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ECOLOGICAL IMPACT OF NATURAL RUBBER, TEAK AND JARUL PLANTATIONS

D. James Jacob, A.P. Chauduri[1], D. Thapliyal[2], R.P. Mondal, R.P.Singh[1], S. Meti[3], H.K. Dekka[2] and A.S. Devakumar[4]

Rubber Research Institute of India, Kottayam, Kerala 686 009.

ABSTRACT

Natural rubber and two other native tree species which are widely used in the local afforestation programs, namely, teak (*Tectona grandis*) and jarul (*Lagerstroemia flos-reginae*) were grown in large plots of two ha each in a continuos stretch of land in the Jalpaiguri district of northern West Bengal. At the end of this period, were studied ecological impact of these three plantations as part of a multi-diciplinary research effort during the summer of 1997. The multi-diciplinary scientific team studied the effects on the soil-plant-atmosphere continuum covering physical, chemical and biological properties of the soil, tree growth, canopy development, solar energy interception and biomass production, litter turn-over and nutrient cycling, biodiversity etc. Trunk girth at breast level was comparable in teak and rubber and very small in jarul. But the total timber biomass per ha was more in rubber than in teak due to the better tree stand in the former. Canopy intensity, light interception and litter fall were comparable in rubber and jarul, but substantially smaller in teak. Under-growth was more profuse and diverse inside the rubber and jarul plantations than the teak plantation. The rubber litter contained slightly more N and P. Total soil N, available soil K and soil organic carbon contents were higher in the rubber soil than the other two soils. Soil moisture content was more in the top layers in the rubber soil and more or less comparable in the lower layers in the three plantations. After 22 years of growth, the rubber soil tended to contain fairly large proportions of silt and clay and small proportion of sand than the other two soils suggesting that the teak soil was perhaps more vulnerable to surface erosion. This appears to corroborate with the profuse undergrowth, large litter production and high soil organic carbon content in the rubber plantation. The action exchange capacity was higher and the soil was more acidic in the rubber plantation than in the other two plantations. The populations of fungi, bacteria and actenomycetes found in the soil were high and comparable in the rubber and teak plantations compared to the jarul plantation. The trunk of the rubber tree had more profuse growth of orchids, sphagnum moss and lichens than the other two species. Our studies show that none of the indicators of ecological health were seriously affected due to natural rubber cultivation. Rubber soils had certainly comparable, and at times, better physical, chemical and biological properties and improved biodiversity than the other two popular afforestation species when they were grown naturally with no external interference

INTRODUCTION

Among the five soil forming factors vegetation including both natural and man –made plantations have a pronounced effect on soil properties (Cernforth, 1970; Fisher and East burn, 1974). Different plant species varying widely in canopy and rooting pattern influence the soil properties primarily through addition of organic matter and actions of roots in binding soil particles. In natural forests and man-made protected plantations,

[1] Regional Research Station, Rubber Research Institute of India, Guwahati, Assam.

[2] Regional Research Station, Rubber Research Institute of India, Tura, Meghalaya.

[3] Regional Experimental Station, Rubber Research Institute of India, Nagrakatta, West Bengal.

[4] Present address: Forestry College, Ponnampettu, Coorg, Karnataka.

cycling of nutrient is an important aspect as considerable amount of nutrients are returned through litter fall and became available for recycling (Pritchett & Fisher, 1987). Banerjee *et al.*, 1986, reported the changes in soil properties having more or less parent material, primarily in response to rooting and litter fall, which were characteristics of perennial vegetation.

Soil harbours a wide variety of micro-organisms, which helps in stimulating the process of decomposition and thus playing an important role in plant nutrient cycling. A number of reports are available elsewhere on the microbial communities of the forest soils (Widden and Parkinson, 1973; Wicklow and Whittingham, 1978; Otrosina *et al.*, 1984). But no information on the microbial communities from Nagrakatta soils in North Bengal is available. Therefore, the present study has been designed to know the ecology and distribution pattern of microbial population from different forest soils of Nagrakatta.

In Dooars region of West Bengal, plantations of different forest species are being raised for a long time. Of late, rubber plantations are introduced commercially in different pockets of this region. Though some studies were attempted to quantify the influence of rubber plantation on soil physical properties with special reference to moisture retention (Krishnakumar et al, 1990) but the influence of different plantation crops as well as natural forest on soil properties and nutrient recycling has not been studied in Sub-Himalayan West Bengal. Therefore, the present investigation was undertaken to see the effect of Rubber, Teak, Jarul and Natural forest on the properties of a sub-tropical alfisol and compared with adjacent fallow land. The amount of litter fall and nutrients returned thereof in different plantations are also estimated.

MATERIALS AND METHODS

The plantation sites used in the present investigations were from Regional Experimental Station, Rubber Research Institute of India, Nagrakata and around the adjacent plantations. The area is located about 90 km from Siliguri (260 38' N, 880 19' E) in Jalpaiguri district of West Bengal at an elevation of 69m msl. The station receives mean annual rainfall of 3000 mm, which is well distributed over May to November and mean annual temperature ranges from 14.50C to 27.80C.

Chemical analyses of soil: Representative soil samples were collected from beneath the canopy of five plantation sites in a contiguous area at four depths *viz.*, d1 (0-15 cm), d2 (15-30 cm), d3 (30-60 cm) and d4 (60-90 cm) with four replications. The soils were collected during pre-monsoon and post moon period. The tree species comprised are as follows:

i). Twenty year old unmanaged rubber plantation (Rubber forest),

ii). Twenty year old plantation of Teak (*Tectona grandis*),

iii). Twenty year old Jarul (*Lagerstroemia reginee*),

The soils were air dried, processed through 2mm sieve and were used for laboratory analysis for Organic Carbon, total nitrogen, available phosphorus, potassium, calcium and magnesium (Jackson, 1973). Core samples were used for measuring bulk-density (Black, 1965). Bulk density, particle density and porosity were measured as described by Baruah and Barthakur (1998). Particle size distribution was determined by Buoycas hydrometer method (Baruah and Barthakur, 1998). Available water storage capacity (AWSC) was calculated from the formula as described Krishnakumar *et al.* (1990). For litter collection, four 2m X 2m quadrates were randomly demarcated under each plantations. Floor accumulation was collected twice in a year i.e. April and December. The litter components were not separated. The litter was washed oven dried at 70°C, powdered and analysed for N, P, K, Ca and Mg (Jackson, 1973).

Soil microbial studies: 1. Soil samples from the selected sites had been collected randomly and vertically from three depths (viz. 0-10 cam, 10-20 cm and 20-30 cm). A pit was dug down the profile and the soil samples were collected from each range of depths, by inserting a clear sterilised shovel. The samples were collected in sterile polythene bags and brought to the laboratory and freezed until processing.

Christensen (1969) reported that freezing had no significant affect on the prevalent of microfungi in the soil samples.

2. Isolation of microbial population : The soil dilution plate method was followed for the isolation of fungi, bacteria and actinomycetes population of the soil samples. For fungi, Peptone – dextrose rose bengal agar medium (Martin, 1950) supplemented with streptomycin sulphate was used, while for bacteria and actinomycetes the medium used were Nutrient agar and Starch-casein agar (Kuster and Williams, 1964) respectively. For isolation of fungal population, a dilution of 1:1000 and for bacteria and actinomycetes 1:10,000 dilution was used. Three replicate plates were maintained for each set of samples. The plates for fungi was incubated at 25+ - 1°C for 7 days in a BOD incubator. The plates for bacteria and actinomycetes were incubate at 30°C for 24 hours and 7 days respectively. The total number of bacteria and actinomycetes colonies was counted with the help of a bacteriological colony counter. The total number of populations per gram dry soil was calculated by taking into consideration f moisture content and dilution factor. The distribution percentage of relative abundance for fungal species was calculated as follows:

$$\frac{\text{Number of colonies of a particular species}}{\text{Total number of colonies of all the species}} \times 100$$

RESULTS AND DISCUSSION

During the study period, rubber and jarul plantations produced more litter than teak plantation (Table 1). The N content of the litter was more in rubber and jarul than teak and hence, there was more N turn over the former two plantations. P, K, Ca and Mg did not vary between the three litters. There was more silt and clay and less and in the rubber soil than the other two soils (Table 1) The soil moisture content remained higher in rubber than in the other two plantations in the top 30 cms (Table 2). Total N and available P were more in the rubber and jarul soils than the teak soil (Table 2) Organic carbon was significantly more in the rubber soil. The soil fungi, bacteria and actenomycetes populations were comparable in the three soils (Table 3 and 4). The quantitative distribution of microbial populations shows a great fluctuations in number of micro-organ-

Table 1. Potential Litter & Nutrient Turn-over

	Dry wt.of litter (T/ha)	Mean Nutrient Turn-over (kg/ha)				
		N	P	K	Ca	Mg
Rubber	6.8	39.9	8.01	12.01	22.12	19.30
Jarul	6.3	35.90	6.98	16.01	19.72	21.78
Teak	1.4	27.14	7.38	13.21	19.98	16.26
(p=0.05)	2.01	7.41	NS	NS	NS	NS

Some Soil Properties (Summer) (0-15 cm only)

	Sand%	Silt%	Clay%	EC m mhos	CEC cmol(p+)/kg	B.D g/cc	pH
Rubber	52.5	22.5	25.0	71.0	13.54	1.37	4.21
Jarul	65.0	15.0	20.0	37.0	9.70	1.28	4.80
Teak	75.0	12.5	12.0	21.0	6.70	1.42	5.23
CD (p=0.05)	9.4	6.1	5.3	14.3	3.90	NS	0.94

Table 2. Per Cent Soil Moisture in Different Plantations (Summer)

Soil depth (cm)	Rubber	Jarul	Teak	CD (p=0.05)
0-15	25	27	18	2.6
15-30	29	22	22	3.2
30-60	24	20	23	NS
60-90	18	17	23	NS

Soil Nutrient Composition (0-15 cm)

(N and OC in %; others in mg per 100g soil)

	Total N	Av.P	K	Ca	Mg	Org.c
Rubber	0.323	1.02	7.1	4.9	1.30	5.06
Jarul	0.261	1.77	5.2	5.25	1.50	3.26
Teak	0.165	0.38	6.5	7.25	0.85	2.28
CD (p=0.05)	0.11	0.42	NS	1.07	0.33	1.02

isms from one forest to another but they are following an identical trend of distribution. The populations of the surface layer (0-10 cm) soil were always maintaining a higher numbers of populations as compared to lower depths. The microbial populations of the deeper layer soils, however, were always less as compared to the top layer and it decreases with the increase of soil depths. The prevalence of anaerobic conditions and less organic matter at lower depths may be the reasons for low counts of populations (Mishra, 1966). A similar pattern of vertical distribution has also been reported by other workers also (Eicker, 1970; Dadalauri, 1975). Quantitatively, the total numbers of bacteria and actinomycetes are manifold higher than those of fungal population. This may be due to the fact that these populations multiply at a much faster rate as compared to fungal population. Not much changes in bacterial and actinomycetes populations were discerned in all the sites studied, though bacteria were more numerous as compared to actinomycetes.

Table 3. Total No. of Fungi/gm dry soil (x 10^3)

Soil depth (cm)	Rubber	Jarul	Teak	CD (p=0.05)
0-10	41(5.2)	37(1.9)	47(2.3)	6.7
10-20	25(1.5)	18(0.8)	29(0.56)	3.2
20-30	24(1.1)	15(0.3)	18(0.27)	4.7

Total No. of Actinomycetes/gm dry soil (x 10^5)

Soil depth (cm)	Rubber	Jarul	Teak	CD (p=0.05)
0-10	9.4(0.13)	8.8(0.17)	9.0(0.55)	NS
10-20	7.1(0.51)	6.8(0.32)	7.5 (0.62)	NS
20-30	5.0(0.23)	5.5(0.18)	6.0(0.31)	NS

Table 4. Total No. of Bacteria/gm dry soil (x 10^3)

Soil depth (cm)	Rubber	Jarul	Teak	CD (p=0.05)
0-10	10.5(0.45)	10.0(1.01)	10.8(1.21)	NS
10-20	7.5(1.01)	8.3(0.67)	8.4(0.63)	NS
20-30	6.5(0.65)	6.3(0.27)	6.2(0.46)	NS

Presence of Epiphytes on the Tree

	Orchids		Lichens Spagnum moss
Rubber	50(100)	50(100)	50(100)
Jarul	46(92)	10(20)	50(100)
Teak	40(80)	5(10)	49(98)

Relative Abundance of Epiphytes on the Tree

	Orchids	Lichens	Spagnum moss
Rubber	10	10	10
Jarul	0.44	0.44	0.8
Teak	3.44	0.66	4.72

Qualitatively, the fungal species composition of all the sites were found to be identical with a minor variations (data not shown). Appar-

ently, no remarkable differences in the fungal taxa were observed between the soils of rubber plantation and other forest type studied. Gochenaur and Whittingham (1967) observed that species shows very little or no correlation with the above ground vegetation covers. There were a total of 19 species isolated and most of the species belongs to the group of fungi imperfect. Amongst the species Penicillium, Fusarium, Pythium, Cladosporium, filamentous yeast were isolated regularly and was found to be quite dominant. A few species like; Papularia, Geotrichum, Stachybotrys, Alternaria Absidia, Cephalosporium and a sterile mycelia were isolated with a low percentage of relative abundance. No marked variation was noticed in the species composition of all the sites. Bissett and Parkinson (2979) pointed out that for a given community, one or a few species were numerically predominant and may strongly affect the environmental conditions for other species. In general, the fungal flora of soil under all the forest soils was fairly constant qualitatively and contained a few dominant genera. The fungal flora in the same depths at different sites showed similarity, while quantitatively, there was population fluctuations in all the forest types studied. Apparently, different forest types did not seem to have any influence on the microbial composition of the soil. Epiphytes were more abundant on the rubber trees than the other two species (Table 4) There were more number of soil invertebrates beneath the rubber litter than the other two litters (Table 5).

Table 5. Number of insects / sq.ft.

Rubber	35 (3.8)
Jarul	12 (2.1)
Teak	9 (1.9)
CD (p=0.05)	3.7

None of the indicators of ecological health studied here showed any apparent damage due to rubber cultivation.

Certain indicators, in fact, showed some favorable effect due to rubber cultivation.

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