SOIL CHEMICAL CHARACTERISTICS IN A NATURAL FOREST AND ADJACENT EXOTIC PLANTATIONS IN KERALA, INDIA

M. Balagopalan

Kerala Forest Research Institute, Peechi 680 653, Kerala, India

&

A.I. Jose

College of Horticulture, Kerala Agricultural University, Vellanikkara 680 654, Kerala, India

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BALAGOPALAN, M. & JOSE, A.I. 1995. Soil chemical characteristics in a natural forest and adjacent exotic plantations in Kerala, India. A comparison of soil properties along a transect in an evergreen forest and adjacent eucalypt and rubber plantations was made in Kerala, India. The soils in the evergreen forest and plantations were moderately acidic and those in the former had higher organic carbon, water holding capacity, cation exchange capacity, total N and P. There was significant difference in soil properties due to vegetational types. The results revealed that soils in the eucalypt plantations were very much depleted and this could affect future productivity of successive rotations.

Key words: Natural forest - eucalypt - rubber - soil properties - productivity

BALAGOPALAN, M. & JOSE, A.I. 1995. Ciri-ciri kimia tanah hutan asli dan ladang-ladang dagang yang bersebelahan di Kerala, India. Perbandingan ciri-ciri tanah sepanjang satu transek di dalam hutan malarhijau dan ladang-ladang eucalypt dan getah yang bersebelahan telah dikaji di Kerala, India. Tanih di hutan malarhijau dan ladang-ladang adalah sederhana asid dan tanih hutan malarhijau mempunyai kandungan karbon organik, kapasiti menyimpan air, kapasiti pertukaran kation, jumlah N dan P yang lebih tinggi. Terdapat perbezaan ketara dalam ciri-ciri tanah bergantung kepada tanaman. Keputusan menunjukkan bahawa tanih di ladang eucalypt kurang subur dan ini boleh mempengaruhi produktiviti kitaran-kitaran di masa depan.

Introduction

Plantations of exotic tree species were established on a large scale in Kerala during the 1970s when *Eucalyptus* species and rubber (*Hevea brasiliensis*) were planted in areas cleared of natural forest. The former was established by the Forest Department and the latter by various governmental and non-governmental agencies. The clearing of the natural vegetation is a dramatic ecological event with short and long-term effects on the soil conditions of the site. The plantations established in

the cleared areas have been found to be ecologically different from the native forests with respect to organic matter production, soil conditions and type of vegetation. Due to clearfelling and subsequent plantation activities, changes in soil properties may either favour an increase in the nutrient status (Chijioke 1980) or a decline (Will 1968) or have no significant difference (Adejuwon & Ekanade 1988). The changes in soil properties were also reported to be greatly influenced by management practices during establishment, tending and harvesting (Lundgren 1978, Shepherd 1986). In Kerala little information is available on the impact of plantation activities on soil properties (Balagopalan & Jose 1986). As soil conditions may differ from one geographical area to another, there is a need to monitor them in all locations where plantations are established (Maro *et al.* 1993). This study was thus undertaken to compare some soil properties in a natural forest and adjacent first rotation eucalypt and rubber plantations in Kerala, India.

Materials and methods

The study area, Peechi, in Trichur Forest Division, located in the centre of Kerala State in southwest India, has a warm humid climate (Figure 1). The terrain is gently undulating. The main sources of atmospheric precipitation are the southwest and northeast monsoons. The annual rainfall for the last ten years (1982-1992) was between 2410 and 3600 mm with an average of 2798 mm.

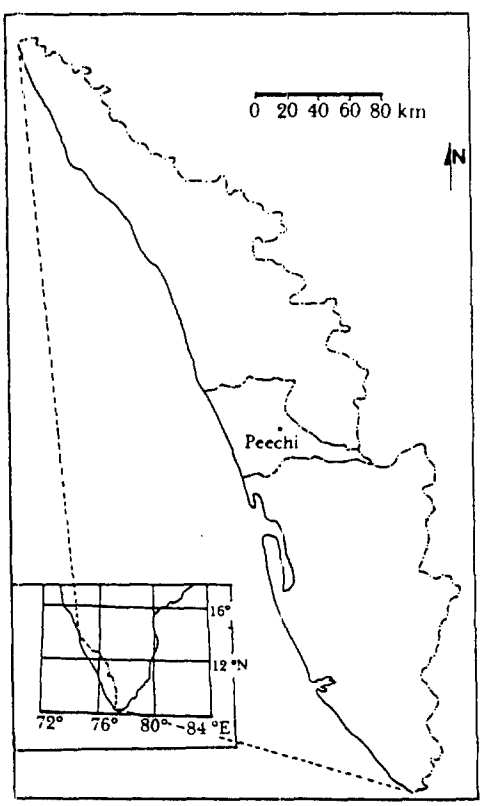

Figure 1. Location of the study area

The temperature extremes recorded for the past ten years were 18.9 and 39.6 °C. Relative humidity was also greater than 55 % and reached 100% during the rainy days. Generally, June to October are the wet months while November to May are dry. The predominant parent material is of metamorphic rocks of the gneiss series.

The natural vegetation is evergreen forest (lowland west coast tropical evergreen). The plantations of eucalypt (*Eucalyptus tereticornis*) and rubber (*Hevea brasiliensis*) were established in 1981. Establishment of the eucalypt plantation was done through the 'Taungya' system during the first three years until the time when the canopy closed. In order to minimise the cost of plantation maintenance, viz. annual weeding and soil working, and also to provide local employment by raising food crops of local importance, the area under plantation was leased for a period of three years to a contractor. During the first year, rice was cultivated followed by tapioca which extended till the end of the second year. In the third year, tapioca was again cultivated. The initial soil working for rice cultivation resulted in severe loss of rich surface soil. The tapioca cultivation in 'mounts' intensified the erosion and in some places, gullies were formed. The eucalypt plantation extending over an area of 100 ha was established by the Kerala Forest Department while the rubber plantation, with an area of about 1000 ha, belonged to a private organisation. A transect, 4.5 km long and 500 m width, starting from the evergreen forest, passing through the eucalypt and rubber plantations was taken. In each vegetation type, five plots of 250 × 250 m were laid out randomly and one soil pit was taken from each plot. Samples were collected from 0-15, 15-50 and 50-100 cm layers of soil pits. The samples were analysed for pH, water holding capacity (WHC), cation exchange capacity (CEC), organic carbon (OC), total as well as available N and P as per standard procedures (Jackson 1958, Black 1965). The data from the analyses were then compared for each parameter (Snedecor & Cochran 1975).

Results and discussion

The results revealed that pH, organic carbon, total as well as available N and P decreased with depth in the evergreen forest while WHC and CEC values showed no general pattern (Table 1). In the case of the eucalypt plantation, organic carbon, CEC, total N and available P decreased whereas the pH increased with depth, while the WHC, available N and total P showed no general trend. Soil pH, WHC, CEC, OC, total as well as available N and P decreased with depth in the rubber plantation. The soils were moderately acidic in the evergreen forest, in eucalypt and rubber plantations. Analysis of variance of soil properties showed that all properties exhibited significant difference in the different vegetation types.

Soil acidity and water holding capacity

Soil pH was lowest in the natural forest followed by those in the eucalypt and rubber plantations. Water holding capacity was highest in the natural forest,

Table 1. Mean, standard deviation and range of values for soil properties in the 0 - 100 cm layer in the three vegetation types

Vegetation type	Properties							
	Soil pH	WHC (%)	OC (%)	Total N (..... ppm .....)	Average N	Total P	Average P	CEC [c mol(+)/kg]
Natural forest (1)	5.4 ± 0.13 (5.3 - 5.6)	42.1 ± 0.77 (41.09 - 43.14)	1.48 ± 0.11 (1.33 - 1.64)	1151 ± 88.64 (1029 - 1253)	241 ± 17.13 (219 - 270)	401 ± 41.09 (333 - 445)	14 ± 0.78 (13 - 15)	14.81 ± 1.26 (12.65 - 16.17)
Eucalypts (2)	5.8 ± 0.15 (5.6 - 6.0)	29.3 ± 3.49 (25.24 - 32.93)	0.89 ± 0.11 (0.82 - 1.07)	560 ± 35.76 (514 - 609)	124 ± 19.35 (99 - 148)	222 ± 24.05 (178 - 245)	14 ± 5.97 (8 - 23)	7.67 ± 1.14 (6.30 - 8.88)
Rubber (3)	6.0 ± 0.10 (5.9 - 6.1)	31.2 ± 2.68 (27.33 - 33.73)	1.17 ± 0.07 (1.05 - 1.24)	501 ± 46.37 (434 - 549)	155 ± 6.01 (145 - 161)	235 ± 33.35 (186 - 274)	15 ± 3.41 (10 - 21)	9.01 ± 0.67 (8.07 - 10.10)
Level of significance								
1 & 2	*	*	*	*	*	*	ns	*
1 & 3	*	*	*	*	*	*	ns	*
2 & 3	*	ns	*	ns	*	ns	ns	ns

* = significant at $p \leq 0.05$; ns = not significant.

followed by the rubber plantation. Water holding capacity and pH differed significantly between the natural forest and plantations.

Soil organic matter and nutrients

Organic carbon, total N, available N, total P and CEC values were significantly higher in the natural forest than in the plantations. There was no significant difference in available P among the different vegetation types.

In the natural forest, cycling of nutrients is an important aspect as considerable amounts of nutrients are returned to the soil through leaf fall and other ways, and made available for readsorption. This re-cycling of nutrients keeps the forests under high fertility status with rich top soil and dense vegetation. The soil pH values showed that soils in the natural forests were more acidic than those in the plantations. Lower pH in the natural forest could be an indication of the contribution of litter. Higher pH values in plantations compared to adjacent natural forest has also been reported by Adjeuwon and Ekanade (1988). It could be seen that the soil pH values in both plantations were not identical. This can be attributed to the intrinsic pH of the soil and the type of tree species growing on the site (Maro *et al.* 1993). There was no significant difference in CEC values between the natural forest and plantations. As regards CEC , varying results have been reported (Chijioke 1980, Kadeba & Onweluzo 1976, Adejuwon & Ekanade 1988). Soils of the natural forest contained more organic carbon and hence more total N and this could be ascribed to the contribution of litter (Aweto 1988), in addition to the diversity of vegetation cover. The lack of erosion in the natural forest also helped in the accumulation of organic matter and hence total N.

Total N was significantly higher in the natural forest than in the plantations. The higher concentration of N was a result of increased organic matter and rapid mineralisation of litter in the surface soil of the natural forest. Similar results have also been reported by Lundgren (1978). The rapid mineralisation could also be due to the diversity of litter substrate contributed by various species which occur together in the natural forest (Maro *et al.* 1993). It has also been found that eucalypt litter takes a longer period to decompose under Kerala conditions (Mary & Sankaran 1991), resulting in lower OC values in the eucalypt plantation compared to the natural forest and rubber plantation.

The total P content was significantly higher in the natural forest than in the plantations. Adjeuwon and Ekanade (1988) also obtained similar results when studying the soil changes of tropical rain forests which were replaced by plantations of different species.

The significant difference in soil properties between natural forests and plantations indicates that plantation activities alter the intrinsic soil status. It has been postulated by Will (1968) that demands on soil by tree species are greatest during the establishment phase. After canopy closure, further growth occurs through accumulation of wood, which requires lower nutrient content, and the nutrient demand is through internal nutrient recycling. However, this was not observed in this study. Here, severe soil changes following clear-felling and subsequent

plantation activities have taken place and the recovery process has not been that intense. It was observed that the differences in WHC, total N and P, available P and CEC between the two plantations were statistically not significant. The relatively lower values of WHC, OC, available N and CEC in soils under the eucalypt plantation indicate that the soils have been depleted and that this can affect the productivity of successive rotations.

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