Indian J. Nat. Rubb. Res. 2 (2) : 91–98, 1989

DISTRIBUTION OF EXCHANGEABLE AND TOTAL MANGANESE IN RUBBER GROWING REGIONS OF INDIA

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Karthikakutty Amma, M., Aleyamma Augusthy, Krishnakumar, V. and Mathew, M. (1989). Distribution of exchangeable and total manganese in rubber growing regions of India. Indian J. Nat. Rubb. Res. 2 (2): 91–98.

Profiles were exposed in the conventional rubber growing areas in Kanyakumari, Kottayam, Trichur and Calicut and in the non-conventional region in Dapchari, Maharashtra. Soil samples were collected horizon-wise from these profiles and analysed for mechanical composition, organic carbon, pH, total iron, total manganese and exchangeable manganese. Correlations were worked out between the two forms of manganese and physico-chemical properties of the soil. It was observed that the total as well as the available manganese are high in Dapchari compared to other regions studied. The total manganese was found to be significantly correlated with the exchangeable manganese, fine sand, silt and total iron. The high content of manganese (1373 ppm) in the soil of Dapchari may not cause any adverse effect on growth of rubber, as rubber is found to be growing satisfactorily in soils having similar manganese status in other rubber growing countries.

Key words.—Traditional and non-traditional rubber growing regions, Total manganese, Exchangeable manganese, Soil mechanical composition, Correlations, India.

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INTRODUCTION

Manganese is one of the essential plant nutrients required in traces and its deficiency leads to chlorosis and, in extreme cases, drying of growing points. The essentiality of this element was established as early as 1922 (Mc Hargue, 1922). Manganese is closely connected with the synthesis of chlorophyll and its deficiency symptom, namely appearance of chlorotic mottling leaving the veins and midrib green, is also shown by iron deficient plants. In *Hevea*, manganese and magnesium are inter-related, high manganese content inducing magnesium deficiency (Bolle Jones, 1957). In young unbranched rubber, deficiency symptoms appear on the lower and middle stories. In acute cases upper stories are also found affected. In branched trees, deficiency symptoms are seen in shade leaves on low branches (Shorrocks, 1964).

Manganese is found to have an important role in the quality of raw rubber, as well as rubber products. A high amount of manganese in manufactured rubber promotes oxidation and hence the tolerance limit is fixed as 10 ppm in sheet rubber (Anon, 1957). Rubber trees growing in soils containing high manganese may absorb large quantity of this element and thus deteriorate the quality of latex.

In soil, manganese occurs as water soluble, exchangeable and higher oxides of manganese and there exists an equilibrium among these forms, depending on the nature of soils. The quantity present in soil is found to be dependent on the geology of the region, reaction of the soil and oxidation-reduction potentials. In Malaysia and Sri Lanka, limestone derived soils are reported to contain more manganese than granite derived soils (Akhurst, 1933; Kalpage & Silva, 1968).

Eventhough extensive studies have been conducted on manganese status in Indian soils (Biswas, 1953; Randhawa & Nijhawan, 1961; Gopalaswamy & Soundararajan, 1969), our knowledge on the distribution of this element in rubber growing soils is limited. Hence, the present project was taken up to study the distribution pattern of different forms of manganese in rubber growing soils of India and to correlate it with some important physico-chemical properties of the soil.

MATERIALS AND METHODS

Six soil profiles, four (Kanyakumari, Kottayam, Trichur and Calicut) in the major agroclimatic regions of south India and two (Dapchari) from Maharashtra were taken for the present study. Details regarding the location and the nature of the soil observed in these locations are given in Table 1. The four profiles of South India represent the conventional rubber growing region, whereas Dapchari represents a non-conventional rubber growing tract where rubber cultivation was started recently.

Soil samples were collected from the different horizons of each profile, air dried and passed through 2 mm seive. The pH of soil was determined using a pH meter in a soil: water ratio of 1 : 2.5. Organic carbon was estimated by the Walkley and Black method (Jackson, 1958). Mechanical composition of soil was estimated by the international pipette method (Piper, 1950). Total iron was estimated as per the method described by Black (1965). Total and exchangeable manganese were estimated by the periodate method (Wilhard & Greathouse, 1917).

Table 1. **Locations of study and types of soil**

Region	Name of Estate	Type of soil
Kanyakumari	New Ambadi	Alluvium/laterite
Kottayam	Mundakayam	Brown hydromorphic
Trichur	Pudukad	Brown hydromorphic
Calicut	Kinalur	Laterite
Maharashtra	Regional Research Station, Dapchari	Laterite

RESULTS AND DISCUSSION

Data on total rainfall, total number of rainy days and temperature recorded from the regions under investigation are given in Table 2. For temperature, not much variation was observed either in the mean, minimum or maximum values. However, in Dapchari a maximum temperature of 40-42°C was recorded during April–May, for four or five days. In winter the minimum temperature in this region came down to 11–12°C. However, the mean maximum and minimum temperatures experienced in this region was 30.4 and 22.3°C, respectively. Diurnal variation was also more marked in this region. Maximum quantity of rainfall was found to be obtained in Calicut region and the least in Kanyakumari region. Compared to that in Kottayam, Trichur and Calicut regions, the rainfall obtained in Dapchari was less and that too restricted to four months. Number of rainy days was also less in Dapchari.

Data on mechanical composition of the soils from the different horizons of the profile

Table 2. **Climatic parameters of different regions**

Region	Annual average temperature (°C)			Total rainfall (mm)	Number of rainy days
	Maximum	Minimum	Mean		
Kanyakumari	31.1	24.3	27.7	1856.3	100.8
Kottayam	30.8	22.4	26.6	3171.1	139.2
Trichur	32.4	23.3	27.9	3159.4	124.1
Calicut	30.9	23.7	27.3	4134.4	120.8
Dapchari	30.4	22.3	26.4	2616.1	72.5

are furnished in Table 3. Data on total and exchangeable manganese, total iron, organic carbon and pH are given in Table 4. The correlation coefficients worked out between manganese fractions and soil physico-chemical properties are given in Table 5.

The total manganese content in the soil was found to vary from 143 ppm in the lowest horizon in Pudukad to 1919 ppm in the second horizon in the profile exposed in location A in Dapchari. The average content of total manganese in the soils from Kanyakumari, Kottayam, Trichur and Calicut regions was 496 ppm, while it was 1373 ppm in Dapchari, Maharashtra region. According to Swaine (1955), total manganese status in soil is reported to range from 200–3000 ppm. In an earlier report Vinogradov (1938) had reported 600 ppm as average value for total manganese content in soil. As per this limit, soils in the conventional rubber growing region can be classified as low in manganese content, except for the soil of Calicut (Kinalur) region. In this region the upper three horizons contained 714 ppm of manganese. The high manganese content in this soil can be attributed to the highly weathered laterite soil with igneous rocks as parent material (Iyer & Nair, 1985). In Kanyakumari (Kulasekharam), the soil is alluvium/laterite (Manickam & Mosi, 1985) and the upper horizons contained 571 ppm total manganese compared to the high value observed at Calicut. Soil of Trichur (Pudukad) and Kottayam (Mundakayam) are classified as brown hydromorphic (Iyer & Nair, 1985) indicating that these soils are also undergoing the process of weathering and hence only lower total manganese values were obtained in these soils compared to highly weathered laterite soils. In Dapchari for the two profiles taken, the total manganese varied from 703 to 1919 ppm.

The high manganese content in Dapchari can be attributed to the parent material, the geological formation of which is an extension of Dharwar system rich in manganiferous ores (Wadia, 1919).

In addition to the parent material, the pH contributes for difference in the distribution of manganese. A positive correlation (r = 0.8151**) was found to exist between pH and total manganese (Fig. 1). Increase in manganese content with increase in pH had been observed in the rubber growing soils of Malaysia (Akhurst, 1933) and Sri Lanka (Kalpage & Silva, 1968). Under acidic conditions manganese becomes more soluble and is lost from the soil during heavy rainfall in tropical regions (Shorrocks, 1964). Data presented in Table 3 indicate that coarse fractions are more

Table 3. **Mechanical composition (%)**

Region & location	Depth cm	Coarse sand	Fine sand	Silt	Clay
Kanyakumari, Kulasekharam					
	0 - 30.0	44.55	7.80	6.13	34.13
	30.0 - 68.8	37.20	5.50	5.02	45.53
Kottayam, Mundakayam					
	0 - 37.5	37.70	14.90	8.88	18.18
	37.5 - 62.5	48.05	10.80	8.60	21.80
Trichur, Pudukad					
	0 - 12.5	48.00	10.90	7.28	24.80
	12.5 - 25.0	28.95	12.30	7.88	41.08
	25.0 - 70.5	33.00	9.10	3.73	39.25
	70.5 - 105.0	44.00	10.40	5.65	28.50
Calicut, Kinālur					
	0 - 10.0	35.00	8.20	11.60	39.68
	10.0 - 17.5	33.00	7.20	9.00	42.40
	17.5 - 47.5	36.45	7.10	8.88	40.05
	47.5 - 102.5	37.40	7.40	9.55	40.23
Maharashtra, Dapchari					
Location A	0 - 10.0	6.00	19.84	26.78	23.14
	10.0 - 20.0	5.95	20.98	28.60	36.50
	20.0 - 60.0	6.99	18.19	47.32	24.13
	60.0 - 105.0	9.18	21.60	21.08	29.50
	105.0 - 120.0	7.17	12.24	14.25	27.35
Location B	0 - 12.0	7.17	14.94	34.68	23.58
	32.0 - 42.0	1.42	11.07	18.93	59.73
	42.0 - 60.0	3.35	13.55	18.18	47.58
	60.0 - 100.0	4.42	10.94	18.90	32.00
	100.0 - 114.0	0.39	12.10	14.95	24.70

predominant in the soils of traditional region when compared to the soil of Dapchari region. Generally fine soils have more of total manganese than coarse textured soils (Yadav & Kalra, 1964). Significant positive correlation was found to exist between silt and total manganese ($r = 0.7940^{**}$). Fine sand was also found to be significantly in-

Table 4. **Total and exchangeable manganese, total iron, organic carbon and pH**

Region & location	Depth cm	Total manganese		Exchangeable manganese		Total iron (ppm)	Organic carbon (%)	pH
		ppm	Average	ppm	Average			
Kanyakumari, Kulasekharam								
	0 – 30.0	571.4		1.4		10500	0.84	4.9
	30.0 – 68.8	285.7		2.7		10200	0.66	5.0
Kottayam, Mundakayam								
	0 – 37.5	428.5		1.4		2340	1.68	5.2
	37.5 – 62.5	285.7		1.4		7500	1.26	4.8
Trichur, Pudukad								
	0 – 12.5	571.4	496.4	2.8	2.5	6870	2.16	5.1
	12.5 – 25.0	571.4		1.4		6150	1.53	5.3
	25.0 – 70.5	285.7		4.2		6690	0.93	5.0
	70.5 –105.0	142.8		5.7		6145	0.90	5.1
Calicut, Kinalur								
	0 – 10.0	714.2		2.8		7350	2.49	5.2
	10.0 – 17.5	714.2		2.8		8250	1.62	4.9
	17.5 – 47.5	714.2		2.8		9450	1.32	5.0
	47.5 –102.5	571.4		1.4		9560	1.02	5.2
Maharashtra, Dapchari								
Location A	0 – 10.0	1729.7		14.8		15500	1.47	6.0
	10.0 – 20.0	1918.9		4.0		11288	1.31	6.2
	20.0 – 60.0	1432.4		4.7		15060	0.99	6.1
	60.0 – 80.0	1013.5		4.0		12960	0.45	6.4
	80.0 –105.0	1270.3		5.3		13380	0.29	6.5
	105.0 –120.0	1283.7		3.2		12900	0.24	6.3
Location B	0 – 12.0	1824.3	1371.4	7.2	6.0	16470	1.31	6.2
	12.0 – 42.0	1297.3		4.3		16080	0.53	6.3
	42.0 – 60.0	1297.3		6.0		15060	0.45	6.1
	60.0 –100.0	702.7		6.2		11250	0.20	6.2
	100.0 –114.0	1337.8		6.5		14310	0.29	6.2

Table 5. **Correlation coefficients of manganese fractions with soil mechanical composition, organic carbon, pH and total iron.**

x	y	r
Fine sand	Total manganese	0.6439**
Silt	Total manganese	0.7940**
Clay	Total manganese	-0.3072
Fine sand	Exchangeable manganese	0.4980*
Silt	Exchangeable manganese	0.6046*
Clay	Exchangeable manganese	-0.2023
Organic carbon	Total manganese	-0.1819
Organic carbon	Exchangeable manganese	-0.1695
pH	Exchangeable manganese	0.5139*
pH	Total manganese	0.8151**
Total iron	Total manganese	0.4339*
Total iron	Exchangeable manganese	0.5487*
Exchangeable manganese	Total manganese	0.5666**

* Significant at 5% level
** Significant at 1% level

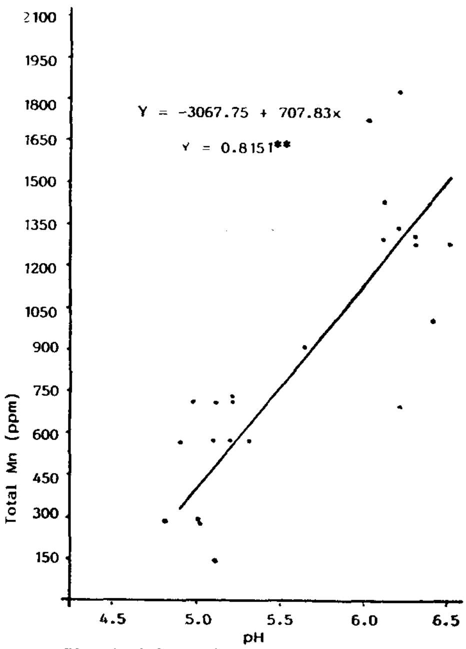

Fig. 1. Relation between pH and Total Mn.

fluencing the total manganese content (Fig. 2). Regarding distribution of total manganese a decrease in the total manganese content with depth could be observed. However, in the profiles taken in Kinalur and Pudukad, consistent values were obtained for the upper horizons, probably due to the highly weathered nature of these soils. In general no consistent pattern is observable in distribution of total manganese in the different horizons. In studies conducted in Punjab soil also, no definite pattern in the distribution of total manganese was reported (Randhawa & Nijhawan, 1961). The total manganese content was found to be positively correlated with the total iron (r=0.4339*). The iron content varied from 2340 ppm in the soil of Mundakayam to 16470 ppm in the soil of Dapchari.

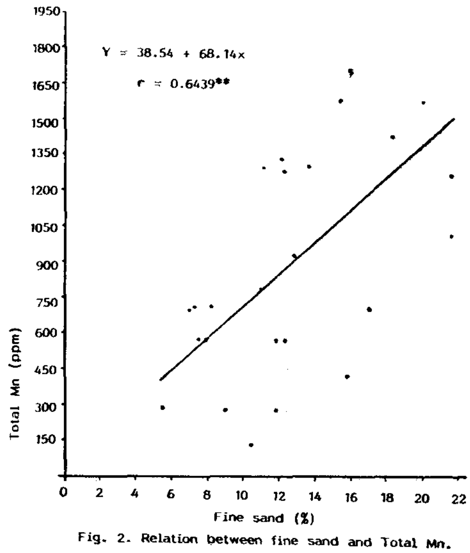

Fig. 2. Relation between fine sand and Total Mn.

The exchangeable manganese content in the soil was very low compared to total manganese, the values ranging from 1.4 to 14.8 ppm. The highest values of exchangeable manganese were recorded for the two profiles in Dapchari and the lowest for soil of Mundakayam. In rubber growing soils of Sri Lanka exchangeable manganese content was reported to vary from 0.7

to 100 ppm and that the high content of manganese was not causing any adverse effect on rubber. Exchangeable manganese is found to be significantly correlated with total manganese (r = 0.5666**). With pH also, exchangeable manganese is significantly correlated (r = 0.5139*, Fig. 3) indicating

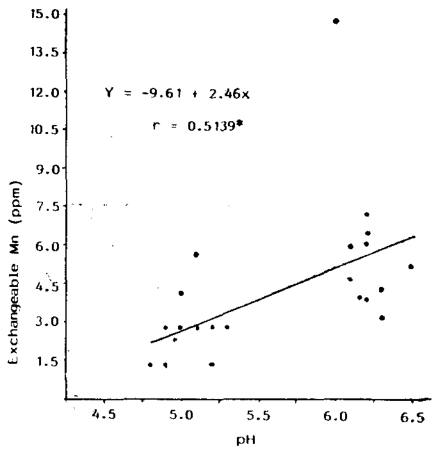

Fig. 3 Relation between pH and Exchangeable Mn.

that high acidity may induce manganese deficiency under the prevailing climatic conditions. For normal growth of plants, it is reported that at least 3 ppm of exchangeable manganese should be present in the soil (Steenbjerb, 1935). Since exchangeable manganese content in the conventional rubber growing soils is less than 3 ppm in most cases the plants may respond to manganese application, eventhough apparent deficiency symptoms are not exhibited. As in the case of total manganese, fine sand fraction in soil is found to be significantly correlated with exchangeable manganese (r = 0.4980*, Fig. 4). No consistent pattern is observed in the distribution pattern of exchangeable manganese down the profile also. With organic carbon and manganese content of soil, no significant correlation was obtained. From the present investigation, it can be concluded that in the soils selected for the present study the manganese content is not

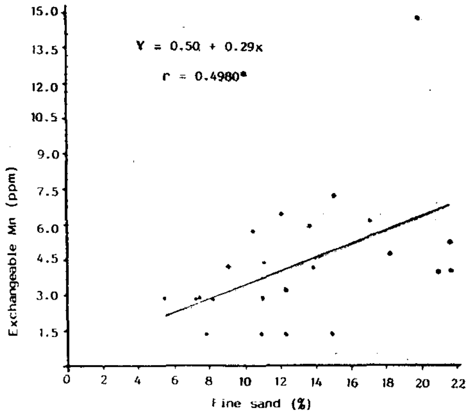

Fig. 4. Relation between fine sand and Exchangeable Mn.

high to cause any manganese toxicity in rubber. The possibility for a high content of manganese in products manufactured out of rubber obtained from these areas is also quite unlikely.

ACKNOWLEDGEMENT

The authors are thankful to Dr. M. R. Sethuraj, Director of Research, for the encouragement given throughout the course of this investigation.

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