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# MICRONUTRIENT STATUS AND THE SOIL PHYSICO-CHEMICAL PROPERTIES AFFECTING THEIR AVAILABILITY IN RUBBER GROWING AREAS OF THE NORTH-EAST INDIA

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Two hundred and ten soil samples were collected from the rubber growing areas of Assam, Meghalaya and Tripura. DTPA extractable cations were estimated and their relations with different physico-chemical properties of the soils were studied. Soils varied from sandy loam to clay loam in texture, extreme to moderately acidic in reaction (pH: 3.9 to 6.1) and medium to high organic carbon content (5.50 to 22.50 mg kg$^{-1}$). Cation exchange capacity of the soil samples ranged from 4.52 to 17.45 cmol (p+) kg$^{-1}$. DTPA extractable Fe, Mn, Zn and Cu content of the soil samples ranged from 41 to 308 (mean 160.5), 6.1 to 72.0 (mean 29.1), 0.13 to 2.86 (mean 0.84) and 0.50 to 2.46 (mean 1.47) mg kg$^{-1}$ of soil, respectively. Based on the prescribed critical limit, all the samples were sufficient in DTPA-Fe and Mn. Cu deficiency was observed in 4.11 per cent of the total soil samples collected. About 29 per cent of the soil samples were deficient in DTPA-Zn. Hill Zone of Assam recorded the highest (33.6%) and Garo Hills of Meghalaya recorded the lowest (21.65%) number of Zn-deficient samples. Organic carbon and clay content of the soils were positively and significantly correlated with the DTPA-extractable micronutrients and contributed significant variations towards their availability.

**Keywords**: DTPA extractable micronutrients, North-East, Physico-chemical properties, Rubber growing soils.

## INTRODUCTION

Essentiality of micronutrients and specific deficiency symptoms in rubber were established long back (Shorrocks, 1964). Though micronutrients are present in different forms such as minerals, inorganic complexes, chelates, ions *etc.* in soils, only a small fraction of these micronutrients is absorbed by plants (Joseph *et al.*, 1995). The absorption of micronutrients by plants depends on various factors such as soil pH, organic carbon content, weathering condition, texture, climate *etc.* Continuous cultivation of rubber with modern high yielding clones and constant use of high analysis fertilizers creates deficiency of micronutrients in soils (Karthikakuttyamma

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*et al.*, 1989). However, no systematic work has so far been done to study the behaviour of micronutrients in rubber growing soils of the North-East India. Keeping in view of the above, it is proposed to take up this investigation on distribution of DTPA-extractable micronutrient cations and their relations with physico-chemical properties of soils in the rubber growing regions of North-East India.

## MATERIALS AND METHODS

The seven major rubber growing regions of North-East India (Lower Brahmaputra valley, Barak valley and hill Zone in the state of Assam, South Tripura, West Tripura and North Tripura in the state of Tripura and Garo Hills in the state of Meghalaya) were considered for the present study. Thirty soil samples (0-30cm depth) from each region (all together 210 soil samples) were collected from the matured rubber plantations. The soil samples were air dried and ground in a wooden pestle and mortar to pass through 2mm plastic sieve and stored in polyethylene bags. Important physico-chemical properties of the soils were analysed using standard methodologies. The available content of zinc, iron, copper and manganese in the soil samples were estimated by atomic absorption spectrophotometer (Model: Chemito AA 203D) in flame mode following DTPA extraction method (Lindsay and Norvel, 1978).

## RESULTS AND DISCUSSION

### Physico-chemical properties of soils

The texture of the soils under study were sandy loam to silty clay loam. Silty clay loam (39%) was the dominant texture followed by loam to clay loam (33%) and sandy loam to sandy clay loam (28%). The sand, silt and clay fractions varied from 16.40 to 59.20, 17.30 to 53.20 and 15.40 to 31.60 per cent, respectively. The mean values for sand, silt and clay in the rubber growing soils of the entire North-East were 42.30, 30.73 and 26.98 per cent, respectively. A wide range of variation (5.50 to 22.50 g $kg^{-1}$) in organic carbon content and the average value was 10.65 g $kg^{-1}$. The pH of the soils ranged from 3.9 to 6.1 with a mean value of 4.96. The cation exchange capacity (CEC) varied from 4.52 to 17.45 cmol (p+) $kg^{-1}$ and mean value of CEC was 7.99 cmol (p+) $kg^{-1}$.

### DTPA-extractable iron (DTPA-Fe)

The DTPA-Fe in the soils (Table 1) ranged from 41 to 308 mg $kg^{-1}$ with an average value of 160.5 mg $kg^{-1}$ of soil. The lowest (141.20 mg $kg^{-1}$) average DTPA- Fe was observed in soils in South Tripura and the highest (176.43 mg $kg^{-1}$) in Hill Zone of Assam (Table 1). The range of DTPA-extractable Fe observed in the present study lies within the range reported by various workers (Samanta *et al.*, 2002). Considering 4.5 mg $kg^{-1}$ of soil as critical value (Lindasy and Norvell, 1978), all the soil samples under the study showed very high amount of DTPA-Fe (Table 1). Very high contents of DTPA-Fe in these soils might be attributed to the effect of high acidity and parent material (Satisha, 2000). DTPA-Fe was significantly and positively correlated with organic carbon content ($r = 0.552^{**}$) (Table 2). DTPA being an organic chelating agent extract micronutrient cations from different pools (Lindsay and Norvell, 1978) and higher amounts of organic carbon in the soil might be the reason for positive and significant correlation with Fe (Singh *et al.*, 2006). Correlation studies (Table 2) also revealed that the DTPA-Fe was significantly

Table 1. **Micronutrient status in the rubber growing soils of North-East India**

| Zone | No. of soil samples | DTPA-Fe Content | DTPA-Fe Deficiency (%) | DTPA-Mn Content | DTPA-Mn Deficiency (%) | DTPA-Zn Content | DTPA-Zn Deficiency (%) | DTPA-Cu Content | DTPA-Cu Deficiency (%) |
|---|---|---|---|---|---|---|---|---|---|
| Lower Brahmaputra Valley of Assam | 30 | 47-294 (168.73) | Nil | 6.1-55.2 (30.19) | Nil | 0.18-2.86 (0.91) | 26.64 | 0.11-2.28 (0.74) | 3.84 |
| Barak Valley of Assam | 30 | 63-214 (155.83) | Nil | 7.3-65.2 (31.89) | Nil | 0.13-2.08 (0.87) | 29.37 | 0.13-2.37 (0.78) | 5.79 |
| Hill Zone of Assam | 30 | 43-231 (176.43) | Nil | 6.6-62.0 (27.41) | Nil | 0.24-2.33 (0.74) | 33.76 | 0.15-2.46 (1.01) | 2.96 |
| North Tripura | 30 | 55-224 (159.40) | Nil | 11.0-59.0 (26.87) | Nil | 0.33-2.10 (0.87) | 27.85 | 0.10-2.24 (0.90) | 3.66 |
| South Tripura | 30 | 41-206 (141.20) | Nil | 7.0-62.0 (24.73) | Nil | 0.24-2.74 (0.83) | 30.74 | 0.19-2.11 (0.71) | 5.47 |
| West Tripura | 30 | 51-242 (159.67) | Nil | 8.0-67.0 (28.50) | Nil | 0.25-2.46 (0.89) | 28.50 | 0.16-2.46 (0.88) | 4.85 |
| Garo Hills of Meghalaya | 30 | 66-308 (162.23) | Nil | 6.1-72.0 (34.07) | Nil | 0.24-2.08 (1.06) | 21.65 | 0.12-2.11 (0.83) | 2.18 |
| North-East as a whole | 210 | 41-308 (160.50) | Nil | 6.1-72.0 (29.09) | Nil | 0.13-2.86 (0.86) | 28.96 | 0.10-2.46 (0.84) | 4.11 |

and positively correlated with clay in all the Zones except the Hill Zone of Assam. Various studies showed that finer particle size fractions had strong influence on the distribution of DTPA-Fe in the soils (Satyavathi and Reddy, 2004). Considering the entire North-East as a whole, multiple regression analysis revealed that organic carbon alone contributed to 30.4 per cent variability in DTPA-Fe, which further increased to 36.3 per cent with the addition of clay and pH (Table 3). However, further addition of other factors did not bring any noticeable changes in the predictability of its variation. Similar observations were also reported by many other workers (Sharma and Chaudhary, 2007).

## DTPA-extractable manganese (DTPA-Mn)

Manganese extracted with DTPA (Table 1) ranged from 6.1 to 72 mg kg$^{-1}$ with an average value of 29.09 mg kg$^{-1}$ in the rubber growing soils of North-East India. The

Table 2. **Correlation coefficients (r) of DTPA-extractable micronutrients with physico-chemical properties of soils**

| Character | DTPA-Fe | DTPA-Mn | DTPA-Zn | DTPA-Cu |
|---|---|---|---|---|
| Sand | -0.0157 | -0.0216 | -0.0503 | -0.0385 |
| Silt | 0.0005 | -0.1089 | -0.0434 | 0.0418 |
| Clay | 0.3939 ** | 0.5110 ** | 0.3395 ** | 0.5853 ** |
| OC | 0.5517 ** | 0.4905 ** | 0.4269 ** | 0.6525 ** |
| pH | -0.1065 | -0.1928 ** | 0.1536 * | 0.0548 |
| CEC | 0.0427 | 0.2422 ** | 0.2867 ** | 0.2468 ** |

highest average value of 34.07 mg $kg^{-1}$ was recorded in the soils of Garo Hills of Meghalaya and the lowest (24.73 mg $kg^{-1}$) in South Tripura. On the basis of 1.0 mg $kg^{-1}$ soil of DTPA-extractable Mn as critical limit (Lindsay and Norvell, 1978) all the soils were adequately supplied with available Mn (Table 1). The finding was in conformity with Joseph *et al.* (1995). Correlation studies (Table 2) indicated that DTPA-Mn was significantly and positively correlated with clay (r= 0.511**), organic carbon (r= 0.490**) and CEC (r= 0.242**) of the soil and negatively correlated with pH (r = -0.193**) of the soil. Clay alone contributed significant variability (26.1%) in DTPA-Mn (Table 3). Addition of organic carbon enhanced the prediction of its variation to 34.8 per cent. However, addition of the other factors considered here, did not enhance its predictability to any noticeably higher level.

Table 3. **Stepwise regression equations for DTPA-extractable micronutrients with different soil properties**

| Zone | Intercept | Co-efficient | | | | | | $R^2$ |
|---|---|---|---|---|---|---|---|---|
| | | Sand | Silt | Clay | OC | pH | CEC | |
| DTPA-Fe | 27.1445 | -0.6880 | -0.3801 | -1.5670 | 6.0786 | 24.3528 | -0.0078 | 0.3694** |
| | -15.2157 | | 0.1071 | -1.4966 | 5.9657 | 23.7645 | 0.1539 | 0.3634** |
| | -12.0665 | | | -1.5362 | 5.9868 | 23.8732 | 0.1906 | 0.3630** |
| | -10.7333 | | | -1.5160 | 5.9787 | 23.8660 | | 0.3629** |
| | 111.0466 | | | -0.6851 | 4.3556 | | | 0.3073** |
| | 99.0894 | | | | 3.8863 | | | 0.3044** |
| DPTA-Mn | 23.8280 | 0.1839 | -0.0307 | 0.7503 | 0.5869 | -2.9498 | 0.2798 | 0.3780** |
| | 10.2262 | 0.1380 | -0.0221 | 0.6827 | 0.6738 | | 0.3839 | 0.3646** |
| | 9.0424 | 0.1474 | | 0.6862 | 0.6773 | | 0.3810 | 0.3644** |
| | 14.8379 | | | 0.7317 | 0.5896 | | 0.4289 | 0.3571** |
| | 17.3587 | | | 0.7698 | 0.6110 | | | 0.3476** |
| | 18.0237 | | | 1.0773 | | | | 0.2611** |
| DTPA-Zn | -0.5749 | -0.0075 | -0.0050 | -0.0112 | 0.0440 | 0.2549 | 0.0778 | 0.2334** |
| | -1.0822 | | -0.0011 | -0.0120 | 0.0441 | 0.2831 | 0.0771 | 0.2289** |
| | -1.1355 | | | -0.0109 | 0.0444 | 0.2832 | 0.0740 | 0.2288** |
| | 0.0397 | | | 0.0172 | 0.0432 | | 0.0180 | 0.2067** |
| | 0.0027 | | | 0.0246 | 0.0430 | | | 0.2053** |
| | 0.5272 | | | | 0.0535 | | | 0.1823** |
| DTPA-Cu | -0.2527 | -0.0109 | -0.0018 | 0.0566 | 0.0672 | -0.0478 | -0.0220 | 0.5020** |
| | -0.9343 | | 0.0060 | 0.0563 | 0.0667 | -0.0474 | -0.0215 | 0.4980** |
| | -0.6343 | | | 0.0565 | 0.0666 | -0.0721 | -0.0216 | 0.4953** |
| | -0.9671 | | | 0.0557 | 0.0664 | | -0.0221 | 0.4935** |
| | -1.0271 | | | 0.0656 | 0.0508 | | | 0.4897** |
| | -0.0455 | | | | 0.0908 | | | 0.4258** |

### DTPA-extractable zinc (DTPA-Zn)

As noticed in Table 1, a wide variation in the DTPA-extractable Zn ranging from 0.13 to 2.86 mg $kg^{-1}$ was observed in the rubber growing soils of North-East India. The average DTPA-Zn content in the soil was 0.84 mg $kg^{-1}$. Studies conducted by many workers in different parts of India revealed that DTPA-Zn ranged from trace to 8.49 mg $kg^{-1}$ (Singh *et al.*, 2006) and the range of DTPA-Zn in the present investigation was well within this range. With 0.6 mg $kg^{-1}$ soil as the critical limit for DTPA-Zn (Lindsay and Norvell, 1978), about 29 per cent of the soils were deficient in DTPA-Zn (Table 1). The highest percentage of soil samples deficient in DTPA-Zn was observed in the Hill zone of Assam. The Garo Hills of Meghalaya showed the lowest percentage of soil samples deficient in DTPA-Zn. Many workers reported deficiency of Zn ranging from 2 to 73 per cent in soils from different parts of India and attributed it to different physico-chemical properties of soil, agro-climatic conditions and crop management practices (Sakal, 2001). DTPA-Zn was significantly and positively correlated with clay (r = 0.339**), organic carbon (r = 0.427**), pH (r = 0.154*) and CEC (r = 0.287**) of the soil (Table 2). Significant positive correlation between organic carbon and DTPA-Zn was reported by different workers (Sharma and Chaudhary, 2007). Stepwise regression analysis showed that organic carbon was the most dominant factor contributing 18.2 per cent variability of DTPA-Zn (Table 3). Further addition of the other factors like clay, CEC, pH *etc.* enhanced its variability to 23.3 per cent.

### DTPA-extractable copper (DTPA-Cu)

The DTPA-Cu in the soils varied from 0.10 to 2.46 mg $kg^{-1}$ with average value of 0.84 mg $kg^{-1}$ (Table 1). Similar range of DTPA-Cu was also reported in many previous studies (Singh *et al.*, 2006) from different parts of India. Considering the critical limit of 0.2 mg $kg^{-1}$ (Lindsay and Norvell, 1978), it was observed that 4.11 per cent soil samples were deficient in Cu in the rubber growing soils of the North-East India (Table 1). Cu deficiencies to the tune of 5 per cent in different parts of India were also observed by Sood *et al.* (2009). Further, it was apparent from the data (Table 1) that the lowest average value of 0.71 mg $kg^{-1}$ soil was recorded in the soils of South Tripura and the highest in Hill zone of Assam. However, the highest percentage of Cu deficient samples (5.79) was observed in Barak Valley of Assam. The deficient samples were the lowest (2.18 per cent) in the Garo Hills of Meghalaya. Such variation in Cu content occurred presumably due to variation in various physico-chemical properties of soils. DTPA-Cu was positively and significantly correlated with clay (r = 0.339**), organic carbon (r = 0.427**) and CEC (r = 0.287**) of the soils. Various workers have reported significant positive correlations of DTPA-Cu with clay content (Siddhamali *et al.*, 1999), organic carbon (Venkatesh *et al.*, 2003) and pH of the soils (Singh *et al.*, 2006). Stepwise regression analysis revealed that organic carbon alone contributed to 42.6 per cent variability of DTPA-Cu (Table 3). Addition of clay enhanced the predictability to 49 per cent. However, addition of other factors did not enhance the predictability to any appreciable level. Singh and Choudhary (1990) also reported similar results.

## CONCLUSION

The study revealed that certain micronutrient, particularly Zn, may be a limiting factor in proper growth and development of rubber. Inadequate attention to their management may adversely affect the growth and yield of rubber in the region. Appropriate management strategies for micronutrient like external addition of micronutrient fertilizers and nutrient recycling through leaf litter may be helpful to tide over the situation.

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