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Comparative evaluation of soil physico-chemical properties under rubber, teak, sal and gamair plantation in south Tripura

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Abstract

Physico- chemical properties of soil under different plantations and surrounding fallow land in South Tripura were compared in the study. Soil was acidic in nature. The soil texture was sandy clay loam in all the sites and coarser fragments dominated the soil separates. Organic carbon content and available nutrients were significantly higher under plantations compared to fallow land. Organic carbon content (1.00%) and available potassium were (5.08 mg/100g) highest under rubber in the surface layer (0-30 cm). Available phosphorus was highest under sal (1.09 mg/100g) in the surface layer. Vertical reduction in available nutrients was observed in all the sites. CEC of soil ranged from 8.62 to 13.39 Cmol (p+)/kg in the surface layer and it was highest under sal. The CEC per unit clay did not show appreciable difference among the sites. The percent base saturation of the soil ranged from 56.01 to 65.90 in the surface layer and 51.36 to 61.96 in the sub surface layer. Ca and Mg dominated the exchange complex followed by K and Na. The divalent: monovalent cations ratios ranged from 6.73-16.00 in the surface layer and 8.25 – 20.33 in the subsurface layer. The Ca:Mg ratios ranged from 1.70 to 2.33 in the surface soil and 1.80 to 3.25 in the subsurface soil.

*Key words: **Hevea brasiliensis***, available nutrients, soil physico-chemical properties, Tripura

Introduction

Tripura is one of the most important rubber growing states in India. An area of 30,270 hectares is under rubber cultivation in the state (Rubber Board, 2006) and is next only to Kerala. Rubber was introduced in Tripura during 1960s by various state government agencies and rubber as a crop for rehabilitation of tribals, to wean them away from the ecologically damaging shifting cultivation was considered in as early as 1970s (Krishnakumar and Rajeswari, 2000). Though the forest department have been using forest species of high timber value viz. sal (*Shorea robusta*), teak (*Tectona grandis*), gamair (*Gmelina arborea*), vast stretches of denuded land still available in the state points to its limited success and various socio-economic factors have been attributed to this. Since its popularisation during late 1980s for rehabilitation of tribals and restoration of denuded land, rubber has occupied a place of pride in the history of ecorestoration in the state of Tripura (Krihnakumar *et al*, 1990a). Though rubber is an introduction from the Amazon rain forest and the tree has all the attributes of a forestry species, still it is not considered as a true forest tree species. Publications available have already proved its worth as a tree of sound ecofriendlyness in the north eastern region of India, however, doubts still prevails in certain corners in the state. Hence an attempt has been made to evaluate the physico-chemical properties of soil under rubber and most commonly used forest tree species in the state.

Materials and Methods

The present study was undertaken at Udaipur, about 50km from Agartala, the capital of Tripura. The area consists of small hillocks with gentle slope. Rubber (*Hevea brasiliensis*) plantation was raised in 1985 with other high value timber forest tree species viz. teak (*Tectona grandis*), sal (*Shorea robusta*) and gamair (*Gmelina arborea*) in the adjoining areas. Fallow land with scant vegetation in the contiguous area was also considered for comparison. The area is situated about 30m above MSL and receives about 2000mm rainfall. The plantations were raised without application of any fertilizer.

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Table 1. Physical properties of soils under different plantations

Site	Soil depth (cm)	Sand (%)	Silt (%)	Clay (%)	Sand/silt ratio	Texture class	Bulk density (kg/m³)	Particle density (kg/m³)	Porosity (%)
Rubber	0-30	52	22	26	2.36	scl	1.32	2.44	45.90
	30-60	54	24	22	2.25	scl	1.38	2.56	43.31
Teak	0-30	52	28	20	1.86	scl	1.35	2.42	42.52
	30-60	50	29	21	1.72	scl	1.38	2.50	40.44
Gamair	0-30	55	23	22	2.39	scl	1.35	2.49	42.15
	30-60	52	24	24	2.17	scl	1.43	2.51	40.28
Sal	0-30	55	20	25	2.75	scl	1.36	2.49	44.25
	30-60	56	20	24	2.80	scl	1.44	2.52	43.15
Fallow land	0-30	55	24	21	2.29	scl	1.40	2.57	42.30
	30-60	56	20	24	2.80	scl	1.48	2.59	41.55
CD (0.05)	0-30	NS	NS	NS	0.58	-	NS	NS	NS
	30-60	NS	5.9	NS	0.77	-	NS	NS	NS

scl: sandy clay loam NS: Not Significant

Five representative soil samples were collected from each of the plantations and the surrounding fallow land for four years starting in the year 2000 at depths of 0-30 and 30-60cms for estimating the physico-chemical properties of soil. Core samples were also used to estimate the bulk density and particle density (Baruah and Borthakur, 1997). Organic carbon, total as well as available NPK and exchangeable cations were determined following standard procedures (Jackson, 1973). Available micronutrients were determined by methods described by Singh et al. (1999). Average of the four years' analytical results has been considered in this study and the same have been subjected to standard statistical method of analysis.

Results and Discussion

Physical properties of the soil from different sites are given in Table 1. Particle distribution of the soils shows homogeneous soil separates and it belongs to sandy clay loam texture in all the sites. Dominance of coarse fragment of soil separate was observed in all the sites. The sand, silt and clay content ranged from 52-56, 20-29 and 20-26 percent in the surface layer (0-30 cm) and 54-56, 20-29 and 21-24 in the sub-surface (30-60 cm) layer respectively. No significant variation in sand, silt and clay content in the surface layer was observed among all the sites. Higher amount of clay content in the surface layer was observed under rubber and it was almost similar to that under sal. Reduction in clay content in the surface layer of the fallow land was observed and it might be due to clay migration (Krishnakumar *et al.*, 1990b).

Bulk density and particle density were less in the surface layer from all the sites compared to subsurface layer. Bulk density in the surface layer ranged from 1.32 -1.40 kg/m³ and in the surface layer it ranged from 1.41-1.48 kg/m³. Particle densities vary from 2.42-2.57 kg/m³ in the surface layer and 2.50-2.59 kg/m³ in the subsurface layer. Porosity in the surface layer ranged from 42.15 to 45.90 percent and in the subsurface layer from 41.55 to 43.31 percent. No significant difference was observed in the bulk density, particle density and porosity among all the sites. Bulk Density and particle density were lowest in the surface layer under rubber and highest under fallow land situation. The values for bulk density and particle density of the soils under teak, gamair and sal were between rubber and fallow land and not much difference was observed among them. Porosity in the surface layer as well as in the subsurface layer was the highest in soils under rubber among all the sites. The lowest porosity was observed in the surface layer under fallow and in the subsurface layer it was observed under gamair plantation. Bulk density, particle density and porosity are mostly affected by soil organic and inorganic fraction, plant root activities and land management practices (Dey and Sehgal, 1987). Krishnakumar *et al* (1990a) reported decline in porosity and increase in bulk density and particle density under rubber and natural forest in Tripura. Mandal *et al.* (2001) attributed the lowering of bulk density in the surface layer to the higher amount of undecomposed organic matter present in the soils under rubber.

Available nutrients in soils from different sites are given in Table 2. Organic carbon content in soil was highest in the surface layer under rubber. Reduction in organic carbon content with depth was observed. All the plantations have shown considerable build up of organic carbon in soil compared to fallow land. Available phosphorus content in surface layer of soil was highest under Teak plantation and lowest in fallow land. Appreciable build up of available phosphorus in the

Table 2. Available nutrients and pH of soils under different plantations

Site	Soil Depth (cm)	OC (%)	P	K	EC (mmhos)	pH(1:2.5)
			mg/100g			
Rubber	0-30	1.00	1.02	5.98	67.38	4.70
	30-60	0.80	0.75	5.00	60.75	4.65
Gamair	0-30	0.89	0.79	4.90	58.74	4.54
	30-60	0.62	0.56	4.30	54.92	4.40
Teak	0-30	0.95	1.09	4.70	60.14	4.62
	30-60	0.76	0.73	4.30	58.22	4.50
Sal	0-30	0.71	0.80	4.25	65.16	4.91
	30-60	0.64	0.69	4.16	61.74	4.44
Fallow land	0-30	0.42	0.33	4.25	63.25	4.50
	30-60	0.37	0.25	4.00	56.48	4.45
CD (0.05)	0-30	0.12	0.16	0.64	NS	NS
	30-60	0.07	0.13	NS	NS	NS

surface layer compared to sub surface layer was observed. Available potassium content in surface layer of soil was highest under rubber plantation among all the sites including fallow land. No significant difference was observed in potassium content among all the sites in the sub surface layer. Horizontal and vertical distribution of soil organic matter, P and K in soils are controlled by soil composition (organic/inorganic matter), plant nutrient recycling and prevailing nutrient management practices (Sharma and Anil Kumar, 2003). Varghese *et al,* (2001) reported total annual leaf fall in rubber plantation ranged from 6.8 to 7.8 t / ha. They also reported that nutrients ranging from 94 - 130 kg N, 5 - 6 kg P, 22 -25 kg K, 106 - 168 kg Ca and 17 - 33 kg Mg were returned to the soil through total litter fall. James *et al* (2002) reported significantly higher amount of organic carbon and available P under rubber compared to Teak and Jarul plantations in Northern West Bengal. Choudhury *et al.* (2001) reported significantly higher amount of available nutrients under rubber compared to jhumed land in Tripura.

Soils from all the sites are highly acidic in nature (Table 2). pH of the surface soil were less acidic then the sub-surface soil. No definite trend was observed in soil pH among sites. Chakrabarty *et al.* (1980) reported significant effect of rainfall on soil pH. They observed that soils from the areas receiving high amount of annual rainfall (2000-3000mm) were acidic to neutral whereas the areas receiving annual rainfall less than 1200 mm annually were alkaline in reaction No significant difference was observed in EC of soil in surface as well as the sub surface layers among all the sites.

Cation exchange capacity of the soil ranged from 8.62 to 13.39 Cmol (p+)/kg in the surface layer and 9.20 to 12.46 Cmol (p+)/kg (Table 3). It was highest in soils under Sal plantation in the surface layer and lower under fallow land. Among the plantations teak showed lowest CEC. CEC is mostly governed by the clay content, surface characteristics of the clay and organic matter content of the soil (Gupta and Tripathi, 1992). Although, CEC of the soil under different plantations were significantly higher than the fallow land, its variation

Table 3. Exchangeable ions of soils under different plantations

Site	Soil depth (cm)	CEC	Ca^{2+}	Mg^{2+}	K^{+}	Na^{+}	PBS*	Ca^{2+}/Mg^{2+} ratio	CEC/Clay ratio	$(Ca^{2+}+Mg^{2+})/(K^{+}+Na^{+})$ ratio
				Cmol(p+)/kg						
Rubber	0-30	13.14	5.4	2.6	0.4	0.2	65.45	2.08	0.51	13.33
	30-60	12.46	4.1	2.0	0.2	0.1	51.36	2.05	0.57	20.33
Teak	0-30	11.35	4.4	1.9	0.3	0.1	65.90	2.33	0.57	15.75
	30-60	10.90	3.9	1.7	0.2	0.1	52.29	2.29	0.52	18.66
Gamair	0-30	12.07	4.1	2.0	0.6	0.2	57.67	2.05	0.55	7.63
	30-60	12.65	4.9	2.1	0.4	0.2	52.17	2.33	0.53	11.67
Sal	0-30	13.39	4.3	2.1	0.8	0.3	56.01	2.05	0.54	5.81
	30-60	11.74	4.6	2.0	0.5	0.3	63.03	2.30	0.49	8.25
Fallow land	0-30	8.62	3.1	1.7	0.2	0.1	59.16	1.82	0.41	16.00
	30-60	9.20	3.7	1.6	0.3	0.1	61.96	2.31	0.38	13.25
CD (0.05)	0-30	3.02	1.4	0.62	0.28	0.09	8.13	0.45	0.12	5.01
	30-60	2.81	1.1	0.45	0.16	0.07	10.24	0.29	0.16	6.24

*PBS: percent base saturation

among different plantation was not significant. The CEC per unit clay did not show significant difference among the sites under plantations and no definite trend was observed in the values from different depths. Sharma and Anil Kumar (2003) reported the range of the values for CEC:Clay ratio as 0.39 to 0.59 and attributed it to the mixed mineralogy of the soil. The percent base saturation of the soil ranged from 56.01 to 65.90 percent in the surface layer and 51.36 to 63.03 percent in the sub-surface layer. Exchangeable cations showed higher values in the surface layer compared to the subsurface layer. Ca^{2+} and Mg^{2+} dominated the exchange complex followed by K^+ and Na^+ and the divalent:monovalent ratio of the cations also reflects the same. Ca:Mg ratio ranged from 1.82 to 2.33 in the surface soil and 2.05 to 2.33 in the subsurface soil. As per Gangopadhyay *et al.* (1989), vertical difference in Ca/Mg ratio of the soil indicates vegetational effect on soil formation. Higher rate of reduction of Ca compared to the proportional amount of the Mg as reflected by the lowering of Ca:Mg in the surface layer indicates greater uptake by the plants from the surface layer.

Table 4. DTPA extractable micronutrient status of soils under different plantations

Species	Soil Depth (cm)	Cu (ppm)	Fe (ppm)	Mn (ppm)	Zn (ppm)
Rubber	0-30	0.59	25.17	10.30	0.38
	30-60	0.40	15.20	5.15	0.39
Gamair	0-30	0.47	28.20	12.49	0.20
	30-60	0.42	16.37	4.57	0.22
Teak	0-30	0.57	24.95	12.30	0.68
	30-60	0.48	15.58	8.12	0.55
Sal	0-30	0.23	25.58	10.89	0.74
	30-60	0.22	15.60	10.21	0.82
Barren land	0-30	0.55	29.48	10.70	0.90
	30-60	0.40	16.43	6.83	0.64
CD (0.05)	0-30	0.21	NS	NS	0.31
	30-60	0.18	NS	2.58	0.22

No definite trend was observed in distribution in DTPA extractable soil micronutrients (Table 4). Significant reduction in copper was observed under sal in surface as well as subsurface layer. No significant difference was observed in Fe and Mn in soils from all the sites in the surface later. Significant reduction in Zn was observed under rubber and gamair in both the layers compared to sal and fallow land. Mandal *et al.* (2001) reported marginal decrease in DTPA extractable micronutrients in soils under rubber compared to fallow land.

It was quite evident from the study that rubber plantation improve the physico-chemical properties of soil in comparison to the fallow land and on par or even better in some of the parameters studied than the plantation forest species commonly raised in the state. Most of the physical and chemical properties studied here showed beneficial effect of rubber plantation in surface as well as subsurface layer. High accumulation of litter and recycling of considerable amount of nutrients as also evident from many previous studies (Eappen *et al*, 2005; Krishnakumar *et al*, 1998a), also suggest the suitability of rubber plantation in Tripura.

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