PROPERTIES OF SOILS UNDER EUCALYPTS

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CONTENTS

ABSTRACT

Extensive *Eucalyptus tereticornis* and *E. grandis* plantations are being raised in Kerala since early 1960s. As short-rotation eucalypt forestry is similar to agriculture and horticulture, whether monoculure of eucalypt can cause soil deterioration is **a** genuine question. The project, *properties of soils under eucalypts,* was initiated with the objective of evaluating changes in soil properties due to continuous eucalypt cropping.

Literature presents the impression that short rotation high-yield forestry like eucalypt forestry may cause changes in soil properties resulting in soil deterioration. Unlike in a long-rotation tree crop such as teak, impact of the highly intensive nature of eucalypt cropping may be felt sooner. However, the intensity of deterioration will depend on initial soil conditions, topography, climate and management practices. On favourable sites there may be no significant effect for two or three rotations but on poorer sites the effect may become apparent soon.

Since most of the eucalypt plantations are in uncoppiced stage, comparative profile studies to establish soil changes due to monoculture of eucalypts would be premature. One profile each was chosen from six eucalypt sites to study the properties in general and 62 surface samples (0-20cm) were taken at random from several eucalypt plantations for an overall evaluation of soil properties in uncoppiced and to some extent in first coppiced plantations. Particle-size separates, pH, organic carbon and cation exchange capacity analyses were done.

Profile data reveal relatively higher levels of organic carbon and cation exchange capacity indicating the generally high fertility of soils under eucalypts. Surface sample data support the profile data and coppice-wise results also demonstrate higher levels of these integrating parameters in uncoppiced and first coppiced soils. These trends combined with the presence of well-established root system of seedling tree for the coppice trees suggest that the chances of soil deterioration due to continuous eucalypt cropping would be less. Also, the relatively higher levels of organic carbon and cation exchange capacity in the surface horizons of profiles and in the surface samples imply that soil parameters should not limit growth of eucalypts in uncoppiced and to some extent in first coppiced plantations.

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Key words: Soils **under eucalypts**

INTRODUCTION

Eucalyptus tereticornisand Eucalyptus grandis, important pulpwood species in Kerala, occupy over 40 000 ha of forest plantations. Here, extensive eucalypt plantations are being raised since the early 1960s. As short-rotation eucalypt forestry is similar to agriculture and horticulture, whether continuous eucalypt cropping can cause any soil deterioration is a genuine question. The present project, properties of soils under eucalypts, was initiated in April 1977 with the objective of evaluating changes in soil properties due to continuous eucalypt cropping.

REVIEW OF LITERATURE

Very little infomation exists on the impact of eucalypt monoculture on soils. Unlike in a long-rotation tree crop like teak, effect of the highly intensive nature of eucalypt cropping may. be felt sooner and the nature of such impact has to be established for formulating scientific soil management practices.

Though there have been studies on different aspects of eucalypt forestry in India. such as (i) effect of soils on eucalypt growth (Kaushik et al 1969, Yadav 1969, Yadav and Prakash 1969) (ii) nutrition (Bhimaya and Kaul 1966, Hussain and Theagarajan 1966, Kaul et al 1970) (iii) microbiological and biochemical aspects (Reddy 1962) (iv) fertilizers (Roy 1976, Sinha 1970 (v) afforestation (Agarwal et al 1961, Chandrasekharan 1968), hardly any study has been done on the effect of eucalypts on soils (Singhal et al 1975). However, the impact of tree crops on soils and successive productivity have been the concern of several workers in other countries. Recent review by Evans (1976) deals with short and long-rotation tree cropping in general and the reports by Chijioke (1980) and Lundgren (1978) deal with short-rotation species *Pinus ceribaea, Pinus patula, Gmelina arborea* and *Cupressus lusitanica.* These have only passing reference to eucalypts and the discussions are mainly on subtropical and temperate investigations, with few examples cited from the tropics. This is mainly because, very few studies have been done in tropical regions to look into the impact of continuous tree cropping on soils.

After reviewing the literature on continuous *Pinus radiata* cropping in Australia, Florence (1967) mentions the following changes in soil properties: increase in bulk density, decrease in organic matter and nitrogen and depletion of cationic nutrients. Lundgren (1978) opines that deterioration of soil properties due to continuous *P. patula* and *C. lusitanica* cropping can occur through increased soil erosion, increased leaching and faunal as well as floral impoverishment. According to him, the magnitude of soil deterioration will depend not only on local soil, climate and topographic conditions, but also to a large extent on management. Or, in other words, soil deterioration is the result of interaction of pedological, environmental and management factors.

In summary, without proper soil management practices, clearfelling of forests and continuous eucalypt cropping may eventually result in soil deterioration in the form of decreased soil organic matter and nutrient levels and alterations in soil physical properties. The intensity of deterioration will depend on initial soil conditions, topography, climate and management practices On favourable sites, there may be no significant effect for two or three rotations but on poorer sites, the effects may become apparent soon.)

MATERIALS AND METHODS

Since most of the eucalypt plantations are in uncoppiced rotation and very few are in the first coppiced stage, comparative profile studies to establish soil changes due to continuous eucalypt cropping would be premature. In order to study the properties in general, one profile each was chosen from six eucalypt sites, the details of which are given in Table 1. Further, as the maximum impact due to eucalypt cropping can occur in the topsoil, surface samples (0-20cm) were taken at random from eucalypt plantations scattered throughout Kerala (Table 8). The surface samples were taken for an overall evaluation of properties of soils under eucalypt plantations. Out of the 62 surface samples, 41 were from uncoppiced and 21 from first coppiced plantations.,

Table 7. Soil profiles from eucalypt plantations

Site	Forest Division	Year of plantation
Vattavada	Munnar	1958: 1969 coppice
Kanthallur	Munnar	1965; 1975 coppice
Kollathirumed	Vazhachal	1966; felled in 1976
Vazhachal	Vazhachal	1977
Kondazhi	Trichur	1977
Chandanathode	Wynad	1976

The soil samples were air-dried, passed through 2-mm sieve and stored for analyses. Parficle-size separates(sand ≤ 2.0-0.02, silt=0.02-0.002, clay= <0.002mm diameter), pH in soil-water suspension, organic carbon and cation exchange capacity analyses were done according to procedures in Methods of Soil Analysis (American Society of Agronomy 1965) and Soil Chemical Analysis (Jackson 1958).

Table 2. Vattavada profile and properties

Hilly, elevation 1750m. well drained, 1958 eucalypt plantation, coppiced in 1969.
0- 15 cm Black (5 YR 2.5/1), loamy sand, granular structure, abundant roots.
15- 33 cm Reddish brown (5 YR'5/4), loam, granular structure, many roots.
33- 75 cm Yellowish red (5 YR 4/6), clay, massive structure, many roots.
75-125 cm Reddish brown (5 YR 5/4), sandy loam, massive structure, very few roots.

Depth (cm)	Sand	Silt	Clay	pH in water	Organic carbon (%)	Cation exchange capacity (me/100g)
	(..............%		.............)			
0- 5	71	19	10	5.4	2 83	31
15- 33	64	18	18	4.8	1.05	16
33- 75	59	6	35	4.4	0.88	16
75-125	77	5	18	4.7	0.49	12

Table 3. Kanthallur profile and properties

Hily, elevation 2300m, well drained, 1965 eucalypt plantation, coppiced in 1975,
0- 20 cm Black (5 YR 2.5/1), granular structure, abundant roots.
20- 50 cm Dark reddish brown (5 YR 2.5/2), loamy sand, granular structure, abundant roots.
50- 70 cm Yellowish red (5 YR 5/8), loam, massive structure, few roots
70–125 cm Reddish yellow (5 YR 6/6), silt loam, massive structure, very few roots.

Depth (cm)	Sand	Silt	Clay	pH in water	Organic carbon (%)	Cation exchange capacity (me/ 100g)
	(..............	%	.............)			
0- 20	Not determined			4.4	4.97	35
20- 50	83	11	6	4.5	4.74	25
50- 70	71	15	14	4.9	1.53	14
70-125	67	27	6	5.5	0.22	10

***Table 4.** * Kollathirumed profile snd properries*

Hilly, elevation 400m, well drained, **1966** eucalypt, felled in 1976.
0- 10 cm Dark reddish brown (5 YR **3/4)**, loam, granular structure, few to many roots.
10- 35 cm Dark reddish brown (5 YR **3/4)**, loam, granular structure, few roots.
35- 80 cm Yellowish red (5 YR **5/6)**, loam, massive structure, few roots.
80-120 cm Reddish yellow **(7.5**YR **7/6)**, loamy sand, massive structure, very few roots.

Depth (cm)	Sand (.........	Silt %	Clay ....)	pH in water	Organic carbon (%)	Cation exchange capacity (me/100g)
0- 10	71	16	13	5.3	2.87	22 .
10- 35	67	16	17	4.3	1.90	18
35- 80	64	18	18	5.0 ,	1.20	14
80-120	78	12	10	5.5	0.49	9

* **Tables 4, 5 and 6 from Alexander, T. G., Sobhana, K., Balagopalan,** M. **and Mary,** M. **V. 1980. Taungya in relation *to* soil properties, soil erosion and soil management. KFRI Research Report 4. p.12-13.**

Table 5. Vazhachal profile and properties

Hilly, elevation 400m, well drained, **1977** eucalypt.
0- 12 cm Reddish brown (5 YR **4/3)**, loamy sand, granular structure, abundant roots.
12- 57 cm Yellowish red (5 YR **4/6)**, loam, granular structure, many roots.
57-107 cm Yellowish red (5 YR **5/6)**, loam, massive structure, few roots.
107-162 cm Reddish yellow **(5**YR **6/6)**, loam, massive structure, very few roots.
162-182 cm Reddish yellow (5 YR **7/6)**, loam, massive structure, no roots.

Depth (cm)	Sand (..............	Silt %	Clay ....)	pH in water	Organic carbon (%)	Cation exchapge capacity (me/100g)
0- 12	83	10	7	5.4	1.60	11
12- 57	75	11	14	5.5	0.77	11
57-117	70	11	19	5.8	0.35	14
107-162	74	11	15	5.6	0.24	11
162-182	75	11	14	5.6	0.21	

Table 6. Kondazhi profile and properties

Level to gently rolling, elevation 100m moderately well drained, 1977 eucalypt.
0- 12 cm Dark reddish brown (5 YR 3/3), loam, granular structure, many roots-
12- 52 cm Dark reddish brown (5 YR 3/41, clay loam, granular to blocky structure, many roots.
52- 90 cm Yellowish red (5 YR 4/6), loam, massive Structure, few roots.
90-140 cm Ysllowisb red (5 YR 4/6), sandy loam, massive structure, few roots.

Depth (cm)	Sand	Silt	Clay	pH in water	Organic carbon (%)	Cation exchange capacity (me/100g)
	(.........	% ...	...........)			
0- 12	76	12	l2	5.3	1.45	17
12- 52	65	10	25	**5.3**	0.69	16
52- 90	71	11	18	5.4	0.18	15
90-140	78	8	14	5.6	0 16	12

Table 7. Chandanathode profile and properties

Hilly, elevation 700m, well drained 1976 eucalypt.
0- 12 cm Dark reddish brown (5 YR 3/4), loam, granular structure, abundant roots.
12- 39 cm Dark reddish brown (5 YR 3/4), loam, granular structure, many roots.
39-102 cm Yellowish red (5 YR 4/6), loam, granular to massive structure, few roots.
102-150 cm Yellowish red (5 YR 5/8), loam, massive structure, very few roots.

Depth (cm)	Sand	Silt .	Clay	pH in water	Organic carbon (%)	Cation exchange capacity (me/100g)
	(...............	% ...	...............)			
0- 12	74	12	14	5.5	1.95	18
12- 39	67	15	18	5.4	1.42	16
39-102	66	15	19	5.3	0.75	15
102-150	64	22	14	5.3	0.20	12

Table 8 Properties of surface samples (0-20cm) from uncoppiced and first coppiced eucalypt plantations

Location	Forest Division	Elevation (m)	Year of plantation	Number of samples	Sand (.........%	Silt	Clay ....)	pH in water	Organic carbon (%)	Cation exchange capacity (me/1 00g)
1	2	3	4	5	6	7	8	9	10	11
Palode	Trivandrum	125	1964; 76 coppice	4	75	1 0	15	5.0	2.48	11
Piravanthur	Punalur	50	1964; 78 coppice	4	74	11	15	5.3	2.60	17
Rajampara	Ranni	450	1964; 77 coppice	1	79	8	13	5 2	3.07	21
Pamba	Grassland Afforestation	950	1962	4	78	12	1 0	5.3	2.79	22
Vattavada	Munnar	1750	1972 & 1974	3	76	13	11	5.8	3.21	32
Kanthallur	Munnar	2300	1965; 75 coppice	7	84	9	7	4.7	10.38	32
Champakkad	Munnar	500	*	2	85	4	11	5.9	0.87	12
Amanthode	Kothamangalam	25	196%	1	82	10	8	4.7	2.22	20
Mullaringad	Kothamangalam	50	1967 & 1969	2	78	11	1 1	4.8	2.22	20
Kuruvanapara	Kothamangalam	50	1966;78 coppice	2	83	9	a	5.6	2.84	22
Erumala	Kothamangalam	50	1979	1	73	14	13	5.6	1.87	22

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1	2	3	4	5	6	7	8	9	10	11
Namboori Coupe	Malayattur	50	1968; 78 coppice	2	81	9	10	5.5	1.78	18
Pothupara	Kaladi	100	1975	1	80	9	11	4.8	2.65	22
Kollathirumed	Vazhachal	400	1968; 77 coppice	1	74	11	15	6.1	2.14	24
Chuzhimed	Vazhachal	375	1977	1	69	12	19	5.4	1.40	9
Kondazhi	Trichur	100	1975	1	77	8	15	5.9	1.33	8
Chempankandam	Trichur	100	1975	1	79	11	10	5.8	1.93	27
Varavur	Trichur	125	1976	3	72	11	17	5.7	1.61	**20**
Kurancheri	Trichur	75	1975	1	75	11	14	5.8	0.97	15
Kalikavu	Nilarnbur (Vested)	125	1976	2	74	10	16	5.8	2.62	23
Vellakkutta	Nilarnbur	75	1972	2	80	8	12	5.8	1.60	13
Karnataka Border	Kozhikode	800	1973	2	78	8	14	6.6	1.78	16
Thariode	Kozhikode	700	1976	3	72	13	15	5 4	3.04	24
Chandanathode	Wynad	700	1976	6	74	12	14	4 9	2.00	10
Begur	Wynad	750	1972	2	78	10	12	6.4	2.18	20
Thirunelli	Wynad	775	1975	3	70	13	17	5.6	1.92	18

* Not available

RESULTS

The relative proportion of sand, silt and clay determines soil texture and it is an important physical property of soil. Hydrogen ion activity or pH value is a measure of soil reaction and any drastic change in pH value indicates drastic change in soil environment. As pH increases, acidity decreases in the soil and vice versa. Both organic carbon and cation exchange capacity (CEC) are integrative properties of soil in that generally higher the levels of these, higher the soil fertility. The sum of exchangeable bases (principally calcium, magnesium, potassium and sodium) and exchangeable hydrogen plus aluminium is a measure of CEC of soil.

In the profiles, texture varies from loamy sand to loam in surface horizons (Tables 2-7). Sand (coarse separate) tends to decrease and silt plus clay (finer separates) tends to increase with depth indicating movement of the latter downwards due to leaching. The profiles have extremely to strongly acid (pH 4.4-5.5) surface horizons and there is no consistent trend in pH distribution with depth, Organic carbon values are fairly high in the surface horizons (1.45-4.97%) indicating the generally high fertility of these soils. In all the profiles organic carbon content decreases with depth. CEC values (11-35 me/100g) also show good fertility of these soils and like organic carbon, CEC also decreases with depth.

In the surface samples (0-20cm), higher levels of organic carbon (0.87-10.38%) and CEC (8-32 me/lOOg) are noted and these also indicate generally high fertility of the soils under eucalypts (Table 8). The very high carbon value in Kanthallur samples (10.38%) is attributable to the slow rate of decomposition of plant residues in the surface layers. The surface sample data show wide ranges in all the properties studied: the ranges are 69-85% in sand, 11-33% in silt plus clay, 4.0-6.6 in pH (extremely acid to neutral , 0.87-10.38% in organic carbon and 8-32mellOOg in CEC (Table 9).

Table 9. Mean and range of properties of surface samples (0-20 cm) from uncoppiced and first coppiced eucalypt plantations

Property	Uncoppiced and coppiced		Uncoppiced*		First coppiced**	
	mean	range	mean	range	mean	range
Sand,%	78	69-85	76	65-85	79	74-84
Silt,%	10	4-14	11	4-14	9	8-11
Clay,%	12	7-19	13	8-19	12	7-15
pH in water	5.4	4.0-6.6	5.5	4.0-6.6	5 3	5.0-6.1
Organic carbon,%	2.49	0.87-10.38	2 .01	0 87-3.21	3.61	1.78-10.38
Cation exchange capacity, me/100g	18	8-32	19	8-32	21	11-32

* 41 Samples
** 21 Samples

DISCUSSION

Profile data show fairly high levels of organic carbon and CEC in soils under eucalypts indicating the generally high fertility of these soils (Tables2-7). Surface sample data support the profile data and coppice-wise results also demonstrate higher levels of organic carbon and CEC in uncoppiced and first coppiced soils (Tables 8, 9 and Fig 1). The surface sample data have been stratified into unco-ppiced and first coppiced to find out the level of organic carbon and CEC, and not for comparison as these samples were taken from several plantations at random. Since most of the eucalypt plantations are in uncoppiced stage arid as very few plantations are in first coppiced stage, it would be too early to establish the impact of continuous eucalypt cropping on soils. Howsver, the profile and surface sample data of this study can give an indication of changes in soil properties due to eucalypt cropping.

Literature gives the impression that short-rotation high-yield forestry like eucalypt forestry may cause changes in soil properties resulting in soil deterioration Lund-gren (1978) reports, in a study on two fast-growing species *Pinus patula* and *Cupressus lusitanica* in Tanzanian Highlands, that without special soil conservation measures, the conversion of natural vegetation (forest or bush) to man-made forests and continued cropping of trees will eventually result in soil deterioration in the form of decreased soil organic matter and nutrient levels, loss of topsoil structure and porosity. The magnitude and speed of deterioration will depend on initial soil conditions, climatic conditions, management practices and species raised. From a study of monoculture of *Pinus caribaea* and *Gmelina arborea* in low land tropics with special reference to Nigeria, Chijioke (1980) feels that there is little reason to suppose that cultivation of fast-growing forest crops will improve soil productivity without remedial measures. His study does not provide any evidence that monoculture per se leads to more rapid depletion of soil nutrients than would mixtures having the same timbar production rate, rotation length and proportion of crops rsinoved in harvesting. Though nutrient depletion is clearly associated with fast growth, further studies are necessary to demonstrate whether a mono-specific crop immobilizes nutrients more quickly than a mixed crop.

Our piofile and surface sample data indicate generally high fertility of soils under eucalypts. Hence the chances of soil deterioration due to eucalypt cropping would be less, at least in the uncoppiced rotation. Whether soil deterioration can occur in the first coppiced rotation is yet to be established. An advantageous factor to be noted incase of eucalypts is the coppicing ability and maintenance of the well-established root system of seedling tree for subsequent trees The fact that the root systems are not disturbed much during a rotation of about 30 years indicates less disturbance underground except of course that caused by logging and related activities. Thus, the relatively higher levels of organic carbon and CEC, two integrative soil properties, plus wide ranges in all the properties suggest that soil parameters should not limit growth of eucalypts in uncoppiced and to some in first coppiced plantations.

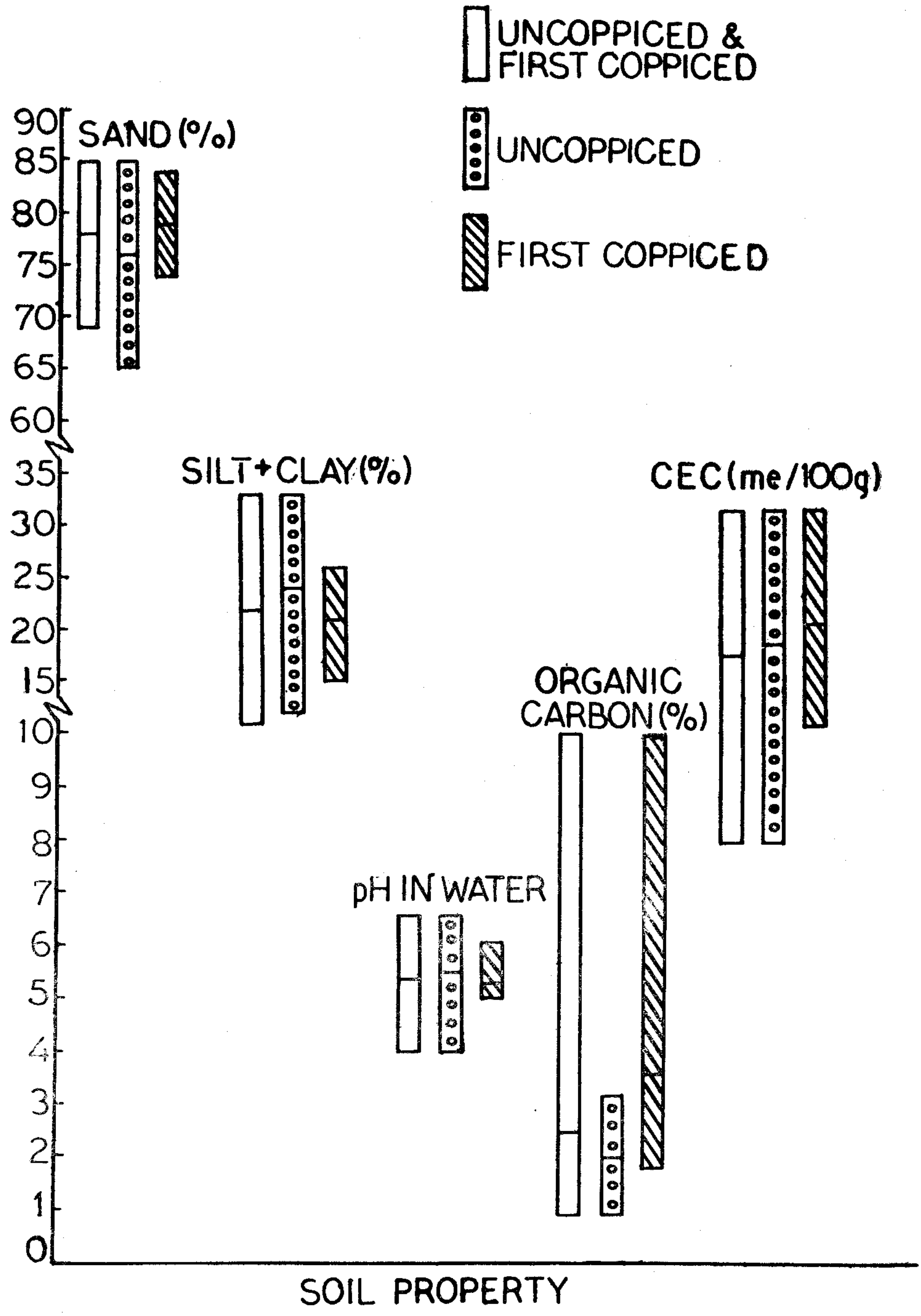

Figure 1. Mean and range of properties of surface samples from uncoppiced and first coppiced eucalypt plantations (mean = inner dash; range = lower and upper dashes)

CONCLUSION

Relatively higher levels of organic carbon and CEC, two integrative properties of soils, in surface horizons of profiles and surface samples indicate generally high fertility of the soils under eucalypts in uncoppiced as well as in first coppiced plantations. These trends combined with the feature of well-established root system of seedling tree for the subsequent trees imply that the chances of soil deterioration due to eucalypt cropping would be less. Also, the relatively higher levels of organic carbon and CECin surfac, samples suggest that soil parameters should not limit growth of eucalypts in uncoppiced and to some extent in first coppiced plantations.

LITERATURE CITED

AGARWAL, S.C , CHINNAMANI, S. and REGE, N.D. 1961. Mixed plantation for effective soil conservation in the Nilgiris. Indian For, 87: 26-33.

AMERICAN SOCIETY OF AGRONOMY. 1965. Methods of Soil Analysis. Parts 1 & 2. Black, C.A. et al (ed), ASA, Madison, Wisconsin, USA. 1572 p.

BHIMAYA, C.P and KAUL, R N. 1966 Levels of macro - and micro -elements in *E. camaldulensis (E. rostrata)* Nature 212:319-320.

CHANDRASEKHARAN, C. 1968. Experience with *E. grandis* in Kerala State. Indian For. 94:835-852.

CHIJIOKE, E. O. 1980. impact on soils of fast-growing species in low land humid tropics. FA0 Forestry Paper 21, FAO. Rome 111 p.

EVANS, J 1976. Plantations : productivity and prospects. Aust For. 39: 150-163.

FLORENCE, R. G. 1967. Factors that may have a bearing upon the decline of productivity under forest monoculture. Aust. For 31:50-71.

HUSSAIN, A. M. M. and THEAGARUAN, K. S. 1966. Preliminary studies in the mineral nutrition of E. *hybrid* seedlings Indian For. 92:285-292.

JACKSON, M L 1958 Soil Chemical Analysis. Prentice-Hall Inc. Englewood Cliffs, NJ, USA. 498p.

KAUL, O. N., SRIVASTAVA, P. B. L. and MATHUR, H. M. 1970. Nutrition studies on *Eucalyptus.* 5. Diagnosis of mineral deficiencies in *E. citriodora* seedlings. Indian For. 96 787-790.

KAUSHIK, R. C., QURESHI, I. M., YADAV, J. S. P and PRAKASH, J. 1969. Suit-ability of soil for *E. hybrid* (Mysore gum syn. E. *rereticornis)* in Haryana and Panjab. Indian For. 95 :377-388.

LUNDGREN, B. 1978. Soil conditions and nutrient cycling under natural and plantation forests in Tanzanian Highlands. Reports in Forest Ecology and

Forest Soils **31,** Dept. of Forest Soils, Swedish University of Agricultura Sciences, Uppsala. 426p.

REDDY, T. K. R. **1962.** Role of plant cover in distribution of fungi in Nilgiri forest soils. Proc. Indian Acad. Sci. 568:185-194.

ROY, B. K. El. **1976.** Experiences of fertilizer treatment in Eucalyptus—a discussion. Indian For. 102:168-I73,

SINGHAL, R. M., BANERJEE, S. P. and PATHAK, T. **C. 1975.** Effect of Eucalyptus monoculture on the status of soil organic matter in natural sal (Shorea robusta) zone in Doon Valley. Indian For. 101:730-737.

SINHA, B. N. **1970.** Use of fertilizers in Eucalyptus plantations. Indian For. **96:755-765.**

YADAV, J. **S.P. 1969.** Soil study for site suitability appraisal of forest plantations in North Bihar. Indian For. 95:139-148.

YADAV, J. S. P. and PRAKASH, **J. 1969.** Soil suitability for E. hybrid (Syn. *E. tereticornis*, Mysore gum) plantations in Tarai and Bhabar region of Uttar: Pradesh. Indian For. 95:834-840.