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STATUS OF MAJOR NUTRIENTS IN RUBBER SOILS OF NORTH-EAST INDIA IN RELATION TO SOIL ACIDITY

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ABSTRACT

Nature of soil acidity under potential rubber growing soils of North-East India was studied. Sixty-six soil samples (0-30 cm) collected from different mature rubber plantations under north-eastern region of India were utilized for this study. These soils were analysed for various soil properties and acidity components. Soil pH ranged from 3.97-5.98, clay from 15.5-50.5% and OC from 2.8-25.7 g kg^{-1}. The mean OC content (11.6 g kg^{-1}) of these soils was relatively low. Mean BS (%) and CEC [cmol (p^{+}) kg^{-1}] of these soils were found 37.3 and 8.7 . Available N, P_2O_5 and K_2O of these soils, ranged from 141.6 to 494.2, 2.5 to 32.9 and 88.2 to 452.6 kg ha $^{-1}$ respectively. Available NPK status of these soils was low to medium and the availability of these nutrients was reduced with increase in soil acidity. Different fractions of soil acidity [cmol (p^{+}) kg^{-1}] revealed that exchangeable acidity varied from 0.42 to 2.51, total acidity 1.54 to 5.60, extractable acidity 0.85 to 4.35 and total potential acidity (TPA) 7.12 to 20.2. Organic carbon was significantly and positively correlated with total acidity and TPA whereas clay was significantly and positively correlated with TPA. Total acidity of soils hold a significant and negative correlation with available phosphorus and potassium. A weak and negative correlation was obtained between nitrogen and total soil acidity. Interrelationship among the various forms of acidity showed that exchangeable, total and extractable acidity are highly correlated among them whereas TPA did not show any relationship with them.

Keywords: Acidity components, nutrient availability, rubber soils, northeast India

INTRODUCTION

The north-eastern region of India has the largest area of acid soils in the country and the extent of occurrence of acid soils is as high as 96% in Assam, 95% in Meghalaya and 98% in Tripura (Barua, 2002). The production potential of acid soils is generally low which may be due to various soils related constraints or in other words infertility of soils (Mandal, 1997). A low soil pH, poor base saturation , low active clay, high degree of aluminum saturation and low level of microbial activity are some of the common factors causing poor fertility status of acid soil (Panda,1987; Gangopadhyay *et al.*, 2001). Though, a lot of work has been carried out on distribution, characterization and amelioration of acid soils in India but informations are still meager on many aspects of soils namely the forms of soil acidity, charge characterizations of soil, forms of aluminum and their relation with soil acidity etc. In north east India, rubber plantation is raised in denuded lands and residual hills. The pH of these soils are usually varied from 4.5 – 5.5. Sometimes pH of these soils goes below favorable range i.e. less than 4.5 due to leaching loss of cations or addition of acid forming N fertilizers to soil for a longer period of time. Such conditions may affect the plant growth (Bhattacharya *et al.*, 1996). Again soil acidity is the cumulative effect of different forms of acidity. Therefore, it is important to understand the contribution of these different forms of acidity on soil fertility of rubber soils in north-east India. With these aims, the present work was undertaken.

MATERIALS AND METHODS

Sixty-six soil samples at the depths of 0-30 cms were collected from some potential rubber growing locations of northeastern region of India viz. Garo Hills of Meghalaya, Goal Para and Kamrup district of Assam (Lower Brahmaputra Valley Zone) and West district of Tripura. The physico-chemical properties of these soils were carried out following standard procedures (Jackson, 1973). Various components of soil acidity e.g. exchangeable acidity, total, extractable and total potential acidity (TPA) were estimated following the procedure described by Barua and Barthakur (1997). Simple correlations were worked out among the various forms of soil acidity with physico-chemical properties of soil (Gomez and Gomez, 1984).

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RESULTS AND DISCUSSIONS

Physico-chemical properties of soil

Soil pH under rubber plantation ranged from 3.97 to 5.98 with a mean value of 4.86 (Table 1). On an average 55% of such soils were strongly acidic (pH < 5) and 44% soils are moderately acidic (pH = 5.0 – 6.0). Organic carbon (OC) status of soil varied from a low of 2.8 to a high of 25.7 g kg^{-1} with a mean value of 11.6 g kg^{-1}. It has been observed that mean OC content under rubber growing soils of Meghalaya (Garo hills) was higher (13.7 g kg^{-1}) than that of Lower Brahmaputra Valley Zone of Assam (11.4 g kg^{-1}) and West Tripura (9.5 g kg^{-1}). Cation exchange capacity (CEC) and base saturation (BS) of these soils ranged from 4.6 – 17.8 [cmol (p^+) kg^{-1}] and 22.4 – 60.8 % respectively. Low CEC and BS values indicated intensed leaching of nutrient cations from soil matrix due to high rainfall prevalent in this region. Clay content of soils which are the active constituent of soil matrix, ranged from 15.5 – 50.5 with a mean value of 23.6 %. The rubber soils in this region were sandy loam to clay loam in texture. Similar observations were recorded by Gangopadhyay *et al.* (2001).

Table 1: Physico – chemical properties of rubber soils

	pH (1:2.5)	Org. Carbon (g kg^{-1})	Clay (%)	CEC (cmol (p^+) kg^{-1})	BS (%)	Av .N (kg ha^{-1})	Av. P_2O_5 (kg ha^{-1})	Av. K_2O (kg ha^{-1})
Min	3.97	2.8	15.5	4.6	22.4	141.6	2.5	88.2
Max	5.98	25.7	50.5	17.8	60.8	494.6	32.9	452.6
Mean	4.86	11.6	23.6	8.7	37.6	279.1	12.2	268.5
SD	0.31	4.1	1.06	1.30	9.6	64.3	4.8	79.9

Available Nutrient status of soils

Available nitrogen of soils ranged from 141.6 – 494.6 kg ha^{-1} with a mean value of 279.1 kg ha^{-1}. These values ranged from low to medium in respect of available nitrogen. Similarly available phosphorus (P_2O_5) and potassium (K_2O) ranged from 2.5 – 32.9 and 88.2 – 452.6 kg ha^{-1} respectively. Poor status of available phosphorus and low to medium values for available potassium in the acid soils of north-eastern region of India has been reported by many workers (Chakraborty *et al*., 1987; Gangopadhyay *et al.*, 2001, Mandal *et al.*, 2011).

Table 2: Available NPK (kg ha^{-1}) status under varying soil pH

pH	Mean	N	Ph	K
3.95-4.50 (20)	4.26	275.8	6.41	209.1
4.50-5.06 (22)	4.81	294.4	9.63	241.3
5.0-5.50 (16)	5.24	319.3	12.84	251.1
5.50-6.0 (8)	5.69	392.5	15.12	265.2

In parenthesis, number of samples analysed

Available NPK status in relation to soil pH

Data on available NPK content of the soils revealed that at low soil pH, availability of these nutrients (Table 2) was reduced and these values increased with progressive increase in soil pH. Though, soil pH may not directly control N-availability to plants but at lower pH mineralization rate for organic matter was reduced due to low microbial activity which may cause poor N-availability. Again, solubility of Al^{+3} and Fe^{+3} increased at low pH (<5.5) which fixed a substantial amount of phosphate ions as insoluble Al-phosphate and Fe – Phosphate complex thereby restricting the availability of phosphate to plants. Highly weathered soils can be deficient in available K at low pH due to leaching loss and provide room for Al and Fe to compete for cation exchange sites of the soil matrix (Singh *et al*. 2003). The low base saturation and poor CEC values in these soils further corroborates our argument.

Table 3: Acidity components [(cmol (p^+) kg^{-1}] of soils under rubber

	Exchange acidity	Total acidity	Extractable acidity	Total Potential Acidity
Range	0.42-2.51	1.54-5.60	0.85-4.35	7.12-20.2
Mean	1.31	3.11	2.21	12.36
SD	0.67	1.18	0.86	3.13

Acidity components of soil

Exchangeable acidity values of soil varied from 0.42 – 2.51 with a mean value of 1.31 [cmol(p^+)kg^{-1}] Exchangeable acidity of soil is the sum total of H^+ and Al^{+3} that saturate the exchange site of soil matrix (Table 3). Relatively higher value of exchangeable acidity was found in the soils of **D.**

Meghalaya (Garo hills) which could be attributed to presence of higher exchangeable aluminum in the exchange site. Total acidity is the titrable acidity of soil within a pH range of 5.5 – 7.0 indicating the relative abundance of hydroxy polymers of aluminum present in soil matrix. Total acidity was ranged from 1.54 – 5.60 with a mean value of 3.11 [cmol (p^+) kg^{-1}]. Higher total acidity in these soils may be attributed to organic matter and exchangeable Al which are present in soil as hydroxy monomeric and polymeric form. Functional groups of organic matter (-COOH and – OH) liberated a considerable amount of H^+ ions to record higher total acidity of these soils. About 55% of total acidity of soil was contributed by exchangeable acidity. Extractable acidity of soil accounts for exchangeable Al, soluble $Al(OH)_3$ and other hydroxy monomer / polymers of Al that are strongly bonded in expanding silicate layers of clay. It also gave an idea about the weathering status of soil. The values ranged from 0.85 – 4.35 with a mean value of 2.21 [cmol (p^+) kg^{-1}]. A high degree of weathering of these soils were noticed which could be attributed to high rainfall and greater degree of soil formation. The soils of Meghalaya (Garo hills) were weathered more in comparison to other two locations. Total potential acidity (TPA) of soils comprised all the above explained acidity plus weakly acidic carboxylic and phenolic hydroxy groups of soil organic matter and partially neutralized hydroxy Al-polymers that could be present in soil at a pH greater than seven. The data revealed that TPA of the soils varied from 7.12 to 20.2 with a mean value of 12.36 [cmol (p^+) kg^{-1}]. The relatively higher TPA could be attributed to organic matter together with nature of inorganic oxides present in clay. Similar observations were recorded by Nair and Chamuah (1993), Kailashkumar *et al.*, (1995) and Gangopadhyay *et al.*, (2008) from the acid soils of north-eastern region of India.

Table 4: Correlation coefficients (r) between soil properties and acidity components

	Exchangeable acidity	Total acidity	Extractable acidity	Total Potential Acidity
pH	0.401	-0.054	0.094	0.065
OC	0.527*	0.584*	0.352	0.564*
CEC	-0.184	0.296	0.185	0.207
Clay	-0.224	0.187	0.514*	0.782*
BS	0.132	-0.091	0.175	0.145

**significant at 5% level*

Correlation study

Organic carbon was positively and significantly correlated with exchangeable acidity, total acidity and TPA. It was quite evident because soil organic matter possessed number of functional group containing H^+ that could contribute to the different forms of soil acidity. Positive correlation was observed between pH and exchange acidity (r = 0.41) but other fractions of soil acidity showed only non significant relationship with soil pH. It is obvious as pH measured only intensity factor of soil acidity. Clay had significant positive relationship with extractable acidity (r = 0.51*) and TPA (r = 0.76*). Clay is the reactive fractions of the soils, controlling most of the exchange reactions; therefore a significant relationship is expected between clay and extractable acidity as well as clay and TPA.

Table 5: Correlation coefficients (r) between acidity components and available nutrients

	Exchange acidity	Total acidity	Extractable acidity	Total Potential Acidity
Avail. N	0.149	-0.254	0.094	0.592*
Avail. P_2O_5	0.173	-0.655*	0.523*	0.754*
Avail. K_2O	0.211	-0.738*	0.185	0.354

**significant at 5% level*

Acidity components and available nutrients

A significant negative correlation was obtained between available P_2O_5 and total acidity (r = - 0.655*) and extractable acidity (r = -0.523*). This could be due to 'Al' which was dominantly contributed to these fractions, is responsible for fixation of phosphorus thereby restricted its availability to plants (Gangopadhyay *et al.*, 2001). The total acidity had a significant negative correlation with available K_2O (r =-0.738*). This was evident as exchangeable K values were decreased with higher total acidity. Exchangeable acidity showed low positive correlation (r=0.211) with available potassium (K_2O) indicating some amount of K^+ is responsible for replacing H^+ and Al^{+3} from exchange site of soil. A negative correlation existed between available N and total acidity of soil indicating that availability of N will be reduced at higher acidity of soil. TPA showed a positive and significant relationship with available N and P which may be due to contribution from organic matter and nature of clay content of soil.

Table 6: Correlation coefficients (r) among acidity components

	Exchangeable acidity	Total acidity	Extractable acidity
Exchangeable acidity	-		
Total acidity	0.925**	-	
Extractable acidity	0.945**	0.887**	-
TPA	0.214	0.256	0.102

***significant at 1% level*

At higher pH, carboxylic acid and phenoxy groups of organic matter may form chelating complex with Al^{+3}/Fe^{+3} which facilitates the release of phosphate ions in the soil solution. As a result a higher value of phosphorus is obtained. Interrelationship of forms of soil acidity components showed that exchangeable, total and extractable acidity were strongly correlated among them whereas TPA showed poor relationship with these components. At lower pH (4.5-5.5), acidity of soil is mainly due to hydroxy momomeric and polymeric forms of Al and Fe which upon dissociation produces large number of H^+ in soil solution to increase the soil acidity. These soil constituents are active at low pH whereas TPA is active only at higher pH (>7.3). Therefore, TPA did not show any significant relationship with the said acidity components. Similar observations were also recorded by Nayak *et al.*, (1996); Medhi *et al.*, (2002).

Conclusion

From the study, it was observed that nutrient availability decreased with decreasing soil pH. Soil organic matter had dominant contribution towards different components of soil acidity. Nature of clay also contributed significantly towards TPA. Among all the forms of acidity, total acidity of soil controlled the availability of P and K of acid soils under rubber.

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