Journal of Tropical Agriculture 31 (1993) : 167- 173

A COMPARATIVE STUDY ON THE PROPERTIES OF SOILS IN RELATION TO VEGETATIONAL TYPES

M. Balagopalan [1] and A.I. Jose
College of Horticulture, Vellanikkara 680 654, Trichur, India

Abstract: Soil properties under six types of vegetative covers, evergreen, semi-evergreen and moist deciduous forests, and plantations of teak, eucalypt and rubber showed that they differed significantly. Soils in the natural forests have higher water holding capacity, cation exchange capacity, organic carbon, N, P_2O_5, K_2O and CaO and MgO. Soils in the plantations, on the other hand, possess greater accumulation of gravel, contain highest amounts of Fe_2O_3 and Al_2O_3. Organic carbon and N contents up to an appreciable depth were considerable in soils under natural forests. It was found that growing eucalypt after clearfelling natural forests has deleterious effect on soil properties.

INTRODUCTION

It has been reported that soil properties vary spatially primarily in response to rooting and litter-fall characteristics of the perennial vegetation on more or less the same soil material (Lescure and Boulet, 1985; David *et al.*, 1988; Nath *et al.*, 1988). Roots take up chemical constituents from a large volume of soil material and concentrate them in the biomass. Litterfall then transfers much of this biomass beneath the canopy and their decomposition releases these biophyllic chemical constituents to the soil material. Hence, soils exhibit difference in properties in relation to the vegetational changes. In Kerala, very few attempts have so far been made to study the soil properties in different ecosystems (Balagopalan and Jose, 1984). This study aims to evaluate the changes in properties of soils in relation to vegetational types in Kerala.

MATERIALS AND METHODS

Peechi (150 m asl) in Trichur Forest Division, Kerala was chosen for studying the effect of vegetational types on soil properties. The average rainfall during the period 1980-1990 was 1910 cm. A linear transect, 9 km long and 500 m wide starting from evergreen (West Coast tropical evergreen), passing through semi-evergreen (West Coast semi-evergreen) and moist deciduous (South Indian moist deciduous) forests, and teak (*Tectona grandis*), eucalypt (*Eucalyptus tereticornis*) and rubber (*Hevea brasiliensis*) plantations was taken. The years of establishment of teak, eucalypt and rubber plantations were 1968, 1973 and 1969, respectively and the latter belongs to a private organisation. The transect was chosen in such a manner that each vegetational type was represented by an area of 1.5 km length and 500 m width. Five sub-plots of 50 m x 50 m were laid out randomly in one vegetational type, each sub-plot separated from the other by about 50 m. One soil pit was taken from every sub-plot and samples from 0-15, 15-50 and 50-100 cm layers were collected.

Analyses were carried out for particle-size separates, physical constants, pH, loss on ignition, acid

[1] Kerala Forest Research Institute, Peechi 680 653, Trichur, India

insolubles, sesquioxides (R_2O_3), cation exchange capacity (CEC), total calcium, magnesium and potassium (in HC1 extract) following the procedures described by Piper (1942), Jackson (1958), AOAC (1960) and ASA (1965).

Organic carbon (OC) was determined by the method of Walkley and Black (1934). Total N was determined by the method described by Hesse (1971). Mean values of soil properties in the six vegetational types are presented in Tables 1 and 2. Analysis of variance of soil properties, due to vegetational types (Snedecor and Cochran, 1975) are given in Table 3.

RESULTS AND DISCUSSION

On comparing soil properties in the 0-100 cm layer in the six vegetational types, it could be seen that soils in evergreen forest contained highest values for silt, water holding capacity, pore space, loss on ignition, K_2O, total N and cation exchange capacity and lowest values for gravel, sand, soil pH, bulk density and acid insolubles. In the case of semi-evergreen forest, the values for clay and acid insolubles were highest while those for electrical conductivity, Fe2O3 and CaO were lowest. For soils in moist deciduous forest, particle density, P2O5, CaO, MgO and OC were relatively higher while Al_2O_3 was lower. Teak soils possessed highest values for soil pH and volume expansion. As regards eucalypt plantation, the values for gravel, sand, electrical conductivity and bulk density were highest and *vice versa* for silt, water holding capacity, pore space, volume expansion, OC and cation exchange capacity. Soils in rubber plantation had highest Al_2O_3 content while particle density, loss on ignition, P_2O_5, MgO and total N values were lowest.

Analysis of variance of soil properties in the vegetational types revealed that excluding clay, particle density and Al_2O_3, all other properties exhibitedsignificantdifference.

On comparing the soils in the six vegetational types, it can be seen that the textural composition of soils in evergreen, semi-evergreen, moist deciduous and rubber are loam while those in teak and eucalypt are sandy loam. The soils in semi-evergreen, moist deciduous, eucalypt and rubber are medium acidic, those in evergreen are strongly acidic while in teak, they are slightly acidic. In natural forests, 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 reabsorption. This re-cycling of nutrients keeps the forests under high fertility status with rich top soil and dense vegetation rendering erosion problem negligible.

The plantations of teak and eucalypt were established after clearfelling a moist deciduous forest and burning the area. In the case of rubber, it was planted after clearfelling a moist deciduous forest. The clearing of the natural vegetation is a dramatic ecological event with short and long-term effects on the soil properties. In pristine ecosystems, most of the nutrients are bound in living and dead biomass present at the sites and tight cycles exist. When there is a disturbance, there will be large amounts of nutrients released

Table 1. Mean values of soil physical properties in the different layers in the six vegetational types

Veg. types	Depth (cm)	Gravel %	Sand %	Silt %	Clay %	Soil pH	EC dS/m	Bulk density	Particle density	WHC %	Pore space %	Vol. exp. %
Evergreen	0-15	12.5	[illegible]	18.0	23.3	5.7	[illegible]	1.13	2.36	[illegible]	52.1	[illegible]
	15-50	9.4	57.4	19.7	22.9	5.5	0.08	[illegible]	2.52	36.8	[illegible]	5.44
	50-[redacted]	8.0	53.8	25.6	[illegible]	5.2	[illegible]	[illegible]	2.59	[illegible]	47.3	4.75
Semi-ev[redacted]	0-15	17.7	64.1	12.4	28.5	5.8	0.11	1.26	2.39	40.9	46.8	5.51
	15-50	16.6	62.4	15.9	21.7	5.5	0.06	1.43	2.60	33.3	45.1	3.85
	50-100	10.0	58.2	16.7	25.1	5.5	0.05	1.45	2.44	[illegible]	40.7	3.77
M[illegible] de[redacted]	0-15	22.2	72.7	15.6	18.4	5.9	0.22	1.35	2.52	46.7	46.2	6.61
	15-50	21.0	[illegible]	15.6	14.0	5.7	0.11	1.49	2.63	[illegible]	43.3	3.57
	50-100	21.2	66.2	18.1	15.7	5.7	0.05	1.48	2.69	30.4	44.9	4.11
Te[illegible]	0-15	20.6	74.1	6.2	[illegible]	6.2	0.17	1.36	2.49	34.2	45.1	6.21
	15-50	20.4	[illegible]	[illegible]	18.3	6.1	0.17	1.37	2.46	31.5	44.2	5.95
	50-100	22.2	[illegible]	6.6	[illegible]	6.1	0.17	1.40	2.43	[illegible]	42.1	6.06
E[redacted]	0-15	24.4	76.8	[illegible]	16.5	[illegible]	[illegible]	[illegible]	2.61	30.7	[illegible]	[illegible]
	15-50	29.2	78.8	5.6	14.1	[illegible]	[illegible]	[illegible]	2.54	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	75.8	5.9	18.3	[illegible]	0.18	[illegible]	[illegible]	[illegible]	36.6	3.95
Rubber	0-15	19.8	[illegible]	14.4	[illegible]	[illegible]	0.16	1.35	[illegible]	35.0	45.1	[illegible]
	15-50	15.9	70.8	[illegible]	[illegible]	[illegible]	0.17	1.43	2.54	29.4	[illegible]	4.09
	[illegible]	13.1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.45	[illegible]	29.4	[illegible]	[illegible]

Table 2. Mean values of soil chemical properties in different layers in the six vegetational types

Veg. types	Depth (cm)	Loss on igni. %	Acid insoluble	Fe_2O_3 %	Al_2O_3 %	P_2O_5 %	K_2O %	CaO %	MgO %	OC %	Total N ppm	CEC cmol(+)/kg
Evergreen	0-15	23.75	45.04	10.44	16.46	0.10	0.15	0.17	0.09	1.98	1566	16.06
	15-50	14.78	46.23	12.08	22.02	0.04	0.23	0.11	0.11	1.34	1071	13.42
	50-100	16.01	47.69	11.83	21.09	0.03	0.22	0.11	0.06	1.12	917	14.95
Semi-evergreen	0-15	17.62	49.79	10.15	19.00	0.07	0.14	0.10	0.08	1.31	1369	12.88
	15-50	10.99	53.70	11.72	21.43	0.05	0.19	0.08	0.07	1.21	1020	10.44
	50-100	11.72	53.06	11.08	21.10	0.03	0.19	0.06	0.04	0.96	837	10.69
Moist deciduous	0-15	26.39	43.49	9.85	18.09	0.06	0.16	0.15	0.15	2.53	1148	11.32
	15-50	14.28	51.41	12.06	19.44	0.05	0.15	0.14	0.12	1.86	872	10.60
	50-100	12.81	50.62	12.32	20.80	0.05	0.21	0.12	0.10	0.45	275	9.28
Teak	0-15	15.07	48.50	13.70	19.67	0.06	0.10	0.13	0.08	1.42	887	11.09
	15-50	13.61	46.04	15.69	22.67	0.04	0.08	0.11	0.06	0.85	692	9.12
	50-100	13.21	45.64	15.03	22.87	0.04	0.09	0.12	0.07	0.77	383	7.76
Eucalypt	0-15	13.04	53.42	11.12	20.14	0.04	0.08	0.13	0.08	1.23	783	9.47
	15-50	10.57	51.08	12.89	22.88	0.03	0.06	0.10	0.06	0.80	482	6.88
	50-100	12.10	51.39	11.35	20.69	0.04	0.08	0.07	0.03	0.66	417	6.67
Rubber	0-15	13.88	48.44	12.80	21.75	0.04	0.12	0.13	0.09	2.01	843	11.19
	15-50	10.14	50.86	11.00	23.14	0.03	0.06	0.09	0.04	0.89	400	8.59
	50-100	9.87	49.34	13.24	20.66	0.03	0.04	0.07	0.03	0.62	315	7.26

Table 3. Analysis of variance of soil pro[redacted]s due to different vegetation types

[redacted]	df	F-values										
		Gravel	Sand	Silt	Clay	Soil-pH	EC	BD	PD	WHC	Pore space	Vol. exp.
Veg. types	5	5[illegible]42	58.90**	[illegible].97**	1.1[illegible]	5.72**	14.05**	19.94**	1.45	16.97**	26.05**	18.89**
	2	11.78	6.92	3.7[illegible]	52.42	58.90	11.78	6.29	0.79	36[illegible]	7.73	31.22

Source	df	F-values										
		Acid insol.	Loss on igni.	[illegible]	Al_2O_3	P_2O_5	K_2O	CaO	MgO	[illegible]	N	CEC
Veg. types	5	22.58[illegible]	14.85	[illegible]24*	1.80	11.[illegible]7**	86.08*	13.8[illegible]	23.[illegible]**	16.[illegible]*	[illegible].37	[illegible]4**
	2	[illegible]	4.34**	4.47*	[illegible]30**	46.95**	9.[illegible]	28.[illegible]	25.98*	107.46**	66.66	64.57**

* Sigificant at 5% level; ** Significant at 1% level.

whether the disturbance is caused by clearfelling of forests or by fire. In other words, the balance in the natural climax forest is disturbed when the forest is cleared and the soil exposed to the influence of climatic factors. The changes in soil properties following clearfelling and subsequent plantation activities have been recorded by several investigators. (Lundgren, 1978; Chijioke, 1980; Covington, 1981; Muller *et al.,* 1985; Aboriasade and Aweto, 1990). The reduction in organic carbon and total N in teak and eucalypt plantations in Kerala when compared with natural forest has also been reported by Balagopalan and Jose (1984).

In the surface soils of eucalypt plantations, it is found that the leaf litter accumulates and it takes longer period for decomposition in Kerala conditions (Mary and Sankaran, 1991). This results in relatively lower incorporation of organic matter (OM) into the soil, as evident from the OC values which indirectly affect other soil properties due to their relationship with OM. Also it could be seen that forest clearance, subsequent logging and plantation establishment led to increased bulk density of soils. Teak being a long rotation crop (55 years under Kerala conditions) and deciduous in nature, the soils under teak are subjected to impact of environmental factors more than the short rotation eucalypt. This brings some of the soil properties in teak plantations close to those of moist deciduous forest (Jose and Koshy, 1972). In the case of rubber plantations, belonging to a private organisation, annual weeding, fertiliser application and soil management measures were practised regularly as a result of which some of the properties exhibit marked difference from other two plantations. The relatively higher values for bulk density and lower for OM in eucalypt can be adduced to the slow decomposition of litter as well as its lower incorporation into the soil in addition to other operations accompanying plantation establishment.

The C:N ratios in the six vegetational types show that there are considerable differences, ranging from 10.78 in the semi-evergreen to 22.52 in the rubber plantations. The relatively higher C:N ratios in moist deciduous forest, teak and rubber plantations are due to the higher additions of litter and its simultaneous faster decomposition.

Analyses of variance of soil properties bring out the fact that varying types of vegetation give rise to difference in soil properties even in the same climatic condition. Another striking point is that soils in evergreen forest stand aloof, even among the natural forests. This is expected because of the difference in the microclimate in evergreen forest compared to other vegetational types.

ACKNOWLEDGEMENT

We express our sincere thanks to Dr. Chand Basha, I.F.S, Director, KFRI, Peechi and the Staff, Computer Centre, Kerala Agricultural University, Vellanikkara for the data analysis.

REFERENCES

Aborisade, K.D. and Aweto, A. 1990. Effects of exotic tree plantations of teak (*Tectona grandis*) and gmelina (*Gmelina arborea*) on a forest soil on south western Nigeria. *Soil Use and Management 6:* 43-45

AOAC. 1960. *Official Methods of Analysis*. Association of Official Agricultural Chemists. Washington DC, p 832

ASA, 1965. *Methods of Soil Analysis*. Parts 1 & 2. C.A. Black *et al*., (eds.), American Society of Agronomy, Madison, Wisconsin, U.S.A, p 1572

Balagopalan, M. and Jose, A.I. 1984. Distribution of organic carbon and different forms of nitrogen in a natural forest and adjacent eucalypl plantation at Arippa, Kerala India. *Eucalyptin India, Past, Present and Future*. J.K. Sharma; C.T.S. Nair; S. Kedharnath and S. Kondas (eds.). KFRI, Peechi, India, p 112-119

Chijioke, E. 1980. Impact on soils of fast-growing species in low-land humid tropics. *FAO Forestry Paper21*. FAO, Rome, p 111

Covington, W. W. 1981. Changes in forest floor organic matter and nutrient content following clear cutting in northern hard woods. *Ecology* 62: 41-48

David, M.B., Grigal, D.F., Ohmann, I.F. and Gertnes, G.Z. 1988. Sulphur, carbon and nitrogen relationships in forest soils across the northern Great Lake states as affected by atmospheric deposition and vegetation. *Can.J. For. Res.* 18: 1386-1391

Hesse, P.R. 1971. *A Textbook of Soil Chemical Analysis*. John Murray, Publishers, London, p 520

Jackson, M.L. 1958. *Soil Chemical Analysis*. Prentice Hall Inc., U.S.A, p 498

Jose, A.I. and Koshy, M.M. 1972. A study of the morphological, physical and chemical characteristics of soils as influenced by teak vegetation. *Indian For.* 98: 338-348

Lundgren, B. 1978. *Soil Conditions and Nutrient Cycling under Natural and Plantation Forest in Tanzanian Highlands. Reports in Forest Ecology and Forest Soils* 31, Department of Forest Soils, Swedish University of Agricultural Sciences, Uppsala, p 426

Lescure, J.P. and Boulet, R. 1985. Relationship between soil and vegetation in a tropical rain forest in French Guiana. *Biotropica* 17: 155-164

Mary, M.V. and Sankaran, K.V. 1991. Ex-situ decomposition of leaf litters of *Tectona grandis, Eucalyptus tereticornis* and *Albizia falcataria*. KFRI Res. Report No. 71.

Muller, H.J., Juo, A.S.R. and Wild, A. 1985. Soil organic C, N, S and P after forest clearance in Nigeria; Mineralisation rates and spatial variability. *J. Soil Sci.* 36: 585-592

Nath, S., Banerjee, M., Chatterjee, G., Ganguly, S.K., Das, P.K and Banerjee, S.K. 1988. Changes in soil attributes consequent upon differences in forest cover in a plantation area. *J. Indian Soc. Soil Sci. 36:* 515-521

Piper, C.S. 1942. *Soil and Plant Analysis*. Hans Publishers, Bombay, p 368

Sankaram, A. 1966. *A Laboratory Manual for Agricultural Chemistry*. Asia Publishing House, p 340

Snedecor, W.G. and Cochran, G.W. 1975. *Statistical Methods*. Oxford & 1BH Publ. Co., New Delhi, p 593

Walkley, A. and Black, I.A. 1934. An examination of the Deglgareff method for determining soil organic matter and a proposed modification of the chromic acid titralion method. *Soil Sci.* 37: 29-38

□■□