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STATUS OF DTPA-EXTRACTABLE MICRONUTRIENTS IN RUBBER GROWING SOILS OF TRIPURA

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The DTPA extractable cationic micronutrients and their relationship with some important soil properties, representing major rubber growing soils of Tripura were investigated. In general, the rubber soils of Tripura were red lateritic, sandy loam or sandy clay loam in texture and acidic in reaction. Micronutrient cations, *viz.* Mn, Fe, Cu and Zn, ranged from 0.62-37.6, 6.1-42.2, 0.25-2.56 and 0.18-6.56 mg/kg soil, respectively. The availability of these micronutrients was found higher in top soil than that in subsoil. All the micronutrients showed significant negative correlation with soil pH indicating that their availability is largely influenced by acidic nature of the soil. Mn, Cu and Zn showed positive and significant relationship with organic carbon and clay content of soil, suggesting that their availability is high and is controlled by these two soil components. Regression analyses for DTPA-Zn revealed that majority of available zinc was organically bound. Fe showed positive and significant relationship with clay and CEC of soil, indicating that availability of Fe is largely controlled by inorganic minerals in the soil. Considering the critical limits of soil micronutrients, the rubber growing soils of Tripura were well supplied with DTPA extractable micronutrients.

Keywords: DTPA-micronutrients, *Hevea brasiliensis*, Rubber-soil

INTRODUCTION

Influence of micronutrients in natural rubber (*Hevea brasiliensis*) plantation was documented by Jones (1954). Though micronutrients are required only in small quantities, their deficiency in soil affects the growth and yield significantly. Increased cropping intensity coupled with continued use of high analysis fertilizer often leads to deficiency of micronutrients in soil. In traditional rubber growing areas (Kerala and Kanyakumari district of Tamil Nadu), zinc (Zn) deficiency was reported by Joseph *et al.* (1995). In north-eastern region of India, deficiency in micronutrients, particularly Zn was reported by many workers (Satisha *et al.*, 2000; Das and Talukdar, 2003; Barua, 2006).

In Tripura, around 46,500 ha land is brought under rubber cultivation till 2008-09 of which around 23,000 ha is under mature plantation. The soils of Tripura are highly weathered and poor in nutrient content (Chaudhury *et al.*, 2001). Intense leaching due to high rainfall in the area causes loss of bases and soil nutrients leading to soil acidity. Therefore, chances of micronutrient deficiency in these soils could

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not be ruled out. Though the Rubber Research Institute of India is offering discriminatory fertilizer application to rubber growers based on soil and leaf analysis, micronutrients are not included in the prescription.

Iron (Fe) is one of the micronutrients necessary for the maintenance of chlorophyll in plants and an essential component of many heme and non-heme enzymes and carriers. Manganese (Mn) deficiency of plant leads to yellowing of leaves with band of green tissue outlining the midrib and main veins. Deficiency of Zn causes interveinal chlorosis of leaves, reduction in leaf lamina resulting in curling of leaves and its effect is much more pronounced for young rubber plants. Zn deficiency also causes reduction in yield and quality of the produce (Das, 2000). Thus, micronutrients play a vital role for the growth and development of crops. In the neighbouring states of Tripura, *viz.* Assam and Meghalaya, a widespread Zn deficiency (34-57 %) was reported by Singh and Saha (1995). In Meghalaya, Mn deficiency was also high (23%). Availability of these micronutrients is, however, influenced by their distribution in soil and other physico-chemical properties (Datta and Ram, 1993; Nayak *et al.*, 2000; Venkatesh, *et al.*, 2003). Thus, knowledge on status of micronutrients and their relationship with soil properties will be helpful in understanding the inherent capacity of soil to supply these nutrients. With this aim in view, the present study was undertaken to evaluate the status of available micronutrients in rubber soils of Tripura.

MATERIALS AND METHODS

During the period 2003-06, 2450 soil samples were collected from of 0-30 cm (top soil) and 30-60 cm (subsoil) depths and they were tested to ascertain the fertility status of the soils for offering discriminatory fertilizer recommendations to rubber growers in Tripura. In general, rubber soils of Tripura are red lateritic, sandy loam or sandy clay loam in texture and acidic in reaction. Rubber is mainly cultivated in residual hills and uplands *(tillas)* and in some areas in valleys *(lunga)*. Most of these soils were once subjected to shifting cultivation. All the above samples were collected from three districts of Tripura, *viz.* West, South and North Tripura and from these populations, 212 soil samples having variation in pH, organic carbon (^{0}C) and clay content were selected for this study. Out of these 212 samples, 74 (34.9%) belonged to West, 98 (46.2%) belonged to South and 40 (18.8%) belonged to North Tripura. These soil samples represented the rubber growing tracts of Tripura.

Physico-chemical properties of these soils were determined by standard analytical methods as described by Singh *et al.* (1999). Mechanical analysis of soil was done by Buoyoucous hydrometer method; OC by Walkley-Black titration method; available phosphorus by Bray's method and available potassium by flame photometric method. Diethylene-triamine-penta acetic acid (DTPA) was used as the common extractant for the determination of available micronutrients, *viz.* Mn, Fe, Cu and Zn, following the procedure given by Lindsay and Norvell (1978). They were estimated by atomic absorption spectrophotometer. Total concentration of these micronutrients in soil size fractions was determined by X-Ray Fluorescence (XRF) techniques. For XRF analysis, accurately weighed 7 g of flux (35.0% Li-Borate and 64.7% Li-Metaborate) and 0.7 g of finely powdered sand/silt/clay were mixed gently in a platinum crucible and heated in a furnace at a temperature of 1050 °C for 45-60 min to make an amorphous glass like bead (Jones, 1982). The critical soil values for Mn, Fe, Cu and Zn are considered as 3.1, 4.5, 0.21 and 0.66 mg/kg, respectively (Follet and Lindsay, 1970). The influence of soil properties on DTPA-extractable Mn, Fe, Cu and Zn was evaluated through simple correlation studies.

RESULTS AND DISCUSSION

Soil properties

The data pertaining to physico-chemical properties of soil (Table 1) revealed that sand was the dominant fraction in soil and it ranged from 24.8 to 80.1% in top soil and 29.7 to 72.5% in subsoil. The corresponding values for silt were 12.5 to 37.8 and 15.2 to 39.7%, respectively. In top soil, clay ranged from 10.1 to 40% with a mean value of 22.4 and in subsoil, it varied from 12.5 to 42.6% with a mean value of 26.6%. A wide variation in clay content of these soils (CV = 21.8-24.3%) was also observed. An increase in clay content in subsoil was recorded in comparison to top soil. In general, rubber soils were found to be sandy loam or sandy clay loam in texture. The variation in soil pH (CV= 3.5-5.2%) was not so pronounced because of its narrow range among the soils studied. Soil pH varied from 4.11 to 5.62 in top soil and 4.31 to 5.82 in subsoil. Surface soils were more acidic than subsoil which may be due to relatively higher organic matter content in the former. CEC of the soils was low and ranged from 5.4 to 11.3 cmol/kg with a mean value of 8.3 in top soil and 4.1 to 9.6 cmol/kg with a mean value of 6.3 in subsoil. The poor CEC could be attributed to highly weathered nature of soils that was prevailing in this region.

Table 2. **Concentration of Mn, Fe, Cu and Zn in soil-size fractions (average of six samples)**

	Mn (ppm)	Fe (%)	Cu (ppm)	Zn (ppm)
Sand	-	0.21	-	-
Silt	399	0.52	21	24
Clay	640	1.75	54	201

XRF analysis of sand, slit and clay (Table 2) showed that sand portion of soil did not contain any Mn, Cu and Zn. Major contribution for these micronutrients was coming from clay and silt indicating that principal minerals of the said three nutrients are present in these two fractions of soil. Soils containing higher amount finer fractions of soil have more power for the nutrient holding capacity than coarse- textured soil. However, all the three soil-size fractions contained appreciable amount of Fe in these soils.

Table 1. **Physico- chemical properties of rubber growing soils of Tripura**

	0-30 cm			30-60 cm		
	Range	Mean	SD	Range	Mean	SD
Sand (%)	24.80 - 80.10	52.50	8.92	29.70-72.50	48.20	9.48
Silt (%)	12.50 - 37.80	26.10	4.03	15.20-39.70	24.70	5.68
Clay (%)	10.10 - 40.00	22.40	5.45	12.50-42.60	26.60	5.80
pH	4.11 - 5.62	4.70	0.17	4.31 - 5.82	4.75	0.25
OC (%)	0.46 - 1.56	0.91	0.16	0.34 -0.98	0.64	0.20
CEC (cmol/kg)	5.40 - 11.30	8.30	1.22	4.10 - 9.60	6.30	0.78

Table 3. **Status of DTPA-extractable Mn, Fe, Cu and Zn (mg/ kg) in rubber growing soils of Tripura**

	0-30 cm			30-60 cm		
	Range	Mean	SD	Range	Mean	SD
Mn	0.86 - 37.61	12.81	2.11	0.62 -27.80	9.56	4.71
Fe	6.84 - 62.12	34.24	5.77	6.19 -45.63	24.24	4.34
Cu	0.28 - 2.56	0.72	0.34	0.25 - 1.71	0.58	0.23
Zn	0.24 - 6.56	1.25	1.05	0.18 - 4.21	1.02	0.82

DTPA-Mn

DTPA-extractable Mn status (Table 3) for the top soil ranged from 0.86 to 37.61 mg/kg with a mean value of 12.81 mg/kg and in subsoil it ranged from 0.62 to 27.8 mg/kg with a mean value of 9.56 mg/kg. The wide variation in available Mn values was also observed by Joseph *et al.* (1995) in traditional rubber growing soils of Kerala as well. Considering 2 mg/kg as the threshold value for DTPA-extractable Mn in acid soil (Takker *et al.*, 1989), only 4.2% soils was found deficient in available Mn among the soils tested. Soils with pH less than 5.5 may contain a large amount of water soluble and exchangeable manganese (Mn^{2+}). With increasing soil pH, Mn^{2+} is converted to its insoluble oxides (Mn^{3+} and Mn^{4+}) which are less available to plants. A significant and negative correlation between Mn and soil pH also supported the above fact. Organic carbon and clay content of soil were significantly correlated with DTPA-Mn. Divalent Mn was absorbed in clay minerals and in soil solution. Mn is mostly present as organic–complexes. Soil pH, organic matter and microbial activity influenced the increased concentration of Mn in soil solution as described by Das (2000).

DTPA-Fe

A wide variation in DTPA-extractable Fe was observed among the soils studied (Table 3). In top soil, Fe ranged from 6.84-62.12 mg/kg with mean value of 34.24 and in subsoil it ranged from 6.19 to 45.63 mg/kg with mean value 24.24. Concentration of Fe was found higher in top soil than subsoil. The relatively lower pH in top soil favoured more extraction of Fe (Borah, 1997). Taking 4.5 mg/kg as the threshold value for iron, all the soils were sufficient in DTPA-extractable Fe. Statistical analysis revealed that Fe was significantly but negatively correlated with pH of the soil whereas its availability was positively and significantly correlated with clay and CEC of soil. These findings suggested that at lower pH, higher amount of Fe was available in soil solution and with increase in pH, soluble Fe became insoluble due to oxidation and mostly found in soil as free ironoxide (Mandal and Mandal, 1997). DTPA-Fe showed a positive correlation with OC; however, its significant correlation with clay and CEC (Table 4) suggested that extractability of Fe is significantly influenced

Table 4. **Correlation between micronutrients and some soil properties**

	Silt	Clay	pH	OC	CEC
Mn	0.082	0.465 *	-0.414 *	0.478 *	0.092
Fe	0.352 *	0 .617 **	-0.342 *	0.208	0.524 **
Cu	0.178	0.135	-0.347 *	0.437 *	0.114
Zn	0.225	0.312 *	-0.355 *	0.582 **	0.145

*Significant at P≤ 0.05 level
**Significant at P≤ 0.01 level

by clay and inorganic minerals present in these soils. The higher amount of Fe (1.75%) present in clay fractions of soil also supported the above fact.

DTPA-Cu

DTPA-extractable Cu ranged from 0.28 to 2.56 mg/kg in top soil and 0.25 to 1.71 mg/kg (Table 3) in subsoil. Considering 0.2 mg/kg as the critical limit for Cu, these soils showed sufficiency in available Cu. DTPA-Cu was significantly and positively correlated with OC and significantly and negatively with pH. In soil matrix, Cu was held by clay particles as easily exchangeable form. Analysis of soil size fractions revealed that concentration of Cu was higher in finer fractions of soil. Organically bound Cu was the main source for DTPA-extractable Cu. Decomposition of OM also favoured the higher availability of Cu (Das, 2000). Therefore, it was evident that at low pH, extraction of Cu by DTPA was mainly from OM and finer fractions of soil. In Tripura, application of Cu-based fungicide in rubber plantation is not undertaken and therefore, its addition to soil through fungicide application does not take place.

DTPA-Zn

Leaving aside 14 samples (8.7%), DTPA-extractable Zn was found above critical value of 0.6 mg/kg in these soils (Table 3). It ranged from 0.24 to 6.56 mg/kg in top soil with a mean value of 1.25 and 0.18 to 4.21 mg/kg in subsoil with a mean value of 1.02. Available Zn was significantly and positively correlated with OC content of soil and negatively with pH. The significant negative correlation with pH indicated that amount of DTPA-Zn decreased with rise in soil pH. At low pH, Zn^{2+} may present in exchange site of clay but at higher pH, availability of Zn was mainly controlled by pH-dependent inorganic equilibrium phase of soil and availability of Zn was thus restricted. DTPA-Zn was also found significantly and negatively correlated with DTPA-Fe (r=0.42*). This antagonistic relationship between Zn and Fe may lead to disorder of zinc-nutrition of soil in the long-run (Datta and Ram, 1993). Considering the importance of zinc nutrition to rubber plants in acid soils as reported (Joseph *et al.*, 1995), multiple regression analysis was done for DTPA-Zn with important soil properties. Result showed that 82% variation in DTPA-extractable Zn in soil was due to combined effect of pH, OC, CEC and clay (Equation I). The step down regression analysis (Equations II – IV) also revealed that 59% variability in DTPA-extractable Zn was due to OC alone indicating that a large amount of Zn was organically bound.

DTPA-Zn = 7.8 - 6.5 pH + 12.4 OC+7.2 CEC + 8.2 clay with R^2 = 0.82....(Equation I)

DTPA-Zn = 9.4 - 3.6 pH + 9.8 OC + 10.2 clay with R^2 = 0.72....(Equation II)

DTPA-Zn = 17.5 - 3.2 pH + 8.6 OC with R^2 = 0.68.... (Equation III)

DTPA-Zn = 8.5 + 17.2 OC with R^2 = 0.59 .... (Equation IV)

Therefore, application of organic matter in addition to fertilizers will be beneficial for maintaining Zn-availability for rubber in Tripura.

CONCLUSION

The soils in the non-traditional rubber growing tract of Tripura are acidic in nature with low to medium organic carbon content.

Rubber soils are predominantly sandy clay loam in texture. Analysis of soil-size fractions showed that major contribution of Mn, Fe, Cu and Zn is coming from clay portion of soil. Wide variation in DTPA-extractable Mn, Fe, and Zn is observed in rubber soils of Tripura. While Fe and Cu are found well above critical values, a marginal deficiency in Mn and Zn is observed in some samples. Soil properties, *viz.* soil pH, OC, CEC and clay, significantly affected the availability of these micronutrients. Since the soils are low to medium in OC, application of organic manures along with fertilizers will be beneficial for long-term availability of these micronutrients in a sustainable manner.

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