared to cultivated and barrenlands. Surface horizon of Nileswar Acacia plantation had a C.E.C. of 4.2 c mol kg^{-1} while that of barrenland was 4.0 and cultivated land had a C.E.C. of 3.9 c mol kg^{-1}. Surface horizon of Kazhakkoottam Acacia plantation had a C.E.C. value of 3.9 c mol kg^{-1} whereas Eucalyptus plantation (3.3), barrenland (3.1) and cultivated land (3.2) had lower values.

Total Nitrogen

In the forested area of Wynad and Kottoor, monoculture plantations of Eucalyptus resulted in a lowering of total N content. The values for barrenland were similar to that of Eucalyptus plantation. More prominent decrease was observed in the surface horizons. Surface horizon of Wynad Eucalyptus plantation had 0.151 per cent nitrogen and barren land contained 0.146 per cent nitrogen when reserve forest had 0.184 per cent

total nitrogen. The mean values were 0.089, 0.082 and 0.098 per cent respectively. Kottoor Eucalyptus plantation (0.124) and barrenland (0.134) also showed reduction in total nitrogen compared to reserve forest (0.146). In sandy profile an increase in the content of total nitrogen was observed in monoculture plantations of Eucalyptus and Acacia. The mean values for Nileswar cultivated land, barrenland and Acacia plantations were 0.012, 0.014 and 0.025 per cent respectively. Surface horizons contained 0.026 and 0.028 and 0.054 per cent nitrogen in Nileswar cultivated land, barrenland and Acacia plantation. At Kazhakkoottam, Eucalyptus (0.033) and Acacia (0.033) plantations recorded an increase in nitrogen compared to barrenland (0.010) and cultivated land (0.014).

Total Phosphorus

A downward decrease in total P_2O_5 was observed in all the profiles. Total P_2O_5 content in reserve forest or cultivated land was found to be highest compared to barrenland, Eucalyptus plantation and Acacia plantation. Total P_2O_5 content in Wynad reserve forest was 0.074 per cent while in barrenland it was only 0.062 per cent and Eucalyptus plantation contained 0.053 per cent total P_2O_5. The values for Kottoor reserve forest, barren land ane Ducalyptus plantation were 0.079, 0.072 and 0.060 per cent respectively. In sandy tract of Nileswar, cultivated land had higher content

of P_2O_5 (0.035) compared to barrenland (0.026) and Acacia plantation (0.024). Kazhakkoottam cultivated land had higher content of P_2O_5 (0.040) whereas barrenland had a value of 0.027, Eucalyptus plantation 0.029 and Acacia plantation 0.026 per cent.

Total potassium

A lowering of total K_2O content was observed in the barren land and Eucalyptus plantations of forested areas as compared to reserve forest. Wynad reserve forest had K_2O content of 0.415 per cent while that of barrenland and Eucalyptus plantation were 0.334 and 0.329 per cent respectively. At Kottoor, reserve forest had total K_2O con ent of 0.426 per cent while barren land (0.349) and Eucalyptus plantation (0.344) recorded lower values. In the sandy tract of Nileswar, Acacia plantation (0.026 per cent) and barrenland (0.026) had lower total K_2O content as compared to cultivated land (0.031). At Kazhakkoottam, the values were 0.029, 0.027, 0.029 and 0.028 per cent respectively for cultivated land, barren land, Eucalyptus and Acacia plantations.

Calcium and Magnesium

Mean values of calcium and magnesium showed not much variation among profiles in a location. But a lowering was observed in the surface horizons. Total calcium content in the surface horizon of Wynad reserve forest was 0.067 per cent while that of barren land was 0.061 per cent and surface horizon of Eucalyptus plantation had a very low value of 0.037 per cent. At Kottoor, the values were 0.061, 0.033 and 0.025 per cent respectively in reserve forest, barrenland

and Eucalyptus plantation. In the sandry tract of Nileswar, surface layer of Acacia plantation had a very low value of 0.041 per cent compared to that of barrenland (0.089) and cultivated land (0.094). At Kazhakkoottam, the values were 0.069, 0.067, 0.021 and 0.053 per cent respectively in cultivated land, barrenland, Eucalyptus and Acacia plantations.

In the case of magnesium also, mean values did not vary much, but there was great variation in the surface horizons. At Wynad, content of magnesium in the surface horizons were 0.042, 0.039 and 0.021 per cent respectively in reserve forest, barrenland and Eucalyptus plantation. Surface horizon of Kottoor reserve forest had 0.032 per cent MgO, while lower values were recorded in barrenland (0.024) and Eucalyptus plantation (0.023). In the sandy tract of Nileswar, the values were 0.039, 0.035 and 0.031 per cent respectively in cultivated land, barrenland and Acacia plantation. At Kazhakkoottam also, lower values were recorded in the surface horizons of soils under Eucalyptus (0.046) and Acacia (0.037) plantations compared to barrenland (0.060) and cultivated land (0.061).

Total Fe_2O_3 and Al_2O_3

Monoculture plantations of Eucalyptus after deforestation resulted in an increase in the content of sesquioxides. At Wynad, total Fe_2O_3 contents in reserve forest, barrenland and Eucalyptus plantation were 10.94, 11.43 and 12.98 per cent

respectively and Al_2O_3 contents in these profiles were 14.36, 16.95 and 17.45 per cent. At Kottoor the values for Fe_2O_3 were 10.03, 10.66 and 11.83 per cent respectively in reserve forest, barrenland and Eucalyptus plantation while the Al_2O_3 contents were 13.88, 16.21 and 16.62 per cent.

In the sandy tract of Nileswar, Fe_2O_3 contents in cultivated land (0.72) was lower compared to that of barrenland (0.74) and Acacia plantation (0.83). The corresponding values of Al_2O_3 were 3.10, 3.19 and 3.43 per cent. At Kazhakkoottam, Eucalyptus (0.75) and Acacia (0.76) plantations had higher Fe_2O_3 contents than barrenland (0.66) and cultivated land (0.64). Al_2O_3 contents in the above four profiles were 2.76, 2.83, 2.72 and 2.40 per cent.

4. Fertility status of soils.

A perusal of Table 9 indicates a reduction in fertility status of soils when we raise Eucalyptus monoculture after deforestation. This was clear from the parameters pH, C.E.C. organic carbon, organic matter, total amounts of N, P_2O_5 and K_2O. Available nitrogen and phosphorus were also lower in Eucalyptus plantation and barrenland compared to reserve forest. At Wynad, available nitrogen contents in soils under reserve forest, barrenland and Eucalyptus plantation were 0.036, 0.023 and 0.025 per cent respectively. At Kottoor also, Eucalyptus plantation (0.022) and barrenland (0.021)

Table 9. Fertility status of the soil profiles

Sample No.	Depth in cm	pH	C.E.C. cmol kg^{-1}	Organic carbon %	Organic matter %	Total N %	Total P_2O_5 %	Total K_2O %	Available N %	Available P_2O_5 ppm	Available K_2O meq 100 g^{-1}	Base saturation %
Profile 1. Wynad Reserve forest												
1	0-36	6.1	17.7	3.28	5.65	0.184	0.088	0.479	0.051	6.85	0.481	73.4
2	36-57	6.0	14.2	1.43	2.47	0.104	0.085	0.481	0.049	4.35	0.472	69.1
3	57-84	6.0	11.3	1.13	1.95	0.086	0.078	0.424	0.038	3.10	0.451	63.3
4	84-127	5.7	5.8	0.71	1.22	0.063	0.061	0.368	0.025	2.85	0.421	54.2
5	127-200	5.8	5.3	0.52	0.90	0.053	0.057	0.323	0.019	2.70	0.330	47.7
	Mean	5.9	10.9	1.41	2.44	0.098	0.074	0.415	0.036	3.97	0.431	61.5
Profile 2. Wynad Barrenland												
6	0-30	6.1	13.9	1.84	3.17	0.146	0.076	0.320	0.032	3.55	0.475	64.2
7	30-55	6.2	13.0	1.21	2.09	0.104	0.067	0.354	0.029	3.15	0.420	55.4
8	55-89	6.2	10.3	0.72	1.24	0.067	0.060	0.356	0.021	2.90	0.371	51.3
9	89-138	6.5	8.2	0.50	0.86	0.051	0.054	0.320	0.017	2.75	0.316	49.8
10	138-200	6.5	4.8	0.39	0.67	0.042	0.051	0.318	0.014	2.10	0.216	45.4
	Mean	6.3	10.0	0.93	1.60	0.082	0.062	0.334	0.023	2.89	0.360	53.2
Profile 3.Wynad Eucalyptus												
11	0-29	5.2	16.4	1.95	3.36	0.151	0.069	0.315	0.038	3.20	0.669	58.2
12	29-45	5.5	14.0	1.26	2.17	0.103	0.061	0.362	0.030	2.60	0.613	52.6
13	45-56	5.1	13.2	0.76	1.31	0.078	0.054	0.365	0.022	2.25	0.509	53.4
14	56-110	5.6	10.3	0.50	0.86	0.061	0.047	0.312	0.020	2.20	0.428	50.5
15	110-200	5.2	5.1	0.40	0.69	0.053	0.036	0.289	0.017	1.60	0.319	44.9
	Mean	5.3	11.8	0.97	1.67	0.089	0.053	0.329	0.025	2.37	0.508	52.0
Profile 4. Kottoor Reserve forest												
16	0-17	5.2	17.1	3.53	6.08	0.212	0.089	0.457	0.029	2.88	0.691	59.6
17	17-45	5.0	15.4	2.83	4.88	0.210	0.084	0.459	0.028	2.10	0.656	53.4
18	45-83	4.8	10.5	0.74	1.28	0.090	0.079	0.398	0.026	1.41	0.631	47.3
19	83-200	4.5	4.8	0.52	0.90	0.071	0.063	0.391	0.025	0.78	0.562	42.1
	Mean	4.9	12.0	1.52	2.62	0.146	0.079	0.426	0.027	1.79	0.635	50.6

(contd..)

Table 3 (contd.)

Sample No.	Depth in cm	pH	C.E.C. cmol kg^{-1}	Organic carbon %	Organic matter %	Total N %	Total P_2O_5 %	Total K_2O %	Available N %	Available P_2O_5 ppm	Available K_2O meq 100 g^{-1}	Base saturation %
	Profile 5. Kottoor Barrenland											
20	0-8	5.0	14.6	1.92	3.31	0.157	0.080	0.346	0.024	1.75	0.623	51.9
21	8-21	4.4	13.5	1.63	2.81	0.178	0.078	0.374	0.022	1.55	0.615	47.7
22	21-37	4.7	11.3	1.21	2.09	0.170	0.075	0.388	0.020	1.30	0.598	49.2
23	37-61	4.4	7.1	0.73	1.26	0.104	0.067	0.320	0.020	1.10	0.571	42.3
24	61-200	4.1	4.6	0.42	0.72	0.061	0.061	0.318	0.020	0.95	0.552	35.5
	Mean	4.5	10.2	1.18	2.03	0.134	0.072	0.349	0.021	1.33	0.592	45.3
	Profile 6. Kottoor Eucalyptus											
25	0-16	4.6	15.5	2.45	4.22	0.202	0.077	0.336	0.026	1.25	0.745	47.3
26	16-34	4.4	13.1	2.02	3.48	0.215	0.071	0.372	0.024	0.75	0.708	45.1
27	34-51	4.4	11.6	0.53	2.64	0.073	0.068	0.391	0.021	0.35	0.659	46.2
28	51-95	4.9	7.5	0.50	0.86	0.071	0.051	0.315	0.020	0.33	0.566	41.7
29	95-200	4.7	4.8	0.40	0.69	0.058	0.034	0.308	0.020	0.33	0.441	33.5
	Mean	4.6	10.5	1.18	2.03	0.124	0.060	0.344	0.022	0.60	0.624	42.8
	Profile 7. Nileswar Cultivated land											
30	0-24	5.1	3.9	0.33	0.57	0.026	0.047	0.036	0.008	6.13	0.163	34.6
31	24-40	5.2	3.6	0.16	0.28	0.014	0.039	0.033	0.006	5.28	0.147	31.4
32	40-61	5.4	3.4	0.09	0.16	0.009	0.034	0.030	0.005	4.41	0.144	27.6
33	61-85	5.2	3.1	0.06	0.10	0.006	0.028	0.028	0.004	2.86	0.140	22.4
34	85-200	4.9	2.6	0.04	0.07	0.005	0.025	0.029	0.003	2.16	0.138	18.3
	Mean	5.2	3.3	0.14	0.24	0.012	0.035	0.031	0.005	4.17	0.146	26.86
	Profile 8. Nileswar Barrenland											
35	0-18	4.7	4.0	0.29	0.50	0.028	0.031	0.028	0.006	4.98	0.165	32.3
36	18-35	5.2	3.7	0.15	0.26	0.015	0.028	0.026	0.003	3.71	0.145	30.4
37	35-75	4.3	3.3	0.06	0.10	0.006	0.026	0.024	0.003	2.88	0.138	24.3
38	75-200	4.9	2.7	0.04	0.07	0.005	0.019	0.027	0.002	2.15	0.135	16.7
	Mean	4.8	3.4	0.14	0.24	0.014	0.026	0.026	0.004	3.43	0.146	25.9

Sample No.	Depth in cm	pH	C.E.C. cmol kg^{-1}	Organic carbon %	Organic matter %	Total N %	Total P_2O_5 %	Total K_2O %	Available N %	Available P_2O_5 ppm	Available K_2O meq 100g^{-1}	Base saturation %
	Profile 9. Nileswar Acacia.											
39	0-16	4.1	4.2	0.53	0.91	0.054	0.030	0.028	0.006	3.95	0.198	30.7
40	16-38	4.6	3.9	0.31	0.53	0.034	0.028	0.025	0.005	2.60	0.184	26.1
41	38-60	3.9	3.7	0.15	0.26	0.017	0.024	0.024	0.004	2.10	0.163	25.8
42	60-79	4.1	2.8	0.10	0.17	0.011	0.020	0.026	0.004	2.01	0.154	20.3
43	70-200	3.7	2.6	0.09	0.15	0.010	0.018	0.026	0.003	1.91	0.148	16.9
	Mean	4.1	3.4	0.24	0.41	0.025	0.024	0.026	0.004	2.51	0.169	23.9
	Profile 10.Kazhakkoottam cultivated land											
44	0-17	5.1	3.2	0.31	0.53	0.022	0.060	0.035	0.010	6.25	0.195	35.7
45	17-38	4.7	3.1	0.19	0.33	0.015	0.051	0.031	0.004	4.18	0.188	31.6
46	38-68	4.7	2.8	0.11	0.19	0.011	0.048	0.028	0.003	3.25	0.179	27.4
47	68-88	4.6	2.7	0.08	0.14	0.010	0.021	0.026	0.003	3.05	0.171	24.1
48	88-200	4.6	2.5	0.07	0.12	0.010	0.019	0.026	0.002	2.28	0.135	24.1
	Mean	4.7	2.9	0.15	0.26	0.014	0.040	0.029	0.004	3.78	0.174	28.8
	Profile 11. Kazhakoottam Barrenland											
49	0-13	4.8	3.1	0.27	0.47	0.021	0.035	0.030	0.010	5.88	0.186	31.8
50	13-44	4.6	3.0	0.08	0.14	0.007	0.031	0.026	0.004	5.71	0.180	29.1
51	44-62	4.6	2.8	0.07	0.12	0.007	0.028	0.025	0.003	5.38	0.175	25.3
52	62-80	4.5	2.3	0.07	0.12	0.008	0.020	0.027	0.002	2.38	0.128	20.3
53	80-200	4.6	2.3	0.07	0.12	0.008	0.020	0.027	0.002	2.38	0.128	20.3
	Mean	4.6	2.8	0.11	0.19	0.010	0.027	0.027	0.004	4.70	0.166	25.6
	Profile 12. Kazhakkottam Eucalyptus											
54	0-4	4.4	3.3	0.53	0.91	0.056	0.040	0.034	0.012	2.75	0.198	29.8
55	4-17	4.5	3.2	0.29	0.50	0.032	0.031	0.031	0.011	2.61	0.181	28.8
56	17-45	4.3	2.9	0.26	0.45	0.029	0.027	0.029	0.011	2.40	0.175	25.1
57	45-84	4.3	2.8	0.21	0.36	0.026	0.026	0.025	0.010	2.15	0.160	21.2
58	84-200	4.4	2.5	0.18	0.30	0.023	0.019	0.027	0.010	1.98	0.121	18.1
	Mean	4.4	2.9	0.29	0.50	0.033	0.029	0.029	0.011	2.38	0.167	24.6
	Profile 13. Kazhakkoottam Acacia											
59	0-9	4.3	3.9	0.63	1.09	0.058	0.038	0.031	0.013	3.53	0.217	30.2
60	9-33	4.3	3.1	0.34	0.52	0.033	0.027	0.028	0.012	3.41	0.208	27.3
61	33-64	4.2	2.6	0.27	0.47	0.027	0.025	0.025	0.011	3.13	0.187	22.6
62	64-80	4.2	2.7	0.23	0.40	0.024	0.021	0.029	0.010	2.71	0.161	19.5
63	80-200	4.2	2.4	0.21	0.36	0.025	0.018	0.029	0.009	2.65	0.119	18.3
	Mean	4.2	2.9	0.34	0.59	0.033	0.026	0.028	0.011	3.09	0.178	23.6

had lower values compared to natural forest (0.027). In the sandy tract of Nileswar, the values were 0.005, 0.004 and 0.004 per cent in cultivated land, barrenland and Acacia plantation. Kazhakkoottam Eucalyptus (0.011) Acacia plantations had higher content of available nitrogen compared to barrenland (0.004) and cultivated land (0.004).

In the case of available P_2O_5, at Wynad, lowest value was observed in Eucalyptus plantation (2.37 ppm) followed by barrenland (2.89 ppm) and reserve forest (3.97 ppm). The values were 1.79, 1.33 and 0.60 ppm respectively at Kottoor reserve forest, barrenland and Eucalyptus plantation. In the sandy tract of Nileswar, Acacia plantation had the lowest content (.251) followed by barrenland (3.43) and cultivated land (4.17). At Kazhakkoottam also, monoculture plantations of Eucalyptus (2.38) and Acacia (3.09) had lower values of available phosphorus as compared to barrenland (4.70) and cultivated land (3.78).

In the case of available potassiu, an increase was noticed in monoculture plantations of Eucalyptus and Acacia. At Wynad, Eucalyptus plantation had highest value (0.508 meq $100\ g^{-1}$) compared to barrenland (0.360) and reserve forest (0.431). Kottoor Eucalyptus plantation had 0.524 meq $100g^{-1}$ available K_2O while that of barrenland was 0.592 reserve

forest 0.635 meq $100\bar{g}^{1}$. Nileswar Acacia plantation recorded 0.169 meq $100\bar{g}^{1}$ available K_2O while lower values were observed in barrenland (0.146) and cultivated land (0.146). At Kazhakkoottam also, monoculture plantations of Eucalyptus (0.167) and Acacia (0.178) had higher contents of available K_2O than in barrenland (0.166) while cultivated land had 0.174 meq $100\ \bar{g}^{1}$ available K_2O.

Base saturation a percentage decreased in monoculture plantations. When Wynad reserve forest had 61.5 per cent base saturation, lower values were recorded in barrenland (53.2) and Eucalyptus plantation (52.0). Kottoor Eucalyptus plantation (42.8) and barrenland (45.3) recorded lower values as compared to reserve forest (50.6). Per cent base saturation in the soils under Acacia plantation in Nileswar was low (23.9) compared to that of barrenland (25.9) and cultivated land (26.86). In the sandy tract of Kazhakkoottam also Eucalyptus (24.6) and Acacia (23.6) plantations had lower values compared to barrenland (25.6) and cultivated land (28.8).

5. Carbon-Nitrogen relationships

Table 10 gives the organic carbon, organic matter, total nitrogen and C/N ratios of the different horizons of the thirteen profiles. All these four parameters decreased with depth. Surface horizon of Wynad reserve forest had 5.65 per cent organic matter while it was only 3.17 per cent in barren land and 3.36 per cent in Eucalyptus plantation. The values for Kottoor reserve forest, barrenland and Eucalyptus plantation were 6.08, 3.31 and 4.22 per cent respectively. In the sandy tract of Nileswar, surface horizon of Acacia

Table 10. Carbon - Nitrogen relationships in the soil Profil

Sample No.	Depth in cm	Organic carbon %	Organic matter %	Total N %	C|N ratio
	Profile 1. Wynad Reserve forest				
1	0-36	3.28	5.65	0.184	17.82
2	36-57	1.43	2.47	0.104	13.75
3	57-84	1.13	1.95	0.086	13.14
4	84-127	0.71	1.22	0.063	11.27
5	127-200	0.52	0.90	0.053	9.81
	Mean	1.41	2.44	0.098	13.16
	Profile 2. Wynad Barrenland				
6	0-30	1.84	3.17	0.146	12.60
7	30-55	1.21	2.09	0.104	11.63
8	55-89	0.72	1.24	0.067	10.75
9	89-138	0.50	0.86	0.051	9.80
10	138-200	0.39	0.67	0.042	9.29
	Mean	0.93	1.60	0.082	10.81
	Profile 3. Wynad Eucalyptus				
11	0-29	1.95	3.36	0.151	12.91
12	29-45	1.26	2.17	0.103	12.23
13	45-56	0.76	1.31	0.078	9.74
14	56-110	0.50	0.86	0.061	8.20
15	110-200	0.40	0.69	0.053	7.55
	Mean	0.97	1.67	0.089	10.13
	Profile 4. Kottoor Reserve forest				
16	0-17	3.53	6.08	0.212	16.65
17	17-45	2.83	4.88	0.210	13.48
18	45-83	0.74	1.28	0.090	8.22
19	83-200	0.52	0.90	0.071	7.32
	Mean	1.52	2.62	0.146	11.42
	Profile 5. Kottoor Barrenland				
20	0-8	1.92	3.31	0.157	12.23
21	8-21	1.63	2.81	0.178	9.16
22	21-37	1.21	2.09	0.170	7.12
23	37-61	0.73	1.26	0.104	7.02
24	61-200	0.42	0.72	0.061	6.89
	Mean	1.18	2.03	0.134	8.48
	Profile 6.Kottoor Eucalyptus				
25	0-16	2.45	4.22	0.202	12.13
26	16-34	2.02	3.48	0.215	9.40
27	34-51	0.53	2.64	0.073	7.26
28	51-95	0.50	0.86	0.071	7.04
29	95-200	0.40	0.69	0.058	6.90
	Mean	1.18	2.03	0.124	8.55

(contd..)

Table 10 (contd.)

Sample No.	Depth in cm	Organic carbon %	Organic matter %	Total N %	C|N ratio
	Profile 7. Nileswar Cultivated land				
30	0-24	0.33	0.57	0.026	12.69
31	24-40	0.16	0.28	0.014	11.43
32	40-61	0.09	0.16	0.009	10.00
33	61-85	0.06	0.10	0.006	10.00
34	85-200	0.04	0.07	0.005	8.00
	Mean	0.14	0.24	0.012	10.42
	Profile 8. Nileswar Barrenland				
35	0-18	0.29	0.50	0.028	10.35
36	18-35	0.15	0.26	0.015	10.00
37	35-75	0.06	0.10	0.006	10.00
38	75-200	0.04	0.07	0.005	8.00
	Mean	0.14	0.24	0.014	9.59
	Profile 9. Nileswar Acacia				
39	0-16	0.53	0.91	0.054	9.81
40	16-38	0.31	0.53	0.034	9.12
41	38-60	0.15	0.26	0.017	8.82
42	60-79	0.10	0.17	0.011	9.09
43	79-200	0.09	0.15	0.010	9.00
	Mean	0.24	0.41	0.025	9.17
	Profile 10. Kazhakkoottam Cultivated land				
44	0-17	0.31	0.53	0.022	14.09
45	17-38	0.19	0.33	0.015	12.67
46	38-68	0.11	0.19	0.011	10.00
47	68-88	0.08	0.14	0.010	8.00
48	88-200	0.07	0.12	0.010	7.00
	Mean	0.15	0.26	0.014	10.35
	Profile 11. Kazhakkoottam Barrenland				
49	0-13	0.27	0.47	0.021	12.86
50	13-44	0.08	0.14	0.007	11.43
51	44-62	0.07	0.12	0.007	10.00
52	62-80	0.07	0.12	0.007	10.00
53	80-200	0.07	0.12	0.008	8.75
	Mean	0.11	0.19	0.010	10.61
	Profile 12. Kazhakkoottam Eucalyptus				
54	0-4	0.53	0.91	0.056	9.46
55	4-17	0.29	0.50	0.032	9.06
56	17-45	0.26	0.45	0.029	8.97
57	45-84	0.21	0.36	0.026	8.08
58	84-200	0.18	0.30	0.023	7.83
	Mean	0.29	0.50	0.033	8.68
	Profile 13. Kazhakkoottam Acacia				
59	0-9	0.63	1.09	0.058	10.86
60	9-33	0.34	0.59	0.033	10.30
61	33-64	0.27	0.47	0.027	10.00
62	64-80	0.23	0.40	0.024	9.58
63	80-200	0.21	0.36	0.025	8.40
	Mean	0.34	0.59	0.033	9.83

plantation had 0.91 per cent organic matter whereas barren land had 0.50 and cultivated land 0.57 per cent. At Kazhakkoottam, Eucalyptus (0.91) and Acacia plantations (1.09) recorded higher organic matter contents compared to barren land (0.47) and cultivated land (0.53).

C|N ratios of all the horizons decreased with depth. Wynad reserve forest had a C|N ratio of 13.16 while it was only 10.81 and 10.13 in barrenland and Eucalyptus plantation. At Kottoor, the ratios were 11.42, 8.48 and 8.55 in soils under reserve forest, barrenland and Eucalyptus plantation. In the sandy tract of Nileswar, cultivated land had a higher C|N ratio (10.42) compared to barrenland (9.59) and Acacia plantation (9.17). At Kazhakkoottam also, monoculture plantations of Eucalyptus (8.68) and Acacia (9.83) had lower C|N ratios compared to that of barrenland (10.61) cultivated land (10.35).

6. Distribution of iron and aluminium in soils

Table 11 gives the distribution of iron and aluminium in different horizons of the soil profiles. Fe_2O_3 and Al_2O_3 contents increased with depth in the forested profiles. Wynad Eucalyptus plantation recorded sesquioxide content of 30.42 per cent which was higher than that of barrenland (28.38) and reserve forest (25.30). At Kottoor also, Eucalyptus plantation had the highest content of sesquioxides (28.44) followed by barrenland (26.86) and reserve forest (23.01). Sandy tracts of Nileswar and Kazhakkoottam had only very low content of

Table 11. Distribution of sesquioxides in the different horizons of the soil profiles

Sample No.	Depth in cm	Per cent on ovendry basis		
		Fe_2O_3	Al_2O_3	R_2O_3
	Profile 1. Wynad Reserve forest			
1	0-36	7.93	10.28	18.21
2	36-57	10.31	12.07	22.38
3	57-84	11.96	13.68	25.64
4	84-127	12.34	15.88	28.22
5	127-200	12.16	19.91	32.07
	Mean	10.94	14.36	25.30
	Profile 2. Wynad Barrenland			
6	0-30	9.17	12.95	22.12
7	30-55	11.19	14.08	25.27
8	55-89	12.69	17.21	29.90
9	89-138	12.14	18.87	31.01
10	138-200	11.87	21.63	33.60
	Mean	11.43	16.94	28.38
	Profile 3. Wynad Eucalyptus			
11	0-29	10.76	13.49	24.25
12	29-45	12.34	14.96	27.30
13	45-56	14.89	17.17	32.06
14	56-100	13.78	19.97	33.75
15	110-200	13.13	21.64	34.77
	Mean	12.98	17.44	30.42
	Profile 4. Kottoor Reserve forest			
16	0-17	7.83	10.15	17.98
17	17-45	5.61	11.96	21.57
18	45-83	11.53	14.68	22.61
19	83-200	11.15	18.73	29.88
	Mean	10.03	13.88	23.01
	Profile 5. Kottoor Barrenland			
20	0-8	8.09	12.16	20.25
21	8-21	9.97	14.28	24.25
22	21-37	11.61	16.97	28.58
23	37-61	11.93	17.89	29.82
24	61-200	11.68	19.76	31.44
	Mean	10.65	16.21	26.86
	Profile 6.Kottoor Eucalyptus			
25	0-16	9.31	12.69	22.00
26	16-34	10.65	14.48	25.13
27	34-51	13.63	17.19	30.82
28	51-95	12.91	18.48	31.39
29	95-200	12.63	20.26	32.89
	Mean	11.82	16.62	28.44

(contd.)

Sample No.	Depth in cm	Per cent on ovendry basis		
		Fe_2O_3	Al_2O_3	R_2O_3
	Profile 7. Nileswar Cultivated land			
30	0-24	0.81	2.61	3.42
31	24-40	0.79	2.94	3.73
32	40-61	0.73	3.13	3.86
33	61-85	0.65	3.34	3.99
34	85-200	0.60	3.48	4.08
	Mean	0.71	3.10	3.81
	Profile 8. Nileswar Barrenland			
35	0-18	0.83	2.79	3.62
36	18-35	0.80	3.11	3.91
37	35-75	0.71	3.38	4.09
38	75-200	0.62	3.49	4.12
	Mean	0.74	3.19	3.93
	Profile 9. Nileswar Acacia			
39	0-16	0.97	2.98	3.95
40	16-38	0.93	3.26	4.19
41	38-60	0.87	3.41	4.28
42	60-79	0.73	3.68	4.41
43	79-200	0.63	3.81	4.44
	Mean	0.82	3.42	4.25
	Profile 10. Kazhakkoottam Cultivated land			
44	0-17	0.70	2.03	2.73
45	17-38	0.68	2.28	2.96
46	38-68	0.63	2.39	3.02
47	68-88	0.61	2.61	3.22
48	88-200	0.58	2.69	3.27
	Mean	0.64	2.40	3.04
	Profile 11. Kazhakkottam Barrenland			
49	0-13	0.73	2.35	3.08
50	13-44	0.71	2.48	3.19
51	44-62	0.68	2.75	3.43
52	62-80	0.60	2.88	3.48
53	80-200	0.59	3.13	3.72
	Mean	0.66	2.71	3.38
	Profile 12. Kazhakkoottam Eucalyptus			
54	0-4	0.83	2.39	3.22
55	4-17	0.81	2.51	3.32
56	17-45	0.78	2.73	3.51
57	45-84	0.71	2.91	3.62
58	84-200	0.61	3.28	3.89
	Mean	0.74	2.76	3.51
	Profile 13. Kazhakkoottam Acacia			
59	0-9	0.87	2.48	3.35
60	9-33	0.83	2.63	3.46
61	33-64	0.76	2.91	3.67
62	64-80	0.74	2.98	3.72
63	80-200	0.62	3.15	3.71
	Mean	0.76	2.83	3.59

iron and aluminium which showed an increase down the profiles. Soils under Nileswar Acacia plantation had sesquioxide content of 4.25 per cent while barrenland (3.93) and cultivated land (3.81) had lower values. At Kazhakkoottam also, monoculture plantations of Eucalyptus (3.51) and Acacia (3.59) had higher contents of sesquioxides as compared to that of barrenland (3.38) and cultivated land (3.04).

7. Free oxides of iron in soils

Table 12 gives the distribution of organic matter and extractable iron in the soil samples of the different horizons Contents of dithionite soluble (Fe_d) and oxalate soluble (Fe_o) iron are presented in this table Dithionite extractable iron increased both in barrenland and Eucalyptus plantation compared to reserve forest. Contents of Fe_d in Wynad reserve forest, barrenland and Eucalptus plantation were 3.81, 4.18 and 4.28 per cent respectively. At Kottoor, the values were 3.38, 3.72 and 3.72 per cent respectively in reserve forest, barrenland and Eucalyptus plantation. In the sandy tract of Nileswar, Acacia plantation had higher content of Fe_d(0.17) compared to barrenland (0.15) and cultivated land (0.12). Kazhakkoottam Eucalyptus (0.18) and Acacia (0.17) plantations also had higher Fe_d contents compared to barrenland (0.14) and cultivated land (0.15).

Oxalate extractable iron content of the soils from various horizons showed a comparatively higher percentage of

Table 12. Distribution of organic matterand extractable iron in soil profiles.

Sample No.	Depth in cm	Per cent on ovendry basis			
		O.M.	Fe_d	Fe_o	Active Fe ratio
	Profile 1. Wynad Reserve forest				
1	0-36	5.65	3.46	0.62	0.18
2	36-57	2.47	3.78	0.91	0.24
3	57-84	1.95	3.99	0.80	0.20
4	84-127	1.22	3.90	0.62	0.16
5	127-200	0.90	3.95	0.63	0.16
	Mean	2.43	3.81	0.71	0.18
	Profile 2. Wynad Barrenland				
6	0-30	3.17	3.87	0.43	0.11
7	30-55	2.09	4.15	0.58	0.14
8	55-89	1.24	4.20	0.59	0.14
9	89-138	0.86	4.31	0.56	0.13
10	138-200	0.67	4.39	0.53	0.12
	Mean	1.60	4.18	0.53	0.12
	Profile 3. Wynad Eucalyptus				
11	0-29	3.36	3.91	0.39	0.10
12	29-45	2.17	4.26	0.68	0.16
13	45-56	1.31	4.48	0.58	0.13
14	56-110	0.86	4.39	0.53	0.12
15	110-200	0.69	4.40	0.53	0.12
	Mean	1.67	4.28	0.54	0.12
	Profile 4. Kottoor Reserve forest				
16	0-17	6.08	3.35	0.57	0.17
17	17-45	4.88	3.43	0.51	0.15
18	45-83	1.28	3.51	0.49	0.14
19	83-200	0.90	3.26	0.46	0.14
	Mean	3.28	3.38	0.50	0.15
	Profile 5. Kottoor Barrenland				
20	0-8	3.31	3.65	0.44	0.12
21	8-21	2.81	3.89	0.43	0.11
22	21-37	2.09	3.97	0.40	0.10
23	37-61	1.26	3.62	0.36	0.10
24	61-200	0.72	3.50	0.32	0.09
	Mean	2.03	3.72	0.39	0.10
	Profile 6. Kottoor Eucalyptus				
25	0-16	4.22	3.68	0.44	0.12
26	16-34	3.48	3.92	0.39	0.10
27	34-51	2.64	3.96	0.36	0.09
28	51-95	0.86	3.59	0.32	0.09
29	95-200	0.69	3.48	0.35	0.10
	Mean	2.37	3.72	0.37	0.10
	Profile 7. Nileswar cultivated land				
30	0-24	0.57	0.11	0.06	0.54
31	24-40	0.28	0.13	0.07	0.54
32	40-61	0.16	0.14	0.08	0.57
33	61-85	0.07	0.12	0.05	0.42
34	85-200	0.03	0.10	0.05	0.50
	Mean	0.22	0.12	0.06	0.51

Table 12.(contd.)

Sample No.	Depth in cm	Per cent on ovendry basis			
		O.M	Fe_d	Fe_o	Active Fe ratio
	Profile 8. Nileswar Barrenland				
35	0-18	0.50	0.15	0.06	0.40
36	18-35	0.26	0.18	0.08	0.44
37	35-75	0.10	0.16	0.07	0.43
38	75-200	0.07	0.14	0.06	0.42
	Mean	0.23	0.15	0.06	0.42
	Profile 9. Nileswar Acacia				
39	0-16	0.91	0.16	0.06	0.38
40	16-38	0.53	0.19	0.08	0.42
41	38-60	0.26	0.20	0.09	0.45
42	60-79	0.17	0.17	0.07	0.41
43	79-200	0.15	0.15	0.06	0.40
	Mean	0.40	0.17	0.07	0.41
	Profile 10. Kazhakkoottam Cultivated land				
44	0-17	0.53	0.13	0.07	0.53
45	17-38	0.09	0.16	0.09	0.56
46	38-68	0.05	0.18	0.11	0.61
47	68-88	0.05	0.15	0.09	0.60
48	88-200	0.05	0.13	0.08	0.61
	Mean	0.15	0.15	0.08	0.58
	Profile 11.Kazhakkoottam Barrenland				
49	0-13	0.47	0.12	0.06	0.50
50	13-44	0.14	0.15	0.08	0.53
51	44-62	0.12	0.16	0.07	0.43
52	62-80	0.12	0.16	0.07	0.43
53	80-200	0.12	0.13	0.05	0.38
	Mean	0.19	0.14	0.06	0.45
	Profile 12. Kazhakkoottam Eucalyptus				
54	0-4	0.91	0.18	0.08	0.44
55	4-17	0.50	0.20	0.09	0.45
56	17-45	0.22	0.21	0.10	0.47
57	45-84	0.36	0.19	0.08	0.42
58	84-200	0.30	0.16	0.07	0.43
	Mean	0.45	0.18	0.08	0.44
	Profile 13. Kazhakkoottam Acacia				
59	0-9	1.09	0.16	0.07	0.43
60	9-33	0.59	0.19	0.09	0.47
61	33-64	0.47	0.19	0.08	0.42
62	64-80	0.40	0.17	0.07	0.41
63	80-200	0.36	0.15	0.06	0.40
	Mean	0.58	0.17	0.07	0.42

this fraction in reserve forest than in barrenland and Eucalyptus plantation. Oxalate extractable iron in soils under Wynad reserve forest was 0.71 per cent while it was only 0.53 per cent in barrenland and 0.54 per cent in Eucalyptus plantation. At Kottoor also, reserve forest had high Fe_o content (0.50) compared to barrenland (0.39) and Eucalyptus plantation (0.37). Fe_o contents in the profiles under cultivated land, barrenland and Acacia plantation at Nileswar were 0.06, 0.06 and 0.07 per cent respectively. At Kazhakkoottam the values showed not much variation in cultivated land (0.08), barrenland (0.06), Eucalyptus (0.08) and Acacia (0.07) plantations.

The active iron ratio was obtained by dividing the content of oxalate extractable iron (amorphous form) by dithionite extractable iron (amorphous and crystalline). The ratio was low both in barrenland and Eucalyptus plantation compared to reserve forest. Wynad Eucalyptus plantation (0.12) and barrenland (0.12) had low active iron ratio compared to that of reserve forest (0.18). At Kottoor also, the values were lower in soils under Eucalyptus plantation (0.10) and barrenland (0.10) as compared to reserve forest (0.15). In the sandy tract of Nileswar, Acacia plantation recorded a ratio of 0.41 while that of barrenland was 0.42 and cultivated land 0.51. At Kazhakkoottam also, monoculture plantations of Eucalyptus (0.44) and Acacia (0.42) had lower ratios compared to that of barrenland (0.45) and cultivated land (0.58).

8. Changes in soil physical characteristics as a function of depth

Table 13 gives the impact of Eucalyptus and Acacia plantations on physical characteristics of soil as a function of depth. The physical parameters studied were moisture, gravel, silt/clay ratio, bulk density, water holding capacity, water dispersible clay and aggregate stability.

Decrease in moisture content was very marked with depth both in Eucalyptus plantation and barrenland compared reserve forest. Upto a depth of 50 cm, Wynad reserve forest had 18.38 per cent moisture, while the values for barrenland and Eucalptus plantation were 10.21 and 8.70 per cent respectively. Moisture content upto 50 cm depth at Kottoor reserve forest was 33.33 while that of barrenland and Eucalyptus plantation were 18.61 and 22.05 per cent. Surface layer (0-50 cm) of Nileswar cultivated land had 4.29 per cent moisture while it was only 3.43 and 3.47 per cent respectively in barrenland and Acacia plantation. At Kazhakkoottam the values were 5.63, 4.99, 4.17 and 4.53 per cent respectively in cultivated land, barrenland, Eucalyptus and Acacia plantations.

An increase in gravel content was observed with depth in all the profiles of forested area. But this increase was more in barrenland and Eucalyptus plantation than in reserve forest. In sandy profiles also, Eucalyptus and Acacia plantations caused an increase in gravel percentage as compared to barrenland and cultivated land. Silt/clay ratio which was suggested

Table 13. Impact of Eucalyptus and Acacia plantations on physical characteristics of soil as a function of its depth

Sample No.	Depth in cm	Moisture %	Gravel %	Silt|clay ratio	Bulk density g cc^{-1}	Water holding capacity %	Water dispersible % clay	Aggregate stability %
	Profile 1. Wynad Reserve forest							
1	0-50	18.38	30.05	0.27	0.89	52.50	7.5	60.95
2	50-100	19.88	32.05	0.33	0.88	53.25	6.4	48.33
3	100-150	23.08	35.05	0.41	0.90	51.95	5.4	40.93
	Profile 2. Wynad Barrenland							
1	0-50	10.21	33.50	0.28	0.92	41.15	6.3	58.49
2	50-100	17.90	34.45	0.36	0.94	39.90	5.8	48.85
3	100-150	18.15	35.20	0.39	0.95	39.55	5.3	41.58
	Profile 3. Wynad Eucalyptus							
1	0-50	8.70	33.25	0.23	0.85	40.90	6.0	59.93
2	50-100	9.60	35.20	0.30	0.89	40.15	5.5	49.81
3	100-150	11.11	35.75	0.32	0.89	38.85	4.9	42.21
	Profile 4. Kottoor Reserve forest							
1	0-50	33.33	30.15	0.27	0.84	51.20	6.9	52.70
2	50-100	30.36	46.20	0.34	0.87	53.53	4.7	36.27
3	100-150	33.33	49.90	0.39	0.85	54.89	4.5	34.33
	Profile 5. Kottoor Barren land							
1	0-50	18.61	47.30	0.26	0.93	44.76	5.0	46.90
2	50-100	22.34	63.25	0.36	0.97	41.45	4.2	36.25
3	100-150	21.21	70.00	0.39	0.96	40.56	4.0	34.61
	Profile 6. Kottoor Eucalyptus							
1	0-50	22.05	43.03	0.21	0.89	46.99	4.9	48.77
2	50-100	26.58	59.75	0.28	0.91	44.32	3.9	39.87
3	100-150	29.03	64.00	0.36	0.92	40.39	3.7	36.63
	Profile 7. Nileswar cultivated land							
1	0-50	4.29	8.15	0.65	1.29	30.38	2.4	41.50
2	50-100	3.62	9.15	0.73	1.29	27.90	2.0	34.48
3	100-150	3.20	9.70	0.77	1.33	26.80	1.9	30.15

(contd.)

Table 13.(contd.)

Sample No.	Depth in cm	Moisture %	Gravel %	Silt|Clay ratio	Bulk density g cc^{-1}	Water holding capacity %	Water dispersible clay %	Aggregate stability %
	Profile 8. Nileswar Barrenland							
1	0-50	3.43	8.30	0.65	1.28	27.75	2.2	40.03
2	50-100	3.65	9.05	0.73	1.32	26.35	1.8	32.20
3	100-150	4.65	9.60	0.76	1.32	26.10	1.7	29.65
	Profile 9. Nileswar Acacia							
1	0-50	3.47	10.90	0.55	1.26	27.80	2.1	42.56
2	50-100	3.27	12.50	0.70	1.30	26.42	1.7	34.58
3	100-150	3.10	13.10	0.72	1.31	25.90	1.5	30.81
	Profile 10. Kazhakkoottam Cultivated land							
1	0-50	5.63	9.80	0.73	1.28	26.08	2.8	43.39
2	50-100	5.54	11.40	1.11	1.30	25.26	2.4	35.45
3	100-150	5.82	11.70	1.17	1.35	24.73	2.1	31.81
	Profile 11. Kazhakkoottam Barrenland							
1	0-50	4.99	10.10	0.13	1.29	25.47	2.7	45.95
2	50-100	4.71	11.50	1.03	1.32	23.92	2.2	37.80
3	100-150	4.71	12.00	1.04	1.34	23.86	2.0	35.38
	Profile 12. Kazhakkoottam Eucalyptus							
1	0-50	4.17	13.10	0.57	1.28	25.43	2.1	43.92
2	50-100	3.63	15.50	0.95	1.28	24.07	1.2	36.67
3	100-150	2.56	15.80	1.01	1.32	24.10	1.1	36.18
	Profile 13. Kazhakkoottam Acacia							
1	0-50	4.53	12.70	0.60	1.27	24.47	2.5	45.68
2	50-100	4.17	14.95	0.76	1.30	23.43	2.0	34.56
3	100-150	2.56	15.30	0.85	1.30	23.75	1.4	30.33

as an index of laterisation showed a lower value in Eucalyptus plantation. This decrease was more with increase in depth. 100-150 cm layer of Wynad reserve forest had silt/clay ratio of 0.41 when barrenland had 0.39 and Eucalyptus plantation showed the lowest value of 0.32. At Kottoor, the corresponding values were 0.39, 0.39 and 0.36 respectively for reserve forest, barrenland and Eucalyptus plantation. Eucalyptus and Acacia plantations of Nileswar and Kazhakkoottam also showed a low silt/clay ratio compared to cultivated and barrenlands. 100-150 cm layer of Nileswar cultivated land (0.77) and barrenland (0.76) had higher values of this ratio than Acacia plantation (0.72). Bottom layer (100-150 cm) of the profiles from Kazhakkoottam recorded values of 1.17, 1.04, 1.01 and 0.85 for cultivated land, barrenland, Eucalyptus and Acacia plantations.

Bulk density of the profiles from forested areas showed values ranging from 0.84 to 0.97 g cc^{-1}. Generally, the values were highest in barrenland, then in Eucalyptus plantation had lowest in reserve forest. Bulk density of these profiles increased with depth. Sandy tracts had bulk density values ranging from 1.26 to 1.35 g cc^{-1}. In the sandy tracts of Nileswar and Kazhakkoottam, a decrease in bulk density was observed in soils under monoculture plantations of Eucalyptus and Acacia.

Drastic reduction in water holding capacity was observed in Eucalyptus plantation and barrenland compared to reserve

forest. The surface layer of Wynad reserve forest had a water holding capacity of 52.50 per cent while barrenland (41.15) and Eucalyptus plantation (40.90) recorded lower values. In the sandy tracts of Nileswar and Kazhakkoottam, not much variation in water holding capacity was observed among the profiles.

Lower water dispersible clay content was observed in Eucalyptus plantation followed by barrenland and the values was high in reserve forest. Surface layer of Wynad reserve forest had 7.5 per cent water dispersible clay whereas barrenland (6.3) and Eucalyptus plantation (6.0) showed a decrease in the content of water dispersible clay. In the sandy tract also, monoculture plantations of Eucalyptus and Acacia resulted in a lowering of the water dispersible content.

Aggregate stability showed variation among the profiles in a location. This was true in sandy tracts also. Surface layer of Wynad reserve forest had an aggregate stability of 60.95 per cent, barrenland had 58.49 per cent had Eucalyptus plantation recorded a value of 59.93 per cent. At Kottoor, surface layer of reserve forest recorded higher value (52.70) compared to that of barrenland (46.90) and Eucalyptus plantation (48.77). At Nileswar, surface layer of Acacia plantation had a higher value (42.56) compared to cultivated (41.50) and

and barrenland (40.03). Aggregate stability values for the surface layer of soil profiles from Kazhakkoottam were 43.39, 45.95, 43.92 and 45.68 respectively for cultivated land, barren land, Eucalyptus and Acacia plantations.

9. Changes in soil chemical characteristics as a function of depth

Table 14 presents the impact of Eucalyptus and Acacia plantations on soil chemical characteristics as a function of depth.

Both barrenland and Eucalyptus plantation resulted in a decrease in pH compared to reserve forest at Kottoor while barrenland at Wynad recorded comparatively higher pH. Lowering of pH was observed in soils under monoculture plantations of Eucalyptus and Acacia in the sandy tracts compared to cultivated or barren lands.

Forested areas showed a decrease in organic carbon content in barrenland and Eucalyptus plantation and this change was more marked in the surface layer. Surface layer of Wynad reserve forest contained 2.36 per cent organic carbon while it was very low in barrenland (1.53) and Eucalyptus plantation (1.61). An increase in organic carbon content was observed in monoculture plantations in sandy tracts and this change was more in the surface layer (0-50 cm). Surface layer of Kazhakkoottam Eucalyptus (0.36) and Acacia (0.41)

Table 14. Impact of Eucalyptus and Acacia plantations on chemical characteristics of soil as a function of its depth.

Sample No.	Depth in cm	pH	Organic carbon %	Total N %	C|N ratio	C.E.C. cmol kg^{-1}	Base saturation %	Total P_2O_5 %	Total K_2O %	Total CaO %	Total MgO %	Total Fe_2O_3 %	Total Al_2O_3 %
	Profile 1. Wynad Reserve forest												
1	0-50	6.1	2.36	0.144	16.38	15.95	71.25	0.087	0.480	0.068	0.040	9.12	11.1
2	50-100	5.9	0.92	0.075	12.27	10.43	62.20	0.075	0.424	0.049	0.036	12.15	14.7
3	100-150	5.8	0.62	0.060	10.33	5.55	50.95	0.059	0.346	0.052	0.031	12.25	17.9
	Profile-2. Wynad Barrenland												
1	0-50	6.1	1.53	0.125	12.24	13.45	59.80	0.072	0.337	0.053	0.038	10.18	13.5
2	50-100	6.3	0.61	0.059	10.34	10.50	52.17	0.057	0.336	0.059	0.035	12.42	18.0
3	100-150	6.5	0.45	0.048	9.38	6.50	47.60	0.053	0.319	0.059	0.030	12.06	20.2
	Profile 3. Wynad Eucalyptus												
1	0-50	5.4	1.61	0.127	12.68	14.53	55.40	0.061	0.339	0.051	0.028	12.66	15.2
2	50-100	5.3	0.63	0.070	9.00	11.75	51.95	0.051	0.338	0.057	0.031	14.33	18.5
3	100-150	5.2	0.45	0.057	7.89	7.70	47.70	0.037	0.301	0.057	0.026	13.46	20.8
	Profile 4. Kottoor Reserve forest												
1	0-50	5.1	3.18	0.211	15.07	16.30	56.50	0.086	0.458	0.061	0.029	8.72	11.0
2	50-100	4.8	0.63	0.080	7.88	7.90	44.70	0.071	0.395	0.031	0.024	11.34	16.7
3	100-150	4.5	0.51	0.073	6.99	5.30	43.50	0.064	0.391	0.025	0.023	11.15	18.7
	Profile 5. Kottoor Barrenland												
1	0-50	4.7	1.37	0.152	9.01	11.63	47.80	0.076	0.357	0.026	0.028	15.33	15.3
2	50-100	4.4	0.57	0.078	7.31	5.90	38.90	0.064	0.319	0.024	0.027	18.83	18.8
3	150-200	4.1	0.41	0.064	6.41	5.00	35.80	0.062	0.318	0.022	0.026	19.76	19.7
	Profile 6. Kottoor Eucalyptus												
1	0-50	4.5	1.67	0.163	10.25	13.40	46.20	0.072	0.366	0.040	0.028	14.79	14.7
2	50-100	4.8	0.49	0.067	7.31	6.40	37.90	0.044	0.312	0.043	0.025	18.48	18.4
3	100-150	4.7	0.40	0.059	6.77	5.10	34.10	0.036	0.309	0.027	0.021	20.26	20.2
	Profile 7. Nileswar Cultivated land												
1	0-50	5.2	0.19	0.019	10.00	3.8	33.00	0.043	0.035	0.090	0.037	0.78	2.8
2	50-100	5.3	0.06	0.007	8.57	3.0	22.80	0.029	0.029	0.080	0.032	0.66	3.3
3	100-150	4.9	0.04	0.005	8.00	2.6	18.30	0.026	0.029	0.079	0.029	0.60	3.4

(contd.)

Table 14 (contd.)

ample No.	Depth in cm	pH	Organic carbon %	Total N %	C|N ratio	C.E.C. cmol kg^{-1}	Base satura tion. %	Total P_2O_5 %	Total K_2O %	Total CaO %	Total MgO %	Total Fe_2O_3 %	Tota Al_2O %
	Profile 8. Nileswar Barrenland												
1	0-50	5.0	0.17	0.016	10.63	3.7	29.00	0.028	0.026	0.086	0.035	0.78	3.09
2	50-100	4.3	0.05	0.006	8.33	3.0	20.50	0.022	0.026	0.095	0.032	0.67	3.44
3	100-150	4.9	0.04	0.005	8.00	2.7	16.70	0.020	0.027	0.093	0.030	0.63	3.49
	Profile 9. Nileswar Acacia												
1	0-50	4.2	0.33	0.035	9.43	3.9	27.50	0.027	0.026	0.069	0.035	0.92	3.22
2	50-100	3.9	0.11	0.013	8.46	3.0	21.00	0.021	0.025	0.077	0.032	0.74	3.63
3	100-150	3.7	0.09	0.011	8.18	2.7	16.90	0.019	0.026	0.061	0.024	0.63	3.81
	Profile 10.Kazhakkoottam cultivated land												
1	0-50	5.0	0.20	0.016	12.50	3.0	31.60	0.053	0.031	0.055	0.052	0.67	2.23
2	50-100	4.6	0.09	0.010	9.00	2.7	25.60	0.030	0.027	0.051	0.047	0.61	2.56
3	100-150	4.6	0.07	0.010	7.00	2.5	24.10	0.019	0.026	0.053	0.046	0.58	2.69
	Profile 11.Kazhakkoottam Barrenland												
1.	0-50	4.7	0.18	0.015	12.00	3.0	30.50	0.033	0.027	0.055	0.057	0.71	2.42
2	50-100	4.5	0.07	0.007	10.00	2.6	22.40	0.024	0.026	0.051	0.050	0.62	2.92
3	100-150	4.6	0.06	0.007	8.57	2.3	20.30	0.020	0.027	0.050	0.043	0.59	3.13
	Profile 12.Kazhakkoottam Eucalyptus												
1	0-50	4.4	0.36	0.039	9.23	3.1	27.90	0.033	0.031	0.026	0.052	0.81	2.54
2	50-100	4.3	0.20	0.025	8.00	2.7	19.70	0.023	0.026	0.039	0.055	0.66	3.10
3	100-150	4.4	0.18	0.023	7.83	2.5	18.10	0.019	0.027	0.038	0.053	0.61	3.28
	Profile 13.Kazhakkoottam,Acacia												
1	0-50	4.3	0.41	0.032	10.51	3.2	26.70	0.030	0.028	0.049	0.048	0.82	2.67
2	50-100	4.2	0.24	0.025	9.60	2.6	20.10	0.021	0.028	0.071	0.048	0.71	3.01
3	100-150	4.2	0.21	0.024	8.75	2.4	18.30	0.018	0.029	0.073	0.043	0.62	3.1

plantations contained more organic carbon than barren land (0.18) and cultivated land (0.20). Same pattern of changes was observed in the case of total nitrogen also. All the soil profiles under monoculture plantations showed a reduction in C|N ratio as compared to that of reserve forest or cultivated land.

In the case of cation exchange capacity, a decrease was the result in the surface layers of barrenland and Eucalyptus plantation compared to that of reserve forest. At Wynad, a slight increase in C.E.C. was observed in the bottom layers of barrenland (6.50 c mol kg^{-1}) and Eucalyptus plantation (7.70) compared to that of reserve forest (5.55). In the sandy tracts of Nileswar and Kazhakkoottam C.E.C. increased slightly in soils under monoculture plantations of Eucalyptus and Acacia.

Base saturation decreased both in barrenland and Eucalyptus plantation compared to reserve forest. Surface layer of Wynad reserve forest had 71.25 per cent base saturation while it was only 59.80 per cent in barren land and 55.40 in Eucalyptus plantation. At Kottoor, the values were 56.50 47.80 and 46.20 per cent respectively in reserve forest barren land and Eucalyptus plnatation. In the sandy tracts of Nileswar and Kazhakkoottam, higher per cent base saturation was observed in cultivated land, barrenland had a lower value and monoculture plantations of Eucalyptus and Acacia recorded lowest values.

Eucalyptus plantation and barrenland of Wynad and Kottoor showed a decrease in total P_2O_5 content compared to serve forest. Decrease was more in the lowest layer. The bottom layer of Wynad reserve forest had 0.059 per cent P_2O_5, barren land had 0.053 per cent and Eucalyptus plantation had only 0.037 per cent P_2O_5. The corresponding values for the profiles at Kottoor were 0.064, 0.062 and 0.036 per cent respectively in reserve forest, barrenland and Eucalyptus plantation. In the sandy tracts, higher values were recorded in soils under cultivated land and Eucalyptus and Acacia plantations had low P_2O_5 contents.

The total content of base (K_2O, CaO and MgO) showed a decline in monoculture plantations in all the four locations Highest values were recorded in reserve forest or cultivated land.

The content of iron and aluminium increased with depth in forest regions. An increase in the sesquioxide contents was observed in barren land and Eucalptus plantation compared to reserve forest. At Wynad, surface layer of Eucalptus plantation had 12.66 per cent Fe_2O_3 while that of barrenland was 10.18 and reserve forest had the lowest content of 9.12 per cent. The corresponding values for Al_2O_3 were 15.21, 13.52 and 11.18. Total Fe_2O_3 in the sandy profiles decreased with depth while aluminium increased with depth. In the sandry tracts also, monoculture plantations of Eucalyptus and Acacia resulted in an increase in the sesquioxide content than in cultivated and

barrenlands. Fe_2O_3 contents in the surface layers of profiles from Nileswar were 0.78, 0.78 and 0.92 per cent respectively in cultivated land, barren land and Acacia plantation whereas the corresponding Al_2O_3 contents were 2.89, 3.09 and 3.22 per cent.

10. Changes in fertility status of soil as a function of depth

Table 15 gives the impact of Eucalyptus and Acacia plantations on fertility status of soil as a function of depth. The parameters studied were organic matter, available nitrogen, phosphorus and potassium, C.E.C. and base saturation.

A sharp decrease in organic matter content was observed in Eucalyptus plantation and barrenland compared to reserve forest. Surface layer of Wynad reserve forest recorded organic matter content of 4.06 per cent while it was only 2.63 per cent in barrenland and 2.77 per cent in Eucalyptus plantation. In the case of sandy tracts, monoculture plantations of Eucalyptus and Acacia resulted in an increase in organic matter content.

Available N content was lower in Eucalyptus plantation and barrenland compared to reserve forest. Surface layer of Wynad reserve forest had 0.050 per cent available N while it was only 0.031 in barrenland and 0.030 in Eucalyptus plantation. At Kottoor, surface layers had 0.029, 0.022 and 0.024 per cent in reserve forest, barrenland and Eucalyptus plantation.

Table 15. Impact of Eucalyptus and Acacia plantations on fertility status of soil as a function of its depth.

Sample No.	Depth in cm	Organic matter %	Available N %	Available P_2O_5 ppm	Available K_2O meq $100g^{-1}$	C.E.C. cmol kg^{-1}	Base saturation %
	Profile 1. Wynad Reserve forest						
1.	0-50	4.06	0.050	5.60	0.477	15.95	71.25
2.	50-100	1.59	0.032	2.98	0.436	10.43	62.20
3.	100-150	1.06	0.022	2.78	0.376	5.55	50.95
	Profile 2. Wynad Barrenland						
1.	0-50	2.63	0.031	3.35	0.448	13.45	59.80
2.	50-100	1.05	0.019	2.83	0.344	10.50	52.17
3.	100-150	0.77	0.016	2.43	0.266	6.50	47.60
	Profile 3. Wynad Eucalyptus						
1.	0-50	2.77	0.030	2.68	0.597	14.53	55.40
2.	50-100	1.09	0.211	2.23	0.469	11.75	51.95
3.	100-150	0.78	0.019	1.90	0.374	7.70	47.70
	Profile 4. Kottoor Reserve forest						
1.	0-50	5.48	0.029	2.49	0.674	16.30	56.50
2.	50-100	1.09	0.026	1.10	0.596	7.90	44.70
3.	100-150	0.90	0.025	0.78	0.562	5.30	43.50
	Profile 5. Kottoor Barrenland						
1.	0-50	2.37	0.022	1.43	0.602	11.63	47.80
2.	50-100	0.99	0.020	1.03	0.562	5.90	38.90
3.	100-150	0.72	0.020	0.95	0.552	5.00	35.80
	Profile 6. Kottoor Eucalyptus						
1.	0-50	3.45	0.024	0.78	0.704	13.40	46.20
2.	50-100	0.86	0.020	0.33	0.566	6.40	37.90
3.	100-150	0.69	0.020	0.33	0.441	5.10	34.10
	Profile 7. Nileswar Cultivated land						
1.	0-50	0.34	0.006	5.27	0.151	3.8	33.00
2.	50-100	0.11	0.004	3.14	0.141	3.0	22.80
3.	100-150	0.07	0.003	2.16	0.138	2.6	18.30
	Profile 8. Nileswar Barrenland						
1.	0-50	0.29	0.004	3.86	0.149	3.7	29.00
2.	50-100	0.09	0.003	2.52	0.137	3.0	20.50
3.	100-150	0.07	0.002	2.15	0.135	2.7	16.70
	Profile 9. Nileswar Acacia						
1.	0-50	0.57	0.005	2.88	0.182	3.9	27.50
2.	50-100	0.19	0.004	2.01	0.155	3.0	21.00
3.	100-150	0.15	0.003	1.91	0.148	2.7	16.90

Table 15 (contd.)

Sample No.	Depth in cm	Organic matter %	Available N %	Available P_2O_5 ppm	Available K_2O meq $100g^{-1}$	C.E.C. cmol kg^{-1}	Base saturation %
	Profile 10. Kazhakkoottam Cultivated land						
1.	0-50	0.35	0.006	4.56	0.187	3.0	31.6
2.	50-100	0.15	0.003	2.83	0.162	2.7	25.6
3.	100-150	0.12	0.002	2.28	0.135	2.5	24.1
	Profile 11. Kazhakkoottam Barrenland						
1.	0-50	0.24	0.006	5.66	0.180	3.0	30.5
2.	50-100	0.12	0.003	3.97	0.155	2.6	22.4
3.	100-150	0.12	0.002	2.38	0.128	2.3	20.3
	Profile 12. Kazhakkoottam Eucalyptus						
1.	0-50	0.62	0.011	2.59	0.185	3.1	27.9
2.	50-100	0.33	0.010	2.07	0.141	2.7	19.7
3.	100-150	0.30	0.010	1.98	0.121	2.5	18.1
	Profile 13. Kazhakkoottam Acacia.						
1.	0-50	0.72	0.012	3.36	0.204	3.2	26.7
2.	50-100	0.41	0.010	2.68	0.156	2.6	20.1
3.	100-150	0.36	0.009	2.65	0.119	2.4	18.3

In the sandy tract of Kazhakkoottam, surface layer of Eucalyptus (0.011)and Acacia (0.012) plantations had higher values compared to that of barrenland (0.006) and cultivated land (0.006).

A drastic reduction in available P_2O_5 content was observed in soils under Eucalyptus plantation compared to reserve forest. Barrenland recorded intermediate values. At Wynad, available P_2O_5 contents were 5.60, 3.35 and 2.68 ppm in the surface layers of soils under reserve forest, barrenland and Eucalyptus plantation. In the sandry tracts also, available P_2O_5 content decreased drastically under monoculture plantations of Eucalyptus and Acacia. The values for the surface layers of the soil profiles from Kazhakkoottam were 4.56, 5.66, 2.59 and 3.36 ppm respectively in cultivated land, barren land, Eucalyptus and Acacia plantations.

Monoculture plantations showed an increase in available K_2O content. Surface layer of Wynad Eucalyptus plantation (0.597 meq 100 $\bar{g}^1$) had a higher K_2O than in barrenland (0.448) and reserve forest (0.477). The corresponding values in the profiles at Kottoor were 0.704, 0.602 and 0.674 meq 100 $\bar{g}^1$ in Eucalyptus plantation, barrenland and reserve forest. Surface layer of Nileswar Acacia plantation had 0.182 meq 100 $\bar{g}^1$ available K_2O while it was only 0.149 and 0.151 in barren land and cultivated land respectively. At Kazhakkoottam, the values were 0.187, 0.180, 0.185 and 0.204 meq 100 $\bar{g}^1$ respectively in the surface layers of profiles under cultivated land, barrenland, Eucalyptus and Acacia plantations.

11. Impact on soil degradation

Table 16 summarises the various parameters used to assess the impact of Eucalyptus and Acacia plantations on soil degradation. The parameters were organic matter, silt| clay ratio, water dispersible clay, water holding capacity, sesquioxides and Fe_o | Fe_d ratio.

$Fe_o|Fe_d$ ratio which was suggested as an index of laterisation was less in Eucalyptus plantation and barren land compared to reserve forest. This ratio was 0.21 in the surface layer of Wynad reserve forest while it was only 0.13 both in barren land and Eucalyptus plantation. At Kottoor, the values were 0.16, 0.11 and 0.10 for the surface layers of the soil profiles under reserve forest, barrenland and Eucalyptus plantation. At Nileswar, surface layers had ratios of 0.55, 0.42 and 0.42 respectively in cultivated land, barrenland and Acacia plantation. $Fe_o|Fe_d$ ratios of the surface layers of soil profiles under Eucalyptus (0.45) and Acacia (0.44) plantations were lower than that of barrenland (0.49) and cultivated land (0.57) at Kazhakkoottam.

12. Biological characteristics of soils

Table 17 gives the total microflora population and nitrifying properties of surface soils. The parameters studied were population of total microflora, Nitrosomonas, Nitrobacter and Rhizobium.

Table 16. Impact of Eucalyptus and Acacia plantations on soil degradation.

Sample No.	Depth in cm	Organic matter %	Silt/clay ratio	Water dispersible clay %	Water holding capacity %	Sesquioxides %	Fe_o/Fe_d ratio
Profile 1. Wynad Reserve forest							
1.	0-50	4.06	0.27	7.5	52.50	20.29	0.21
2.	50-100	1.59	0.33	6.4	53.25	26.93	0.18
3.	100-150	1.06	0.41	5.4	51.95	30.15	0.16
Profile 2. Wynad Barrenland							
1.	0-50	2.63	0.28	6.3	41.15	23.70	0.13
2.	50-100	1.05	0.36	5.8	39.90	30.46	0.14
3.	100-150	0.77	0.39	5.3	39.55	32.31	0.13
Profile 3. Wynad Eucalyptus							
1.	0-50	2.77	0.23	6.0	40.90	27.87	0.13
2.	50-100	1.09	0.30	5.5	40.15	32.91	0.13
3.	100-150	0.78	0.32	4.9	38.85	34.77	0.12
Profile 4. Kottoor Reserve forest							
1.	0-50	5.48	0.27	6.9	51.20	19.78	0.16
2.	50-100	1.09	0.34	4.7	53.53	26.25	0.14
3.	100-150	0.90	0.39	4.5	54.89	29.88	0.14
Profile 5. Kottoor Barrenland							
1.	0-50	2.37	0.26	5.0	44.76	25.72	0.11
2.	50-100	0.99	0.36	4.2	41.45	30.63	0.10
3.	100-150	0.72	0.39	4.0	40.56	31.44	0.09
Profile 6. Kottoor Eucalyptus							
1.	0-50	3.45	0.21	4.9	46.99	25.98	0.10
2.	50-100	0.86	0.28	3.9	44.32	31.39	0.09
3.	100-150	0.69	0.36	3.7	40.39	32.89	0.10
Profile 7. Nileswar cultivated land							
1.	0-50	0.34	0.65	2.4	30.38	3.67	0.55
2.	50-100	0.11	0.73	2.0	27.90	3.98	0.50
3.	100-150	0.07	0.77	1.9	26.80	4.08	0.50
Profile 8. Nileswar Barrenland							
1.	0-50	0.29	0.65	2.2	27.75	3.87	0.42
2.	50-100	0.09	0.73	1.8	26.35	4.11	0.43
3.	100-150	0.07	0.76	1.7	26.10	4.12	0.42
Profile 9. Nileswar Acacia							
1.	0-50	0.57	0.55	2.1	27.80	4.14	0.42
2.	50-100	0.19	0.70	1.7	26.42	4.38	0.42
3.	100-150	0.15	0.72	1.5	25.90	4.44	0.40

(contd.)

Table 16. (contd.)

Sample No.	Depth in cm	Organic matter %	Silt/Clay ratio %	Water dispersible clay. %	Water holding capacity %	Sesquioxides %	Fe_o/Fe_d ratio
	Profile 10. Kazhakkoottam cultivated land						
1.	0-50	0.35	0.73	2.8	26.08	2.90	0.57
2.	50-100	0.15	1.11	2.4	25.26	3.17	0.61
3.	100-150	0.12	1.17	2.1	24.73	3.27	0.61
	Profile 11. Kazhakkoottam Barrenland						
1.	0-50	0.24	0.73	2.7	25.47	3.23	0.49
2.	50-100	0.12	1.03	2.2	23.92	3.54	0.41
3.	100-150	0.12	1.04	2.0	22.86	3.72	0.38
	Profile 12. Kazhakkoottam Eucalyptus						
1.	0-50	0.62	0.57	2.1	25.43	3.21	0.45
2.	50-100	0.33	0.95	1.2	24.07	3.76	0.43
3.	100-150	0.30	1.01	1.1	24.10	3.89	0.43
	Profile 13. Kazhakkoottam Acacia						
1.	0-50	0.72	0.60	2.5	24.77	3.49	0.44
2.	50-100	0.41	0.76	2.0	23.43	3.72	0.41
3.	100-150	0.36	0.85	1.4	23.75	3.77	0.40

Table 17. Total microflora population and nitrifying properties of surface soils.

Location	Total microflora no. g^{-1}	Nitrosomonas no. g^{-1}	Nitrobacter no. g^{-1}	Rhizobium no. g^{-1}
1. Wynad				
1.Reserve forest	5.67×10^6	7.33×10^4	5.67×10^4	3.00×10^4
2.Barrenland	4.67×10^6	5.33×10^4	4.00×10^4	2.00×10^4
3.Eucalyptus	5.00×10^6	5.67×10^4	4.33×10^4	2.33×10^4
2. Kottoor				
4.Reserve forest	6.67×10^6	7.67×10^4	5.67×10^4	4.33×10^4
5.Barren land	5.67×10^6	5.67×10^4	4.00×10^4	4.33×10^4
6.Eucalyptus	5.33×10^6	6.00×10^4	4.33×10^4	4.00×10^4
3.Nileswar				
7.Cultivated land	2.00×10^6	2.00×10^4	2.00×10^4	2.33×10^4
8.Barren land	1.33×10^6	1.67×10^4	1.33×10^4	2.00×10^4
9.Acacia	1.67×10^6	1.67×10^4	1.67×10^4	3.33×10^4
4. Kazhakkoottam				
10. Cultivated land	3.00×10^6	3.33×10^4	2.33×10^4	2.67×10^4
11. Barrenland	1.33×10^6	2.67×10^4	1.67×10^4	1.67×10^4
12. Eucalyptus	1.67×10^6	2.67×10^4	1.33×10^4	1.67×10^4
13. Acacia	2.33×10^6	3.00×10^4	1.67×10^4	3.33×10^4

Total microflora population was less in barrenland and monoculture plantations compared to reserve forest or cultivated land. Total microflora population in Wynad reserve forest was $5.67 \times 10^{6} g^{-1}$ while it was 4.67×10^{6} in barrenland and 5.00×10^{6} in Eucalyptus plantation. In the sandy tracts, monoculture plantations and barrenland had lesser population compared to cultivated land. Kazhakkoottam Eucalyptus(1.67×10^{6} and Acacia (2.33×10^{6}) plantations and barrenland(1.33×10^{6}) had less total microflora compared to cultivated land (3.00×10^{6}. Lowest values were recorded in barrenland.

Population of Nitrosomonas and Nitrobacter decreased in barrenland and Eucalyptus plantation compared to reserve forest. Even in sandy tracts, there was a decrease in the population of these microorganisms. At Wynad, population of Nitrosomonas were 7.33×10^{4}, 5.33×10^{4} and $5.67 \times 10^{4} g^{-1}$ in reserve forest, barrenland and Eucalyptus plantation. The corresponding values for Nitrobacter were 5.67×10^{4}, 4.00×10^{4} and 4.33×10^{4} $\bar{g}^{1}$. In the sandy tract of Kazhakkoottam Eucalyptus (2.67×10^{4}) and Acacia (3.00×10^{4}). Plantations and barrenland (2.67×10^{4}) had lower population of Nitrosomonas compared to cultivated land(3.33×10^{4}). The corresponding values for Nitrobacter were 1.33×10^{4}, 1.67×10^{4}, 1.67×10^{4} and 2.33×10^{4}.

Eucalyptus plantations in all the locations had lesser number of Rhizobium population compared to reserve forest or

cultivated land. Population of Rhizobium in Wynad Eucalyptus plantation (2.33×10^4) and barren land (2.00×10^4) were less than that in reserve forest (3.00×10^4). An increase in the population of Rhizobium was observed in Acacia plantations. Population of Rhizobium in Nileswar Acacia plantation was 3.33×10^4 while it was only 2.00×10^4 and 2.33×10^4 in barrenland and cultivated land respectively.

13. Biomass studies

Tables18 and 19 give the height and diameter at breast height (DBH) of Eucalyptus tereticornis and Acacia auriculiformis from different locations. These values are the mean height and DBH of 50 trees from each plantation.

Seventeen year old Eucalyptus trees in Wynad had a mean height of 21.69 m and DBH of 54.90 cm. Eucalyptus plantations of Kottoor and Kazhakkoottam were 7 years old. The mean height and DBH of Eucalyptus in Kottoor were 10.43 m and 40.30 cm respectively while in the sandry tract the height and DBH of trees of the same age were 9.30 m and 22.38 cm respectively.

Height and DBH of Acacia were measured from the sandy tracts of Nileswar and Kazhakkoottam. Both plantations were 7 years old. Nileswar plantation recorded mean height and DBH of 5.34 m and 20.00 cm respectively while in Kazhakkoottam the values were 8.22 m and 25.03 cm respectively.

Table 18. Mean height and diameter at breast height (DBH) of Eucalyptus tereticornis from different locations

	Wynad (17 yrs old)	Kottoor (7 yrs old)	Kazhakoottam (7 yrs old)
Height (m)	21.69	10.43	9.30
DBH (cm)	54.90	40.30	22.38

Table 19. Mean height and diameter at breast height (DBH) of Acacia auriculiformis from different locations

	Nileswar (7 yrs old)	Kazhakkoottam (7 yrs old)
Height (m)	5.34	8.22
DBH (cm)	20.00	25.03

14. Manurial value of the leaves of Eucalyptus and Acacia.

Table 20 gives the manurial value of the leaves of Eucalyptus and Acacia. Contents of N, P, K, Ca, Mg, Crude fibre and crude protein were given in the Table. The nitrogen content in the leaves of Eucalyptus was 1.25 per cent while it was 1.82 per cent in Acacia leaves. Phosphorus content was almost similar in the leaves of Eucalyptus (0.08) and Acacia (0.07). Eucalyptus leaves contain higher content of potassium (0.99 per cent) in comparison to that of Acacia (0.66 per cent). Calcium content in the leaves of Acacia was very high (1.78 per cent) compared to Eucalyptus leaves (0.59 per cent). Eucalyptus and Acacia leaves had 0.48 and 0.30 per cent respectively of magnesium. The crude fibre contents were 21.9 and 25.8 per cent in Eucalyptus and Acacia leaves.

15. Chlorophyll content in the leaves of Eucalyptus and Acacia.

Table 21 gives the total chlorophyll content, chlorophyll-a and -b values in the leaves of Eucalyptus and Acacia. Eucalyptus recorded total chlorophyll content of 3.1 mg dm^{-2} while the chlorophyll-a and -b values were 2.0 and 0.8 mg dm^{-2} respectively. Acacia leaves had total chlorophyll content of 4.5 mg dm^{-2} and chlorophyll-a and -b values were 3.0 and 1.1 mg dm^{-2} respectively. The ratio of chlorophyll-a to chlorophyll-b (a|b) in the leaves were 2.5 and 2.7 respectively for Eucalyptus and Acacia leaves.

Table 20. Nutrient contents in the leaves of Eucalyptus and Acacia

Sample No.	N %	P %	K %	Ca %	Mg %	Crude fibe %	Crude protein %
A. Eucalyptus							
1	1.26	0.06	0.95	0.50	0.51	21.2	7.9
2	1.10	0.08	0.93	0.58	0.47	23.9	6.8
3	1.31	0.10	0.91	0.61	0.49	19.6	8.2
4	1.28	0.11	1.03	0.59	0.50	22.5	8.0
5	1.22	0.05	0.98	0.63	0.46	21.6	7.6
6	1.26	0.09	0.98	0.57	0.45	23.1	7.9
7	1.26	0.10	0.97	0.59	0.47	22.9	7.9
8	1.26	0.06	1.10	0.62	0.44	21.7	8.3
9	1.33	0.08	1.02	0.61	0.51	20.9	8.1
10	1.22	0.09	0.98	0.60	0.49	21.8	7.6
Mean	1.25	0.08	0.99	0.59	0.48	21.9	7.8
B. Acacia							
1	1.73	0.07	0.52	1.38	0.26	26.3	10.8
2	1.78	0.08	0.61	1.96	0.29	27.1	11.1
3	1.81	0.06	0.63	1.56	0.26	26.9	11.3
4	1.74	0.06	0.69	1.78	0.28	24.3	10.9
5	1.76	0.08	0.53	1.76	0.35	24.7	11.0
6	1.90	0.05	0.71	1.69	0.34	26.1	11.9
7	1.94	0.10	0.62	1.80	0.36	28.3	12.1
8	1.89	0.07	0.80	2.01	0.29	23.2	11.8
9	1.86	0.08	0.71	1.91	0.28	25.8	11.6
10	1.81	0.07	0.73	1.93	0.27	24.9	11.3
Mean	1.82	0.07	0.66	1.78	0.30	25.8	11.4

Table 21. Chlorophyll content in the leaves of Eucalyptus and Acacia

Sample No.	Total Chlorophyll mg dm^{-2}	Chlorophyll-a mg dm^{-2}	Chlorophyll-b mg dm^{-2}	a|b
	Eucalyptus			
1	3.5	2.3	0.9	2.6
2	3.1	2.1	0.8	2.6
3	3.0	1.9	0.9	2.1
4	2.7	1.7	0.6	2.8
5	2.9	2.2	0.6	3.7
6	3.1	1.9	0.9	2.1
7	3.0	1.8	0.7	2.6
8	3.7	2.5	0.8	3.1
9	2.9	1.6	0.9	1.8
10	3.1	2.1	0.6	3.5
Mean	3.1	2.0	0.8	2.5
	Acacia			
1	4.7	3.1	1.2	2.6
2	4.9	3.0	1.4	2.1
3	4.4	2.8	1.1	2.5
4	4.6	3.0	1.3	2.3
5	4.0	2.7	0.9	3.0
6	4.2	2.9	0.8	3.6
7	4.7	3.1	1.2	2.6
8	4.8	3.2	1.1	2.9
9	4.5	3.0	1.2	2.5
10	4.4	3.0	0.9	3.3
Mean	4.5	3.0	1.1	2.7

DISCUSSION

DISCUSSION

Since Eucalyptus tereticornis and Acacia auriculiformis are two new introductions under the National Social Forestry programme, their impact on soil characteristics has not yet been fully studied. Hence the present study on the impact of Eucalyptus and Acacia plantations on soil properties in different pedogenic environments in Kerala justify the aim of filling the gap in our knowledge about the impact of these plantations on soil characteritics with special reference to Kerala. The objectives of such an investigation were attempted to achieve through field and laboratory studies, the results of which have been presented in the previous chapter.

1. Morphology of the pedons

Table 2 present the morphological description of the soil profiles. Since it was intended to have uniformity in profile description and to keep in line with Soil Taxonomy, soil harizons extending upto 2 meters were taken into consideration.

A critical examination of the profile descriptions reveals that in forested areas, profiles under barren land and Eucalyptus plantation came under the soil order Alfisols while profile under reserve forest came under the soil order Mollisols. This was true both in Wynad and Kottoor. This is due to a lower

level of organic matter content both in Eucalyptus plantation and barren land compared to reserve forest (Soil Survey Staff, 1987). All the sandy profiles from Nileswar and Kazhakkoottam were included under the soil order Entisols since they satisfy the requirements as suggested by the U.S. Soil Survey Staff (1987).

The moist colour of the epipedon of Wynad reserve forest was found to be very dusky red (2.5YR 2.5/2), in Eucalyptus plantation it was very dark grey (5 YR 3/1) and in barrenland it was dark reddish brown (5YR 3/2). The moist colours of the epipedon of Kottoor reserve forest, barren land and Eucalyptus plantation were very dark grey (10YR 3/1), dark brown (10YR 4/3) and dark reddish brown (5YR 2.5/2) respectively. The variation in colour is attributed to the changes in the contents of humus and iron oxides in profiles of the forested regions. In sandy profiles, monoculture plantations recorded dark colours compared to cultivated or barrenland which is mainly due to higher humus content in these plantations. The subsurface horizons of profile from forest areas showed different shades of reddish brown. red and yellowish brown. The difference in the hydration of iron compounds has been responsible for the variation in the colour of these horizons (Buol et al, 1980). Hence, colour notations can, to a certain extent, serve as a guide in judging the change in soil characteristics under monoculture plantations of Eucalyptus and Acacia.

With regard to texture, not much variation was observed among profiles in a location. Almost all the profiles from forest areas came under the textural class clay and almost all the profiles from sandy tracts came under the textural class sandyloam.

With regard to structure, surface horizons of profiles from forested areas, in general, had angular blocky structure while it was granular in sandy soils. The percentage of Macroaggregates was higher in Eucalyptus plantations and barrenlands compared to reserve forest. This is attributed to the relative increase in sesquioxide content which act as a binding agent(Buol et al, 1980) and increase the percentage of macroaggregates.

Morphological observation of the pedons reveal that in Eucalyptus plantations roots go as deep as 2 m and more and its distribution was in such a way that at the surface there was a layer of fine roots and in the middle layer roots were comparatively less and then larger roots were present at the bottom of the profiles. In Acacia plantations a dense mat of fine roots was present at the surface and few, coarse roots are below.

Signs of slight plinthisation was evident in soils under Eucalyptus plantations at Kottoor at a depth of 95 cm below the soil surface.

2. Soil physical characteristics

As evident from Table 3 and Fig.1 an increase in gravel content was observed both in Eucalyptus plantation and barrenland compared to reserve forest of Wynad and Kottoor. Even in sandy tracts of Nileswar and Kazhakkoottam gravel content increased in monoculture plantations compared to cultivated or barren land. Increase in gravel content increases induration and it can depress plant growth if it occupies significant volume in coarse soils (Raunach, 1967; Armson, 1977; Pritchett, 1979).

Among the soil separates sand, silt and clay, the one which showed variation was percentage of clay. Eluviation of clay was marked in soils under Eucalyptus and barrenland than in reserve forest. In these profiles, clay increase was to the tune of 1.2 times in the subsurface horizon which qualifies it to be called an argillic horizon (Buol et al, 1980). Even in the sandy profiles of Kazhakkoottam, downward movement of clay was more in soils under monoculture plantations of Eucalyptus and Acacia compared to cultivated or barrenlands. When the extent of mechanical eluviation and clay migration increases, the process of laterisation also proceeds at a faster rate. This was observed in the laterite soils of Kerala by Varghese (1981).

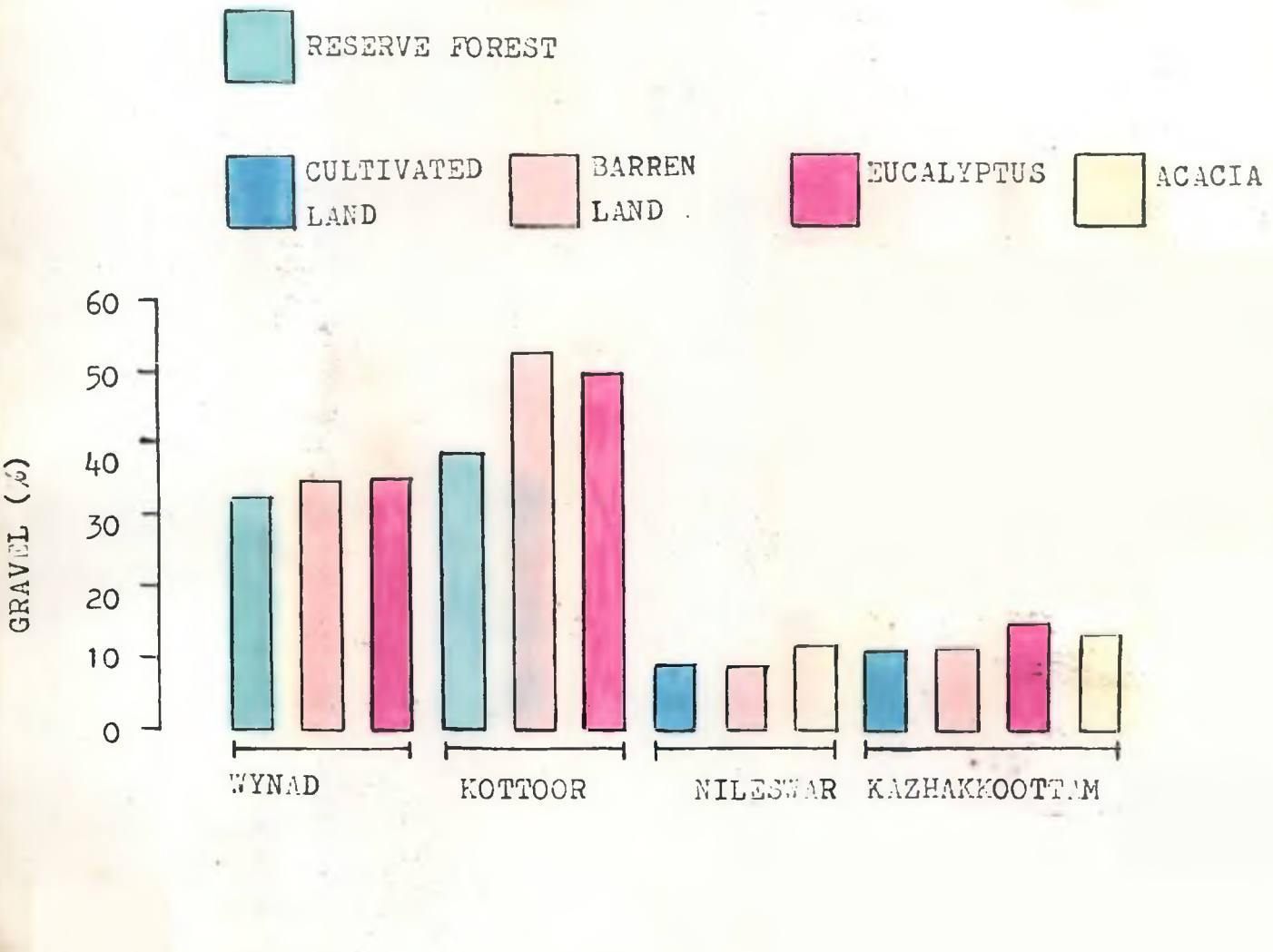

Fig 1. Variation in gravel content in different soil profiles.

With regard to textural classification, almost all the profiles from forested areas were found to come under clays whereas the coastal sandy profiles belonged to sandyloams.

Silt|clay ratio (Van Wambeke, 1962) is considered to be both an index of weathering and index of the extent of lateri-sation. The critical value is considered to be 0.25(Buringh,1970). If we analyse L|A values of the profiles from forested areas, we can see that the values were near to the critical value in Eucalyptus plantations while higher values were recorded in soils under reserve forest. Barrenlands recorded intermediate values. This very low value of silt|clay ratio in soils under Eucalyptus plantation reflects their rapid rate of ferrallitisation compared to barrenlands or reserve forests. Even in sandy tracts, a decrease in the value of silt|clay ratio was observed in soils under these monoculture plantations compared to that of cultivated or barren lands

The single value physical constants of the soils also reflect the rate of pedogenesis to a certain extent. Of these. bulk density appears to be the significant variable (Table 4 and Fig.2). An increase in bulk density was observed both in barrenlands and Eucalyptus plantations compared to reserve forests. The low bulk density of the highland forests is mainly attributed to the higher organic matter content. Increase in bulk density in Eucalyptus plantation and barren

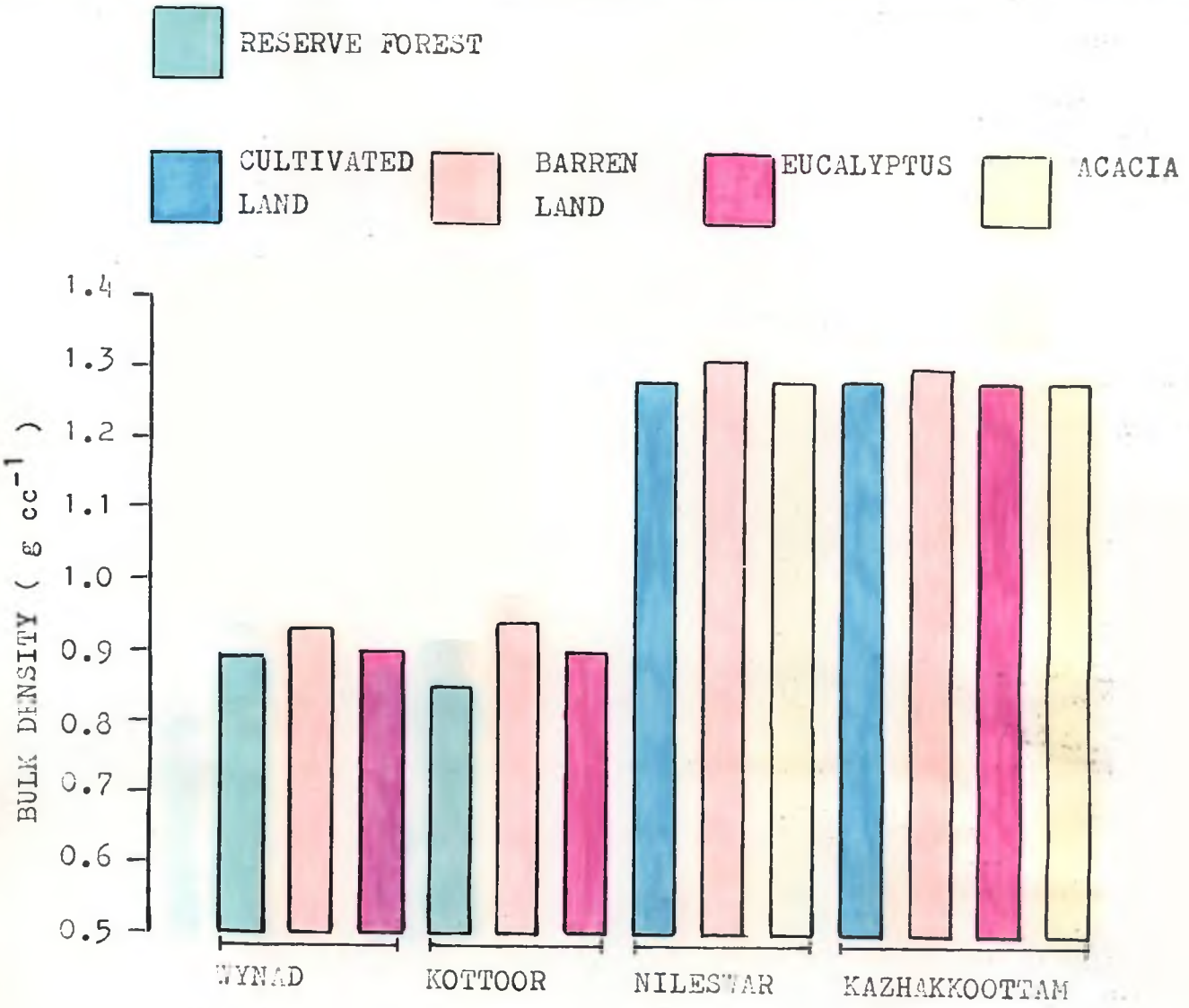

Fig 2. Variation in the mean values of bulk density in different soil profiles.

land was also due to this phenomenon. In the sandy tracts monoculture plantations showed a decrease in bulk density compared to cultivated or barrenland which was due to the addition of organic matter through leaf litter in these plantations. In the case of particle density, not much variation was observed among profiles in a location which indicates their similar mineralogy and same course of pedogenesis.

Porosity, water holding capacity and volume expansion decreased both in Eucalyptus plantations and barrenlands compared to reserve forests of Wynad and Kottoor. Maximum variation was in the case of water holding capacity (Fig.3) In the sandy tracts of Nileswar and Kazhakkoottam, not much variation was seen in the case of porosity and water holding capacity while an increase in volume expansion was observed in soils under Acacia plantation. These variations can also be attributed to the changes in organic matter content.

The changes in macroaggregates, mean weight diameter(MWD) and aggregate stability were presented in Tables 5 and 6. Majority of soil scientists have used the percentage of aggregates larger than 0.25 mm as the basis for comparison as proposed by Tuilin (1928). In all the four locations the percentage of macroaggregates increased in soils under monoculture plantations of Eucalyptus and Acacia compared to reserve

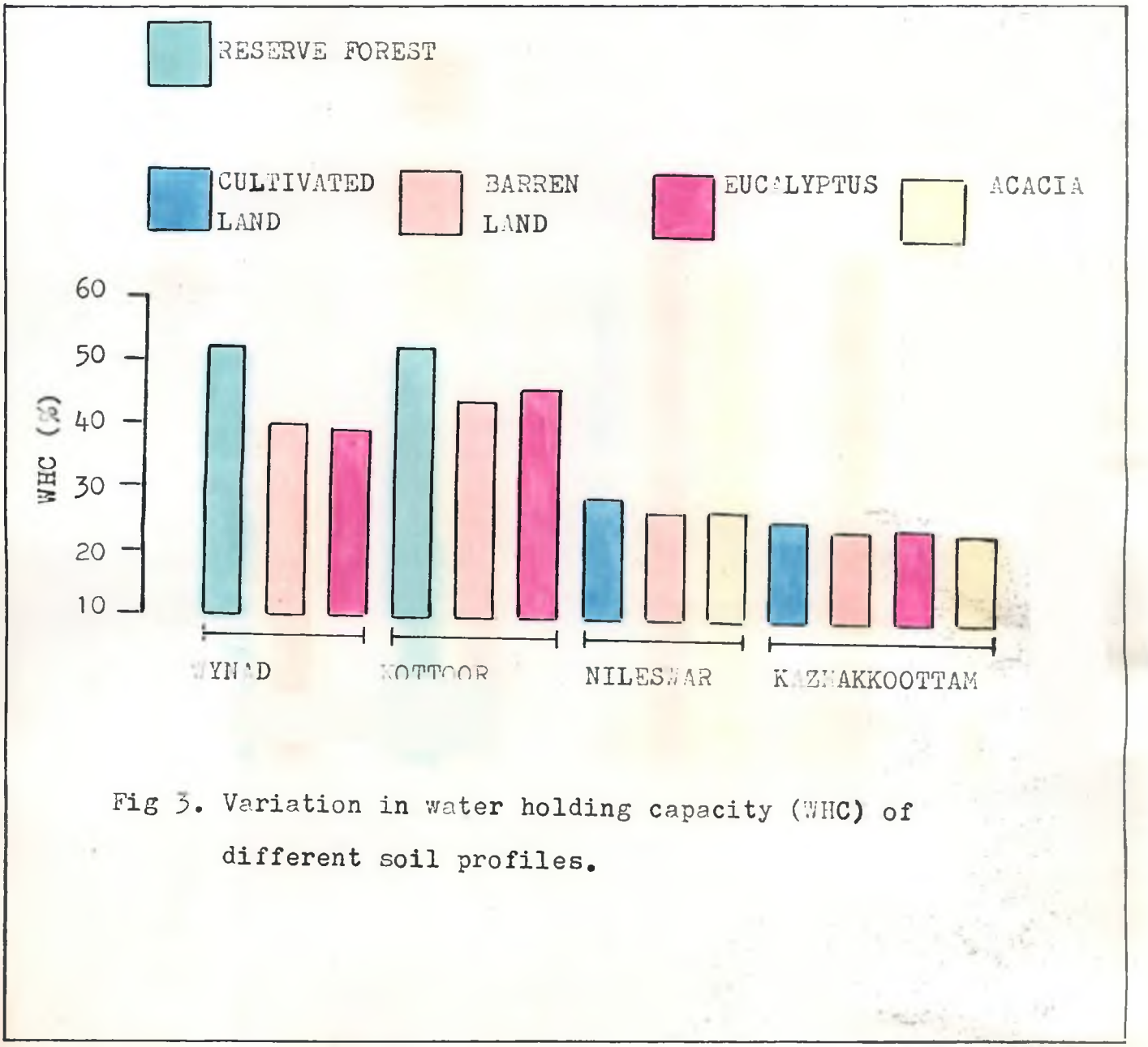

Fig 3. Variation in water holding capacity (WHC) of different soil profiles.

forest or cultivated land. In forested regions, barrenland also showed higher percentage of macroaggregates compared to reserve forest. Higher amount of macroaggregates in these plantations resulted due to the actionof cementing agents like Fe and Al oxides and clay in forest regions and organic matter in sandy tracts (Sharma and Uehara, 1968; Uehara et al, 1972; De Vleeschauwer et al; 1979).

With regard to MWD, highest diameter was observed in soils under monoculture plantations in all the four locations. In highland forest regions of Wynad and Kottoor, barrenland also had a high MWD compared to that of reserve forest. In the sandy tract, highest MWD was observed in soils under Acacia plantation. The MWD which is a statistical index of aggregates gives an estimate of the average size of the water stable aggregates. The probable reason for the large MWD in soils under Eucalyptus plantation and barren land in forest regions is the higher content of the cementing agents as Fe and Al oxides and clay in these soils and the higher MWD in Acacia plantations in sandy tract is due to the presence of organic matter as cementing agent (Yadav and Banerjee, 1968; Greenland, 1979)

Aggregate stability values were similar in profiles from a location in the caseof forest regions while in sandy tracts of Nileswar and Kazhakkoottam, Acacia plantation showed higher aggregate stability values This higher value in Acacia plantation is also due to the action of organic matter as a cementing agent.

Moisture percentage and water dispersible clay content in the thirteen soil profiles are given in Table 7. A perusal of the data reveals that under monoculture plantations of Eucalyptus and Acacia, soil moisture content was reduced drastically especially in a forest environment (Fig.4) This was true even in the coastal sandy tracts of Nileswar and Kazhakkoottam. These results indicate the high moisture depleting power of Eucalyptus and Acacia. These results agree with the previous observations of Karschon and Heth(1967) Sharma (1984) and Dabral and Raturi (1985).

Reduction in the content of water dispersible clay is suggested as an index of laterisation (Sivarajasingham et al, 1962; Buringh, 1970). From Table 7, it can be seen that in a forest environment, Eucalyptus plantation and barrenland had very low percentage of water dispersible clay compared to reserve forest suggesting that the process of laterisation proceeds faster when a forest is deforested and kept either as barren or planted with Eucalyptus. In the sandy tracts also, a decrease in water dispersible clay content was observed in monoculture plantations of Eucalyptus and Acacia compared to that of cultivated or barrenlands.

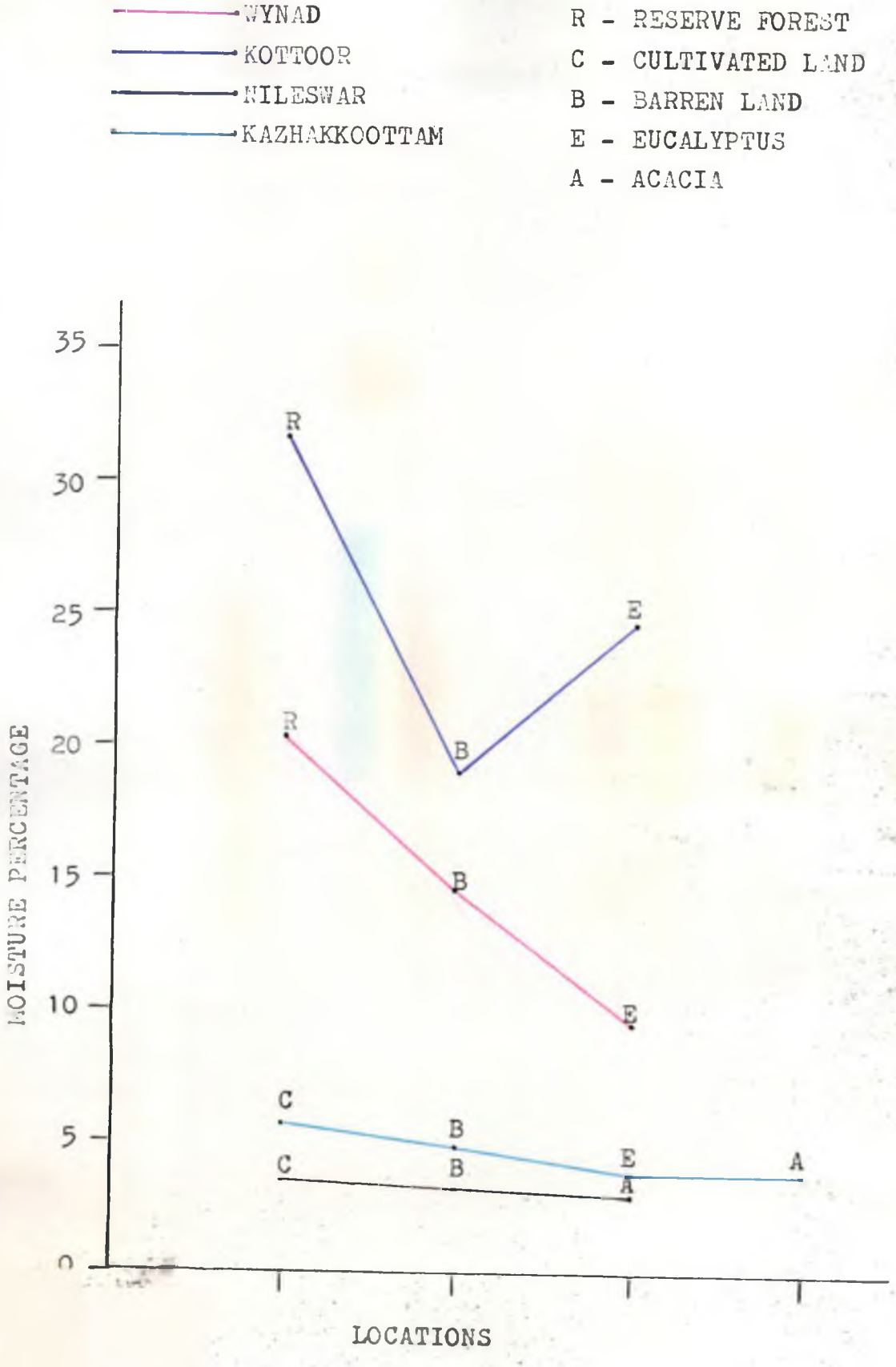

Fig 4. Content of moisture (%) in different soil profiles.

3. Soil Chemical characteristics

Chemical characteristics form an integral part of study of soils from the point of view of nutrition of plants and fertility considerations because they serve as indispensable tools in judging the pedogenic processes that have taken place from the initial state of the soil ie, parent material, to its present state. Table 8 presents the chemical composition of soil samples of different horizons of thirteen soil profiles. The chemical parameters include pH, E.C, C.E.C, organic carbon, total contents of nitrogen, phosphorus, potassium, calcium, magnesium, iron and aluminium expressed as percentage of soil on ovendry basis.

The pH of various horizons of different profiles showed an acid reaction. The mean values of pH of the thirteen soil profiles is illustrated in Fig.5. In general, lowering of pH was noticed in monoculture plantations of Eucalyptus and Acacia. Barreland also had a lower pH compared to reserve forest or cultivated land except at Wynad where a higher pH was noticed in soils under barrenland. Lowering of pH in monoculture plantations can be attributed to the high base removal by these plantations as compared to reserve forest or cultivated land. Higher pH recorded in Wynad barrenland may be due to the lower rate of base removal and low content of organic matter that undergo decomposition. In the sandy tract, lowering of pH was more in soils under Acacia compared to Eucalyptus which is due to the high calcium requirement of

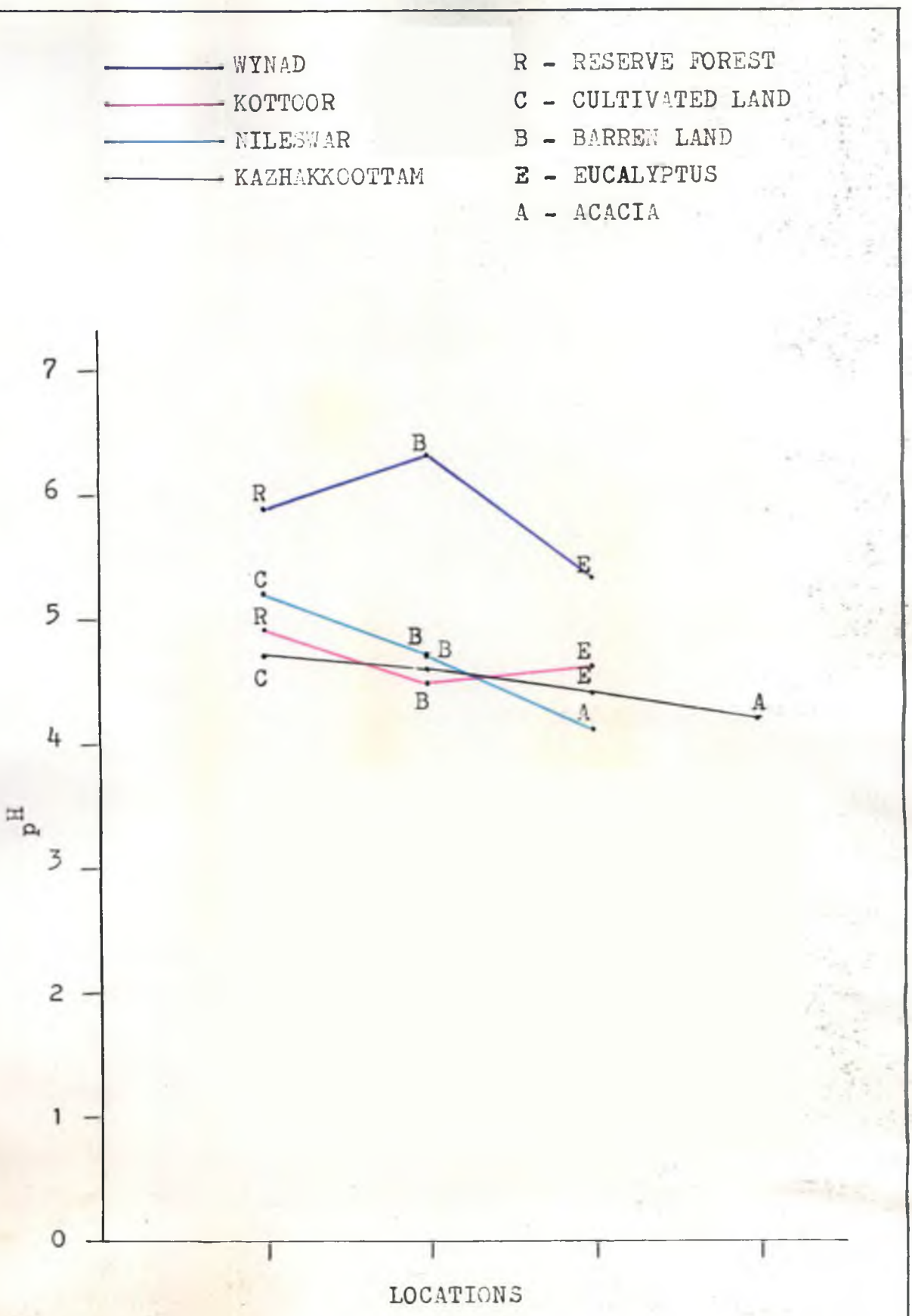

Fig 5. Variation in the mean values of p^H in different soil profiles.

Acacia plantations. These observations are in consonance with the previous results given by Yadav et al (1973) and Banerjee et al (1986).

In the case of electrical conductivity, not much variation was observed among the profiles in a location. All the soil profiles from a location had more or less same values indicating that monoculture plantations will not cause any marked change in electrical conductivity in non-saline soils.

With regard to organic carbon, a reduction was observed in Eucalyptus plantation and barrenland in forested regions. The content of organic carbon in different soil profiles is illustrated in Fig.6. The relatively low organic carbon values in Eucalyptus plantation in the forested areas showed that oxidation of organic matter had proceeded at a faster rate in Eucalyptus plantation than in natural forest, obviously due to the exposure to the heat of the baking sun and other environmental factors. Moreover, since the erosion hazard was minimum and the disturbance to the soil less, incorporation of organic matter into deeper layers was more in natural forest This agrees with the earlier observations of Kowal and Tinker (1959) Balagopalan and Alexander (1983) Balagopalan and Jose (1986) and Banerjee et al (1986) In the sandy tracts, organic carbon

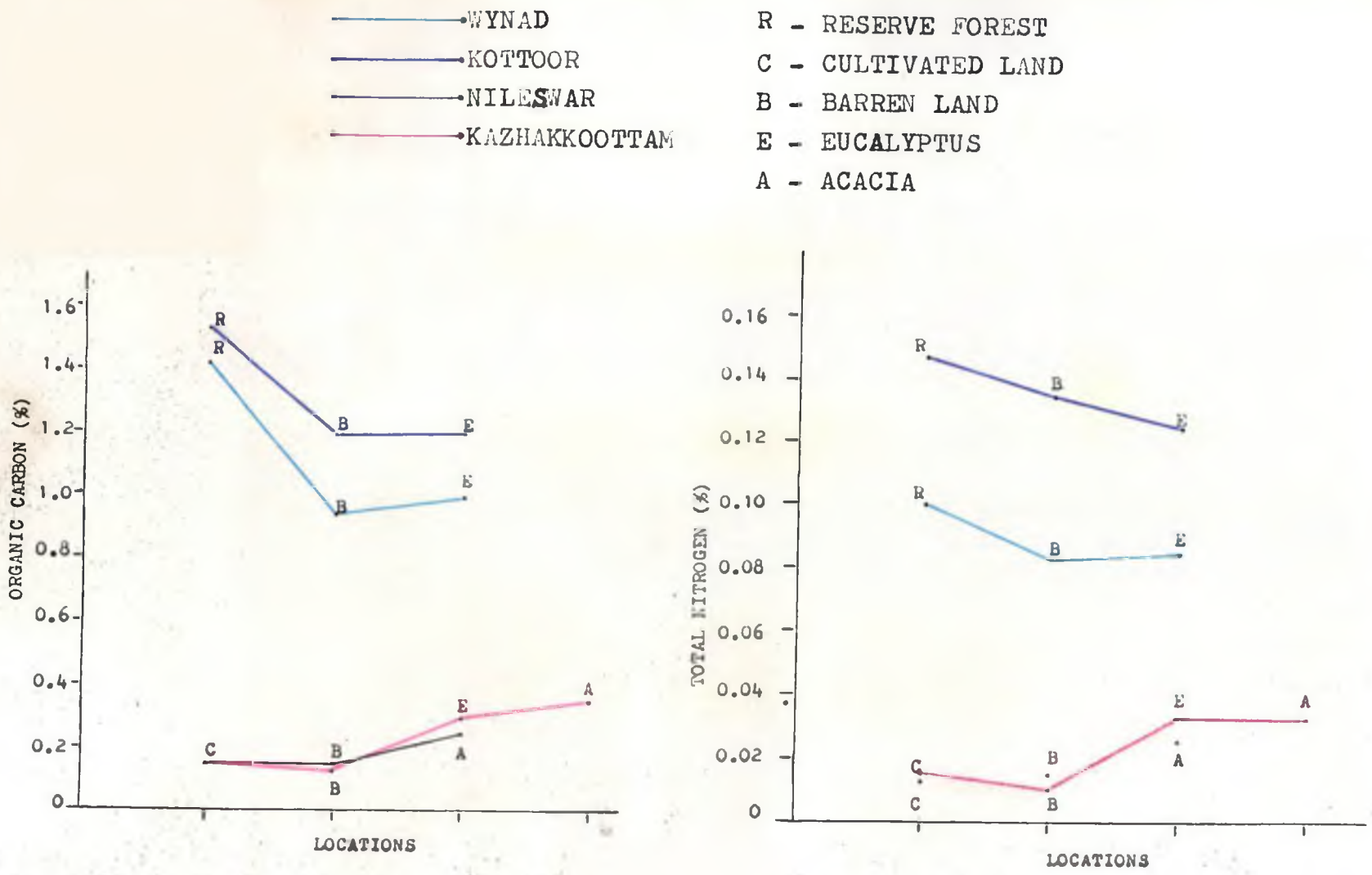

Fig 6. Variation in the mean values of organic carbon and total nitrogen in different soil profiles.

content has increased in soils under monoculture plantations which is mainly due to the leaf fall from these trees. With regard to the extent of laterisation or plinthisation, a negative relationship exists between organic matter content and intensity of induration. The fact that deforestation causes an increase in the rate of ferrallitisation is a proof for the need to maintain high organic matter levels in soils existing in pedogenic environments conducive for laterisation. The further observation on concomitant increase in bulk density with a decrease in the organic matter content signify their negative relationships.

The capacity of a soil to sorb or hold cations and to exchange them in reversible reactions is a property of significance to soil fertility and for soil genesis and classification. From the present study, it was observed that C.E.C. values were lowered greatly in the surface horizons of soil profiles under Eucalyptus plantation and barrenland compared to reserve forest. An increase in C.E.C was the result in monoculture plantations of the sandy tracts and this increase was more in soils under Acacia than under Eucalyptus. Higher C.E.C. noted in soils of reserve forest and monoculture plantations in sandy tracts is definitely a contribution of organic matter. The variation in C.E.C values is more due to variation in the organic matter status rather than due to differences in the qualitative and quantitative nature of clay. A reduction in C.E.C

values in soils under Eucalyptus was reported by Balagopala and Jose (1986).

With regard to total nitrogen content, Eucalyptus and barrenland recorded lower values as compared to reserve forest and an increase was noted in soils under monoculture plantations in the sandy tracts (Fig.6). The relative accumulation of organic matter in a comparatively cooler climate in natural forest explains their higher content of nitrogen compared to barrenland and Eucalyptus plantation. Higher nitrogen content in the monoculture plantations of sandy tract is attributed to the organic matter accumulatio through leaf fall.

The phosphorus content of soils and its distribution in successive horizons of the profile had been suggested as a means of understanding the course of pedogenesis in soils. The variation in total phosphorus and its content in different soil profiles are illustrated in Fig.7

The present study has shown that monoculture plantations of Eucalyptus and Acacia from all the four locations had lower total phosphorus content compared to reserve forest or cultivated land Lowering of total P_2O_5 content was observed in barrenlands also The content of total phosphorus in the soil fraction (below 2 mm) is found to decrease as pedogenesis advances (Varghese 1981) and the lowering of

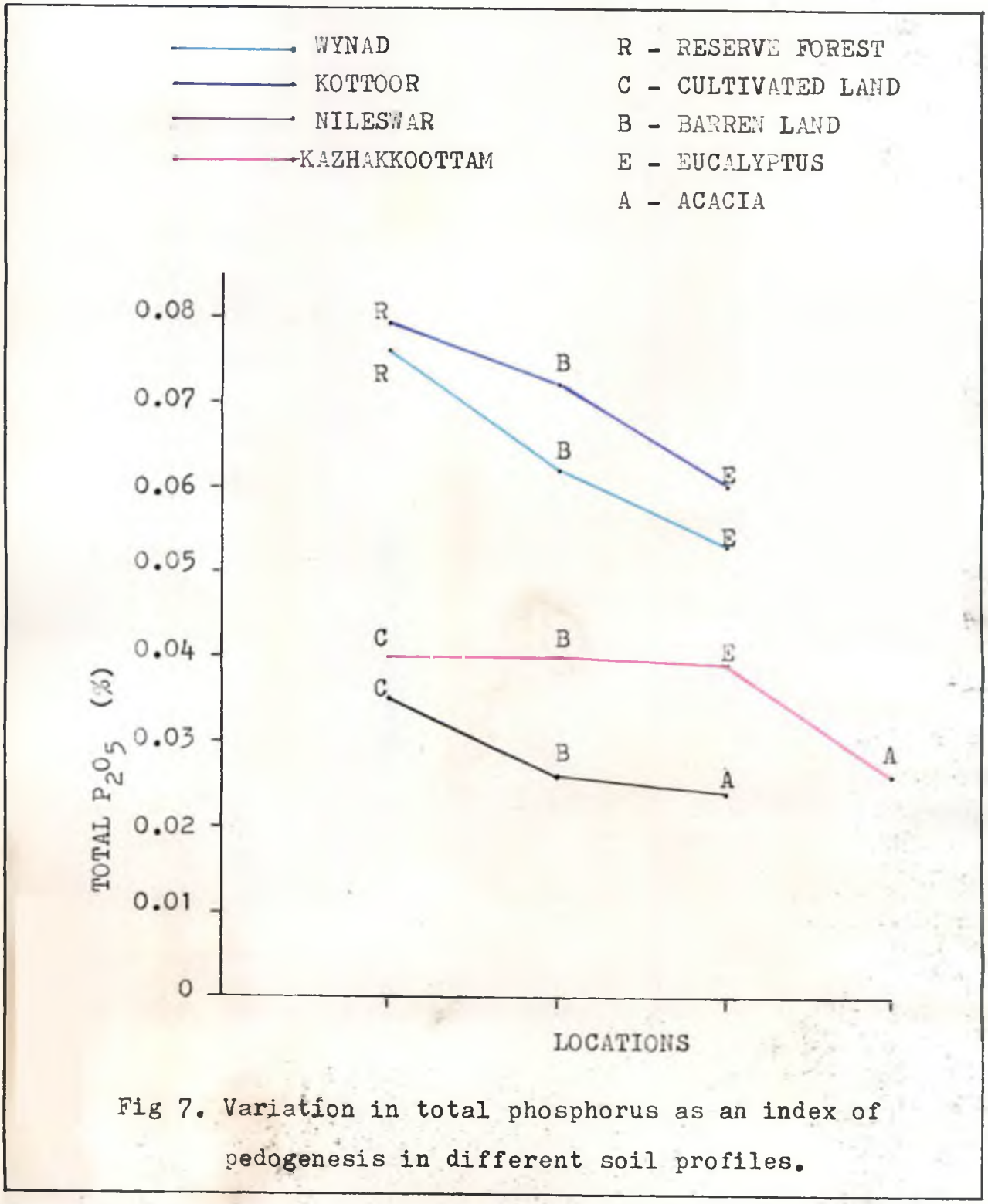

Fig 7. Variation in total phosphorus as an index of pedogenesis in different soil profiles.

P_2O_5 contents may also be due to the higher phosphorus uptake by these plantations. Similar results were obtained by Yadav et al. (1973).

The content of bases viz. calcium, magnesium and potassium was lower in soils under monoculture plantations and barrenlands compared to reserve forest or cultivated land. This change was more in the surface horizons. In the forested areas, soils under Eucalyptus recorded very low values of bases indicating that the process of weathering proceeds faster under these plantations. The surface soils of the reserve forest contained appreciable amount of these bases probably due to the effect of biocycling in a forest vegetation and also because of their juvenility Lower contents of bases may also be due to higher base removal by these plantations. Requirement of calcium by these plantations is very high (Singh, 1984). Decrease in the content of bases in Eucalyptus plantations were also reported by Yadav et al (1973) and Banerjee et al (1986)

The pattern of distribution of sesquioxides in the different profiles are discussed separately.

4. Fertility status of soils

As evident from Table 9 in general monoculture plantations resulted in a reduction in the fertility status of soils. In the forested regions, there was a decrease

in pH, organic matter and cation exchange capacity. Total contents of nitrogen, phospnorus, potassium, calcium and magnesium were also very low. In addition to these an increase in the contents of iron and aluminium were observed which contribute to a high phosphate fixing capacity.

In the sandy tracts eventhough organic matter and total nitrogen contents increased, all the above parameters showed unfavourable effects on soil fertility. Apart from the above, other parameters studied include available nitrogen, phosphorus and potassium and base saturation.

With regard to available nitrogen and phosphorus the results indicated that monoculture plantations of Eucalyptus and Acacia had lower contents suggesting that they remove higher amounts of these nutrients and returns only very little. But in the case of available potassium, an increase in the content was observed in soils under monoculture plantations which agrees with the previous observation of Yadav et al (1973). This increase in available potassium is due to the addition of this nutrient through leaffall.

Percent base saturation is an important criterion used to study soil genesis and classification(Buol, et al. 1980). This is an important criterion used to study the

extent to which exchangeable basic cations have been removed from the soil and replaced by exchange acidity. So this is important in soil classification and fertility studies. The present study revealed that monoculture plantations of Eucalyptus and Acacia caused a reduction in base saturation as compared to reserve forest or cultivated land in all the locations indicating a reduction in soil fertility. Low base saturation under these monoculture plantations can be attributed to the high base removal by these trees and also to downward movement of bases like calcium. Yadav et al (1973) also reported a downward movement of calcium in soils under Eucalyptus plantation.

5. Carbon-Nitrogen relationships

As evident from Table 10 monoculture plantation of Eucalyptus resulted in a decrease in the contents of organi carbon and total nitrogen under a forest environment. But in sandy tracts, monoculture plantations of Eucalyptus and Acacia caused an increase in organic carbon and total nitrogen contents. In all these locations, C|N ratio was lower under monoculture plantations of Eucalyptus and Acacia. Barrenland also recorded ratios lower than that of natural forest or cultivated land. The relatively low organic carbon values in Eucalyptus plantation under a forest environment showed that the oxiation of organic matter had proceeded at a faster rate in Eucalyptus than in natural forest. Lower content of nitrogen is also related to the organic carbon

content. Higher contents of organic carbon and total nitrogen in soils under monoculture plantations of Eucalyptus and Acacia in sandy tracts are attributed to the leaffall from the trees.

Relatively low values of C|N ratio under these monoculture plantations supported the faster rate of decomposition of organic matter and subsequent washing away of mineralised form of nitrogen. These observations are in consonance with those of Balagopalan and Jose (1986).

6. Distribution of iron and aluminium in soils

Forms, content and distribution of iron and aluminium in the profiles are considered as important criteria in studying the extent of laterisation of soils. As evident from Table 11 and Fig.8 Eucalyptus and Acacia plantations resulted in a relative increase in the contents of iron and aluminium compared to that of reserve forest or cultivated land. The sesquioxide contents in soils under these plantations were even higher than that of the barrenland. Variation in the contents of organic matter, clay and iron in the surface horizons of the different profiles are shown in Fig.9. All these results indicate an increase in the relative proportion of sesquioxides under monoculture plantations of Eucalyptus and Acacia which in turn shows that the process of ferrallitisation proceeds faster under these plantations.

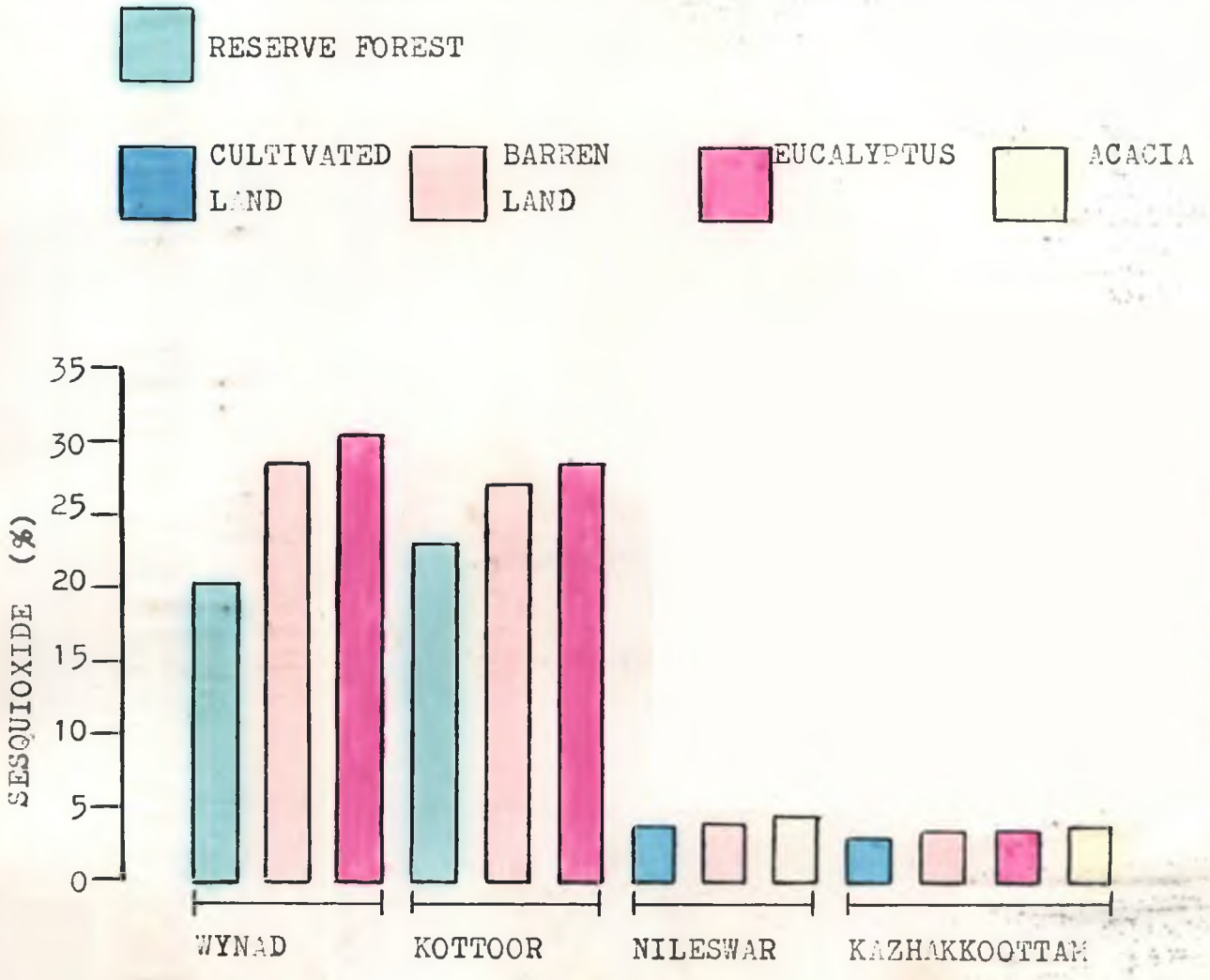

Fig 8. Variation in sesquioxide content in different soil profiles.

WYNAD

1 - RESERVE FOREST

2 - BARREN LAND

3 - EUCALYPTUS

KOTTOOR

4 - RESERVE FOREST

5 - BARREN LAND

6 - EUCALYPTUS

NILESWAR

7 - CULTIVATED LAND

8 - BARREN LAND

9 - ACACIA

KAZHAKKOOTTAM

10 - CULTIVATED LAND

11 - BARREN LAND

12 - EUCALYPTUS

13 - ACACIA

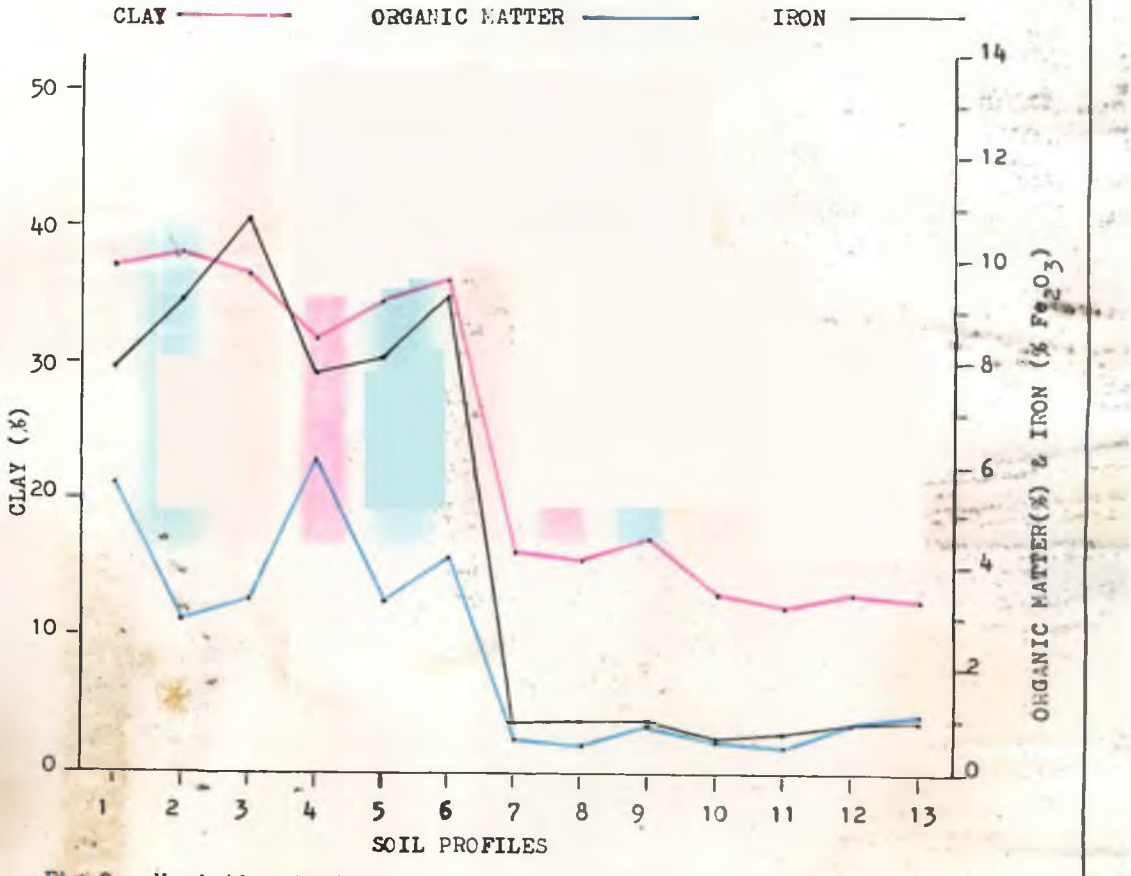

Fig. 9. Variation in the contents of organic matter, clay and iron in the surface horizons of the soil profiles.

Increase in the content of iron oxides shows an advancement of senility of soils as previously reported by Varghese (1981) Increase in the relative accumulation of sesquioxides is due to the leaching of bases and silica (Buringh, 1970) which favours the process of ferrallitisation.

7. Free oxides of iron in soils

Mc Keague and Day (1966) introduced the ratio of oxalate extractable iron (Fe_o) to dithionite extractable iron (Fe_d) as a measure of relative proportion of amorphous and crystalline iron oxides and suggested this as an index of the degree of ageing or crystallinity of free iron oxides In the present study, content of Fe_o and Fe_d were determined in different horizons of the soil profiles to assess the changes in crystallinity due to the planting of Eucalyptus and Acacia in reserve forest or in cultivated land. Table 12 gives the distributionof organic matter and extractable iron in the soil samples of the different horizons.

The contents of Fe_d increased in soils under monoculture plantations in all the four locations compared to that of reserve forest or cultivated land. Barrenland also had values closer to that of the Eucalyptus or Acacia plantations. In the case of Fe_o, a decrease in the content was the result in Eucalyptus plantation and barrenland compared to reserve forest. In the sandy tracts, slight increase was noted in

soils under Eucalyptus and Acacia. With regard to active iron ratio ($Fe_o | Fe_d$), in all the four locations, a lower value was recorded in soils under Eucalyptus and Acacia as well as in barrenland. Changes in the content of Fe_o is attributed to the changes in organic matter content. The higher values of $Fe_o | Fe_d$ in soils under reserve forest or cultivated land indicate their relative enrichment of amorphous oxides than crystalline ones. Higher organic matter content reduces the extent of crystallisation of iron oxides (Schwertmann, 1966) in reserve forest and this process proceeds faster in Eucalyptus plantation and barrenland because of their lower organic matter content.

8. Changes in soil physical characteristics as a function of depth

When soil samples were collected at definite depth intervals and analysed, the changes in soil parameters were similar to that when they were collected horizonwise. So the reasons and explanations given in the previous sections hold good here also. Major physical characteristics studied were moisture, gravel, silt|clay ratio, bulk density, water holding capacity, water dispersible clay and aggregate stability (Table 13). In the case of moisture percentage, silt|clay ratio, water holding capacity and water dispersible clay, monoculture plantations of Eucalyptus and Acacia had lower values compared to reserve forest or cultivated land.

With regard to gravel and bulk density, an increase was the result in Eucalyptus and Acacia plantations and aggregate stability showed not much variation. All these results were in consonance with those obtained in horizonwise soil samples collected from different pedons.

9. Changes in soil chemical characteristics as a function of depth

As evident from Table 14, monoculture plantations of Eucalyptus resulted in a decrease in pH, organic carbon, total nitrogen, C|N ratio, cation exchange capacity, base saturation, total phosphorus, potassiu. calcium and magnesium and an increase in total Fe_2O_3 and Al_2O_3 compared to reserve forest. In sandy tracts, the changes were similar except that organic carbon, total nitrogen and cation exchange capacity showed higher values compared to cultivated and barrenlands. All these changes agree with those obtained when the soil samples were collected horizonwise and analysed.

10. Changes in fertility status of soil as a function of depth

To assess the changes brought about by Eucalyptus and Acacia on the fertility status of soils, soil samples were analysed for organic matter, available nitrogen, phosphorus and potassium, C.E.C. and base saturation. Contents of organic matter, available nitrogen and phosphorus decreased

in soils under monoculture plantations compared to reserve forest or cultivated land. In the case of available potassium, an increase was noted in soils under these plantations compared to reserve forest or cultivated land. These results also agreed with those obtained when horizonwise samples were collected and analysed.

11. Impact on soil degradation.

Various parameters used to assess the impact of Eucalyptus and Acacia plantations on soil degradation include organic matter, silt|clay ratio, water dispersible clay, water holding capacity, sesquioxides and $Fe_o|Fe_d$ ratio and the results are summarised in Table 16. These different parameters have been suggested by different workers to evaluate the extent of soil degradation. Results of all the above parameters showed that deforestation and planting with Eucalyptus in a natural forest resulted in a rapid degradation of the soil by its effect on fertility, ferrallitisation, ageing and extent of crystallinity. Even in sandy tracts, though organic matter content showed an increase when we raise Eucalyptus and Acacia, all other parameters taken to assess the extent of soil degradation showed unfavourable results. All these observations indicate the strong influence of the type and nature of vegetation rather than the nature of the parent material in deciding

the extent of soil degration and underline the significance of conserving the forested highlands of our state as well maintaining a soil cover and organic matter content in the surface horizons to maintain the fertility status of our soils.

12. Biological characteristics of soils.

Biological characteristics are very important to assess the fertility of surface soils and in this regard total microflora population and nitrifying properties were analysed in the surface soils of the different locations and the results are givenin Table 17. A perusal of the data shows that a reduction in total microflora occured by planting Eucalyptus and Acacia in natural forest or cultivated land. Barrenland also had lower population of total microflora. Decrease in the number of total microflora is attributed to the allelopathic effects of certain toxic compounds present in the leaves of Eucalyptus and Acacia (Setiadi and Samingan, 1978; Shiva, Vandana and Bandyopadhyay, 1985).

Population of Nitrosomonas and Nitrobacter also decreased in the surface soils of Eucalyptus and Acacia monoculture plantations of the four locations compared to that of natural forest or cultivated land and the reason for this is also the allelopathic effects of certain chemicals present in the leaves of these trees.

With regard to the population of Rhizobium, Eucalyptus plantation had deleterious impact on its number compared to reserve forest or cultivated land. But in Acacia plantations, an increase in the number of Rhizobium was observed compared to cultivated land and barrenland. Acacia auriculiformis is a tree belonging to Leguminosae family and has got the capacity to fix atmospheric nitrogen in its root nodules with the help of Rhizobium (Roughley, 1987) Eventhough the population of total microflora decreased, an increase in the population of Rhizobium was observed due to the above reason. In Eucalyptus, such type of association is not there and hence due to its allelopathic effect, population of Rhizobium also decreased.

So in the case of biological characteristics also, monoculture plantations of Eucalyptus and Acacia had adverse effects and affect soil fertility and various nutrient transformations in the soil which require different types of microorganisms.

13. Biomass studies

The height and diameter at breast height (DBH) of Eucalyptus and Acacia from different locations are given in Table 18 and 19. A perusal of the data shows the rapid rate of growth of Eucalyptus in forest areas. A seven year old plantation at Kottoor had mean height and DBH of 10.43 m and 40.30 cm while a 17-year old plantation at Wynad had

mean height and DBH of 21.69 m and 54.90 cm respectively which indicates its rapid growth and it will be at the expense of the natural fertility of soil in our forested areas. In the case of Acacia also, data show its rapid rate of growth in sandy areas of Nileswar and Kazhakkoottam which is an indication of its capacity to survive in any adverse climatic and soil conditions.

14. Manurial value of leaves of Eucalyptus and Acacia.

The contents of nitrogen, phosphorus, potassium, calcium, magnesium, crude fibre and crude protein in the leaves of Eucalyptus and Acacia are given in Table 20. Nitrogen content in the leaves of Acacia was found to be higher than that in Eucalyptus since it is a leguminous tree. Both Eucalyptus and Acacia leaves had high content of potassium which may be responsible for the increase in available potassium content in soils by its addition through leaflitter. Calcium content in Acacia leaves was more than that in Eucalyptus and that may be one of the reasons for the lower pH recorded in soils under Acacia plantations because of its heavy removal from soil. Crude fibre content in the leaves of Eucalyptus and Acacia is very high and hence the rate of decomposition is found to be very low. The higher crude fibre content and the resultant low digestibility in the rumen may be cited as one of the reasons for these leaves not being browsed by cattle.

15. Chlorophyll content in the leaves of Eucalyptus and Acacia

Chlorophyll is the green pigment present in leaves responsible for the process of photosynthesis and is the most important light absorbing pigment in the photosystem. A positive correlation has been reported between phto-synthesis rate, biomass production and the content of chlorophyll. Table 21 gives the chlorophyll content, chlorophyll-a and -b values and the ratio of chlorophyll a|b in the leaves of Eucalyptus and Acacia. Chlorophyll-a and-b are the two most important chlorophylls in the photosystem. In the hypothetical model of photosynthesis unit, the chlorophyll a|b value is 2.60 (Thornber and Alberta, 1977) and since this ratios for Eucalyptus and Acacia leaves were nearer to the hypothetical optimum value, we can attri-bute it as the reason for their higher biomass production and rate of photosynthesis under varied climatic conditions.

SUMMARY AND CONCLUSION

3. In highland forest regions of Wynad and Kottoor. an increase in gravel content was noticed in soils under Eucalyptus plantation and barrenland compared to reserve forest. In sandy tracts of Nileswar and Kazhakkoottam, slight increase in gravel content was noticed in soils under Eucalyptus and Acacia. Increase in gravel content increases induration which is indicative of soil degradation.

4. Eluviation of clay was marked in soils under Eucalyptus and barrenland than in reserve forest. This increase in clay content in the surface horizon was to the tune of 1.2 times which qualifies it to be called an argillic horizon. In sandy tracts, downward movement of clay was more in soils under Eucalyptus and Acacia. These results indicate that the process of laterisation proceeds faster under Eucalyptus and Acacia.

5. The structure of the surface horizons of profiles from forest areas was angularblocky while it was granular in sandy soils. The macroaggregate content increased in soils under Eucalyptus and Acacia due to changes in sesquioxide content and organic matter.

6. All the profiles from forest areas came under the textural class clay and almost all profiles from sandy tracts came under the textural class sandyloam.

SUMMARY AND CONCLUSIONS

Eucalyptus tereticornis and *Acacia auriculiformis* are two important exotic tree species introduced into our environment through National Social Forestry Programme. Eventhough they are found to survive in a wide range of environments in its native habitat, its environmental impact in our fragile ecosystem has not yet been fully studied. So this study was undertaken to find out the impact of these monoculture plantations on soil properties with special reference to Kerala. The salient observations from these studies are presented below:

1. Deforestation and planting with Eucalyptus or keeping it as barren resulted in a depletion of soil organi matter as evidenced by profile morphology and this caused a change in soil order under Soil Taxonomy in which it belonged. Under reserve forests of Kottoor and Wynad, soils belonged to the order Mollisols while soils under Eucalyptu plantation and barrenland came under the order Alfisols. In sandy tracts, all the soils belonged to the order Entiso

2. There was variation in soil colour in Eucalyptus plantation and barrenland compared to reserve forest due to changes in the content of humus and iron oxides. In sandy tracts, monoculture plantations of Eucalyptus and Acacia recorded darker colour due to addition of organic matter.

11. With regard to moisture content, the results showed drastic reduction in moisture content in soils under Eucalyptus and Acacia. This shows the higher water requirement of these plantations which is responsible for the lowering of water table.

12. Water dispersible clay content was determined to assess the extent of laterisation and the results showed that Eucalyptus and barrenland had very low values compared to that of reserve forest in forest areas. In the sandy tracts, Eucalyptus and Acacia plantations recorded lower values compared to cultivated or barrenlands. All these show the rapid rate of laterisation under Eucalyptus and Acacia plantations.

13. A decrease in pH was the result in soils under Eucalyptus in forest areas due to high base removal from soils through leaching and plant uptake. In the sandy tracts, Acacia monoculture resulted in a lowering of pH due to high calcium removal by these plantations.

14. With regard to organic carbon and organic matter, Eucalyptus plantation and barrenland recorded lower values compared to reserve forest at Wynad and Kottoor due to the faster rate of oxidation of organic matter under Eucalyptus and in barrenland. In the sandy tracts of Nileswar and Kazhakkoottam, monoculture plantations of Eucalyptus and Acacia recorded higher values due to addition through leaf fall.

15. Cation exchange capacity values were lowered greatly in the surface horizons of soil profiles under Eucalyptus and in barrenland compared to reserve forest due to depletion of organic matter. In sandy tracts, highest C.E.C. was recorded in Acacia plantation due to addition of organic matter through leaflitter. Eucalyptus plantation had a still lower value.

16. For total nitrogen, Eucalyptus plantation and barrenland recorded lower values as compared to reserve forest and an increase was noted in soils under Eucalyptus and Acacia compared to cultivated and barrenlands in sandy tracts. There appeared a positive relationship between the content of organic matter and the percentage of nitrogen.

17. Total contents of phosphorus and potassium were lower in soils under Eucalyptus and Acacia from all the four locations which is an indication of advanced pedogenesis and higher uptake of these nutrients by these plantations.

18. The contents of calcium and magnesium were also lower under plantations of Eucalyptus and Acacia and in barrelands compared to reserve forest or cultivated land and this change was more in surface horizons. This is also an indication of faster weathering and heavy base removal by Eucalyptus and Acacia.

19. With regard to the contents and distribution of sesquioxides, Eucalyptus and Acacia plantations recorded relatively higher values compared to reserve forest or cultivated land and this shows that the process of ferrallitisation proceeds faster under these plantations.

20. With regard to available nitrogen and phospnorus, Eucalyptus and Acacia plantations had lower contents compared to reserve forest or cultivated land suggesting that they remove higher amounts of these nutrients and returns only very little.

21. In the case of available potassium content, an increase was the result in monoculture plantations of Eucalyptus and Acacia due to the addition of this nutrient through leaffall.

22. Persent base saturation is an important criterion used to study soil genesis and classification and soil fertility status. The present study concluded that Eucalyptus and Acacia plantations caused a reduction in base saturation as compared to reserve forest or cultivated land in all the locations indicating a reduction in soil fertility status and is due to higher base removal and downward movement of bases like calcium.

23. With regard to C|N ratio, Eucalyptus and Acacia plantations and barrenland recorded lower ratios as compared to reserve forest or cultivated land indicating that oxidation of organic matter had proceeded at a faster rate.

24. The ratio of oxalate extractable iron to dithionite extractable iron was found to be lower in soils under Eucalyptus and Acacia and in barrenland indicating a relative enrichment of crystalline iron oxides which may lead to induration.

25. When the soil samples were collected depthwise and subjected to physio-chemical analyses, the changes brought about by planting Eucalyptus and Acacia monocultures were found to be the same as in horizon-wise samples.

26. Population of total microflora, Nitrosomonas and Nitrobacter were adversely affected by planting Eucalyptus and Acacia due to its allelopathic effects. In the case of the population Rhizobium, a decrease was the result in Eucalyptus plantation while there was increase in its number in soils under Acacia plantation because of its capacity of root nodulation.

27. Height and diameter at breast height (DBH) of Eucalyptus and Acacia plantations of different ages showed their high rate of photosynthesis and biomass production under varied climate and soil conditions.

28. Eventhough the leaves of Eucalyptus and Acacia had good amounts of different nutrients, due to the high content of crude fibre their digestibility and decomposition are slower.

29. Chlorophyll content and chlorophyll-a and -b values showed that the leaves of Eucalyptus and Acacia had an ideal ratio of a|b for photosynthesis and is the reason for their higher rate of photosynthesis and biomass production.

From the foregoing discussion, it becomes evident that planting of Eucalyptus and Acacia as monoculture has got very deleterious impact on soil characteristics. The extent and severity of deterioration and degradation of soil under these plantations are more marked in forested highlands of Kerala. The results throw light on the imminent necessity to have a rethinking about the introduction of monoculture plantations with these exotic species in the reserve forest areas. As a compromise, Eucalyptus and Acacia, being fast growing pulpwood trees, may be restricted for planting in regions of sandy tracts and degraded waste-lands away from farmlands.

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IMPACT OF EUCALYPTUS AND ACACIA PLANTATIONS ON SOIL PROPERTIES IN DIFFERENT PEDOGENIC ENVIRONMENTS IN KERALA

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ABSTRACT OF A THESIS

submitted in partial fulfilment of the

requirement for the degree

MASTER OF SCIENCE IN AGRICULTURE

Faculty of Agriculture

Kerala Agricultural University

DEPARTMENT OF SOIL SCIENCE AND AGRICULTURAL CHEMISTRY

COLLEGE OF AGRICULTURE

VELLAYANI - TRIVANDRUM

1989

ABSTRACT

Eucalyptus tereticornis and *Acacia auriculiformis* are two important exotic tree species introduced into our environment through National Social Forestry Programme. These two species are said to have many qualities which qualify them for inclusion under the social forestry programme. These fast growing tree species have the unique capability of surviving and regulating their growth to prevailing growth factors. But environmentalists in India and abroad have questioned the feasibility of bringing fertile lands under these exotic species which they claim to have deleterious impact on soil properties, hydrological parameters, biotic associations and long-term socio-economic consequences. However, these arguments do not have a sound scientific basis due to lack of sufficient research data base. So a study was undertaken to find out the impact of these monoculture plantations on soil properties in different pedogenic environments in Kerala.

Soil profiles were taken from four locations representing different geoclimatic regions of Kerala. The locations were Wynad (Northern forested highland), Kottoor (Southern forested highland), Nileswar (Northern coastal) and Kazhakkoottam (Southern coastal). Altogether thirteen

pedons were studied from different locations representing reserve forest, cultivated land, barreniand, Eucalyptus plantation and Acacia plantation. Pedons were described systematically and subjected to physico-chemical analyses and also for assessing the extent and nature of microflora. Biomass studies and chemical analyses of plant samples have alsobeen undertaken.

From the studies, it was revealed that monoculture plantations of Eucalyptus and Acacia have got deleterious impact on soil physical, chemical and biological characteristics. These deleterious effects were more in a forest environment compared to sandy tracts. Increase in gravel content, eluviation of clay, lower silt|clay ratio, increase in bulk density, lower water holding capacity, low moisture content and low water dispersible clay in soils under Eucalyptus in forest areas show that the process of ferrallitisation and soil degradation proceed faster under Eucalyptus. Chemical composition also showed decrease in soil fertility under Eucalyptus. In the sandy tracts, Eucalyptus and Acacia increased the soil organic matter, total nitrogen and available potassium, while almost all other parameters used for the study showed deleterious effects. Active iron ratio (Fe oxalate| Fe dithionite) was calculated to assess the extent of induration and the results indicated a relative enrichment of crystalline

iron oxides in monoculture plantations of Eucalyptus and Acacia which may also lead to induration. A decrease in microbial population was also observed in these plantations except the population of Rhizobium whose number increased in plantations of Acacia which is a leguminous tree.

The above results indicated that planting of Eucalyptus and Acacia as monoculture has got very deleterious impact on soil characteristics and fertility. All these throw light on the imminent necessity to have a rethinking about the introduction of monoculture plantations with these exotic species especially in the reserve forest areas.