Nature of acidity in some soils of south Tripura

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Abstract: Seven pedons representing the major landforms of southern part of Tripura associated with different land use were studied for their characteristics with special reference to the nature of acidity. The total potential acidity of the soils is high, contributed mainly by the pH dependent acidity (30.0 to 97.7 per cent) and exchangeable acidity (2.3 to 70.0 per cent). All types of acidity are relatively low in these soils. The higher exchangeable acidity and pH dependent acidity were noticed in the soils of undulating upland and flat-topped denuded hills supporting the horticultural crops, forests and rubber. The lowest value of exchangeable acidity was noticed in soils of the flood plain supporting paddy and vegetables. The exchangeable acidity is mainly contributed by the exchangeable Al^{3-} whereas the pH dependent acidity is mainly influenced by organic carbon and free iron oxides. The exchangeable Al^{3+} and per cent aluminium saturation tends to be zero at pH 5.3. The management of these soils (with pH less than 5.3) includes liming to neutralize exchangeable Al^{3+} to the tolerance level of crops.

Additional keywords: *Total potential acidity, pH dependent acidity, exchangeable acidity, exchangeable Al^{3+}, Aluminium saturation, liming*

Introduction

The north-eastern region of India with alpine to humid tropical climate posses the problem of soil acidity which is the major limiting factors for low productivity potential. In Tripura, about 98.9 per cent soils are acidic (Prasad *et al.* 1981; Bhattacharyya *et al.* 1998). The conditions conducive for the formation of acid soils in Tripura are high rainfall, high temperature and hilly topography. The rapid weathering and intense leaching under high rainfall condition favours the development of soil acidity. Though there are several theories on nature of soil acidity (Panda 1987), soil acidity is mainly defined in terms of KCl extractable (permanent) and pH dependent acidity (Coleman and Thomas 1967). The knowledge of different forms of acidity helps in the management of the soil by liming for better crop yield. Very little information is available on the nature of acidity of the soils of Tripura and hence an attempt has been made to study the nature of acidity of the soils of south Tripura in respect of topography and other soil properties.

Materials and Methods

The study area lies between 91° 25' to 91° 40′ E longitude and 23° 05' to 23° 28'N latitude of southern part of Tripura. The major landform includes foot hill slope (8 to 15% slope), flat-topped denuded hills (3 to 8% slope), undulating upland *i.e.* Tilla (3 to 8% slope), undulating plain with low mounds *i.e.* Lunga (3 to 8% slope) and flood plain (1 to 3% slope).

The soil samples were collected from different landforms associated with different land use (Table 1). The geology of the area is mainly sandstone, shale and clay belonging to the Surma group, Tipam group and Duptila group. The climate of this area is humid sub-tropical with mean annual rainfall 2100mm. The mean annual temperature is 25.1 °C with mean summer and winter temperatures of 27.9° C and 21.3°C respectively. Soil moisture regime is udic and temperature regime is hyperthermic.

The soil samples were collected horizon-wise from different pedons and processed (<2mm) for laboratory analysis. The soils were analysed for pH in water and 1*M* KCl solution (Black 1965). Total potential acidity was determined by $BaCl_2$ triethanolamine buffered at pH 8.0 (Peech *et al.* 1962). The free oxides of iron in soils were determined by citrate – bicarbonate – dithionate method (Jackson 1966) and the extractable Fe was determined using atomic absorption spectrophotometer (Black 1965). The lime requirement of soils were determined based on exchangeable Al^{3+} following the equation of Kamprath (1970), as shown below: $CaCO_3$ (t ha^{-1}) = 1.65 (exchangeable Al^{3+} in cmol (+) kg^{-1})

Results and Discussion

Morphological Characteristics

The morphological characteristics of the soils (Table 1) show that soils are deep, well to poorly drained and have developed from sandstone and alluvium on gently to moderately sloping landforms of south Tripura *i.e.* foot hill slope, flat-topped denuded hills, undulating upland, undulating plain with low mounds and flood plains, supporting different land use. Generally, in Tripura, forest and rubber cultivation are growing well on foot hill slope and flat-topped denuded hills, horticultural crops on undulating upland and paddy on undulating plain with low mounds and flood plains.

The soils of foot hill slope, flat-topped denuded hills and gently sloping upland are characterized by dark brown (10YR 4/3) to dark yellowish brown (10YR4/4) surface horizon and strong brown (7.5 YR 4/6) to yellowish red (5 YR 4/6) sub-surface horizons owing to better drainage and in turn relatively uniform distribution of iron oxides through depth. The soils of undulating plain with low mounds and flood plains are characterized by dark grey brown (2.5Y 4/2) to light olive brown (2.5 Y 4/4) sub-surface horizons with redoximorphic features indicating prolonged water-logging.

The texture of soils varies from sandy loam (Pedon 1 and 6) to sandy clay loam (Pedon 2, 3, 4 & 7) to silty loam (Pedon 7) in surface and the particle-size class (control section) remains fine- loamy in all the cases. The presence of coarser surface horizons except in the soils of flood plain indicates either erosion and /or clay translocation (Sen *et al.* 1997). The increase in clay with depth is common (except pedon 7) indicating the influence of topography and rainfall in the eluviation of clay from upper to the lower horizons. However, none of the pedons (except pedon 5) indicates the formation of an argillic horizon either by the presence of clay skins or by the clay increase in lower horizons. Due to obscure clay skin and with the increase in clay content with depth in soils of undulating upland (Pedon 5), the concept of Kandic horizon was brought into (Bhattacharyya *et al.* 1994) and results with the formation of argillic sub-surface diagnostic horizon (CEC/Clay ratio 16 or less and ECEC/clay ratio 12 or less). The silt content of the soils do not follow any definite pattern, except in the soils of flood plain (Pedon 7) which is dominated by silt due to the deposition brought down by flood water.

Soil characteristics

The soils are strongly to moderately acidic with pH ranging from 4.2 to 5.9 (Table 2). The soils supporting forest and horticultural crops on hill slope and undulating upland are strongly acidic (pH ranges from 4.2 to 4.5) whereas the rubber growing soils of flat-topped denuded hills are strongly to moderately acidic (pH ranges from 4.2 to 5.2). The paddy-growing soils are moderately to slightly acidic with pH ranging from 4.5 to 5.9. The strongly acidic nature of the forest and horticultural crop-supporting soils may be due to leaching of bases under high rainfall condition. However, the production of humic and fulvic acids by the decomposition of leaves and litters of forest species may also be the cause for the strongly acidic nature of the soils. The moderately to slightly acidic nature of the paddy-growing soils may be due to reducing environment under water-logged condition and also due to deposition of bases from the surrounding upland areas. However, in all the cases, pH (pH_{KCl} - pH_{H2O}) is always negative indicating that the soil colloid has a net negative charge and all the soils contain considerable amount of reserve acidity (Gangopadhyay *et al.* 2001).

The organic carbon content of the soils varies from 1.3 to 12.6 g kg^{-1}. The organic carbon content is high at the surface and decreased with depth. The organic carbon content of soils under forest, rubber, horticultural crops and paddy varies from 2.3 to 11.4 g kg^{-1}, 1.3 to 12.6 g kg^{-1}, 5.6 to 9.8 g kg^{-1} and 1.5 to 6.8 g kg^{-1} respectively, indicating the influence of vegetations. The low values of organic carbon in the soils of flood plain and valley may be due to the active fluvial process operating in that area (Table 2).

Except in the flood plain soil, all the soils had low CEC due to dominance of kaolinitic clay minerals in soils (Das *et al.* 1976). The higher clay CEC value of the flood plain soil justifies the mineralogy as mixed. Many of these soils are dominated by hydroxy interlayered vermiculites (HIV) and kaolin interstratified with HIV (KI/HIV) (Bhattacharyya *et al.* 2003). The base saturation of these soils varies from 12.7 to 97.1 per cent. Except pedon 1, 6 and 7, others are low base saturated. The high base saturation value of the flood plain soil particularly in the surface and sub-surface horizon is mainly due to deposition of bases washed out from the surrounding up-land (tilla land). The free iron oxide content of these soils varies from 7.1 to 42.8 g kg^{-1} (Table 2) and it increased with depth indicating the migration of Fe, which may possible due to the chelation by humus (Nayak *et al.* 1996).

Nature of Soil Acidity

The different forms of acidity account for total acidity and lime requirement of an acid soil. The extent of occurrence of various forms of acidity in the soils is presented in table 3.

Total potential acidity: Total potential acidity of the soils varies from 1.9 to 16.1 c mol (p+) kg^{-1} and it gradually increases with soil depth except in pedon 1 and 6. The soils of flat-topped denuded hills and undulating upland supporting rubber, forest and horticultural crops show greater total potential acidity in comparison to the soils of flood plain and undulating plain with low mounds supporting paddy crop. This is possibly due to high content of organic matter, clay and free iron oxide. The total potential acidity of soils shows significant positive correlation with CEC, exchangeable Al^{3-}, clay and free iron oxide (Table 4).

Exchange acidity : Exchangeable acidity includes the exchangeable H^{-} and Al^{3+} held at permanent charge sites of the exchange complex. The exchangeable acidity of soils varies from 1.1 to 6.7 c mol (p+) kg^{-1} and it increases gradually with depth. The higher value of exchangeable acidity is observed in the soils of flat-topped denudated hills and undulating upland supporting the forests, rubber and horticultural crops and low values are observed in the soils of undulating plain with low-mounds and flood plains which support paddy. . The contribution of exchange acidity to total potential acidity ranges from 2.3 to 70.0 per cent.

The exchangeable Al^{3+} contributes more towards the exchangeable acidity than the exchangeable H^{+}. The exchangeable acidity shows significant relationship with pH, exchangeable Al^{3-}, clay and free iron oxide content of the soils (Table 4).

pH dependent acidity

The pH dependent acidity (variable charge) of the soils is the difference between the total potential acidity and the amount of H^{-} and Al^{3+} exchanged with 1 *N* KCl solution and it varies from 0.8 to 12.5 c mol (p+) kg^{-1} . The pH dependent charge may arise from the structural –OH groups at the corners and edges of soil clay minerals, which dissociates into H^{+} ions in slightly acid to alkaline pH range. At higher pH, amorphous aluminium and iron hydroxy complexes may undergo hydrolysis and contribute to hydrogen ions in the system .The pH dependent acidity of the soils

Table 1. Morphological characteristics of the soils

Location	Horizon	Depth (m)	Boun-dary	Colour (m)	Mottle colour	Tex-ture	Struc-ture	Consis-tence	Slope (%)	Land-forms	Parent material	Present Land use
Pedon 1	A	0- 0.12	gs	10YR 4/4	-	sl	f 1 gr	s_0 p_0	8-15	Foot	Sandstone	Moderately
Manubazar	Bw1	0.12 - 0.47	gs	10YR 4/4	-	scl	m 1 sbk	ss ps		hill		dense forest
South Tripura	Bw2	0.47 - 0.80	gs	10YR 4/6	-	scl	m 2 sbk	ss ps		slope		
	BC	0.80 - 1.25		10YR 4/6	-	sl	m 1 sbk	ss ps				
Pedon 2	A	0 - 0.11	gs	10YR 4/4	-	scl	m 1 sbk	s_0 p_0	3-8	Flat	Sandstone	Moderately
Betaga R.F.	Bw1	0.11-0.44	gs	7.5YR 4/4	-	scl	m 2 sbk	ss ps		topped		dense forest
Manu ,	Bw2	0.44 - 0.85	gs	7.5YR 4/6	-	sc	m 2 sbk	ss ps		denudation		
South Tripura	BC	0.85 - 1.30		5YR 4/6	-	sc	m 2 sbk	ss ps		hills		
Pedon 3	A	0 - 0.12	gs	10YR 3/4	-	scl	m 1 sbk	ss ps	3-8	Flat topped	Sandstone	
Kalma R.F.	Bw1	0.12-0.29	gs	10YR 3/4	-	scl	m 2 sbk	ss ps		denudated		Rubber
South Tripura	Bw2	0.29-0.52	cs	7.5YR 4/4	-	scl	m 2 sbk	s p		hills		plantation
	Bw3	0.52-0.74	gs	7.5YR 4/6	-	cl	m 2 sbk	s p				
	Bw4	0.74 -1.15		7.5YR 4/6	-	cl	m 2 sbk	s p				
Pedon 4	A	0 – 0.11	cs	10YR 4/3	-	scl	m 1 sbk	ss ps	3-8	-do-	-do-	-do-
Muhiripur	Bw1	0.11-0.37	gs	10YR 4/6	-	scl	m 2 sbk	ss ps				
R.F.	Bw2	0.37-0.56	cs	10YR 4/6	2.5YR 4/6	scl	m 2 sbk	sp				
South Tripura	Bw3	0.56-0.92	gs	10YR 5/4	2.5YR 4/6	cl	m 2 sbk	sp				
	BC1	0.92-1.15	gs	10YR 5/3	2.5YR 4/6	cl	m 2 sbk	sp				
	BC2	1.15-1.40		10YR 5/3	2.5YR 4/6	cl	m 2 sbk	sp				
Pedon 5	Ap	0-0.12	gs	10YR 3/4	-	scl	m 1 sbk	ss ps	3-8	Undulating	Sandstone	Horticultural
Birchandra	Bt1	0.12-0.39	cs	7.5YR 3/4	-	cl	m 2 sbk	ss ps		upland		crops
Manu,	Bt2	0.39-0.66	gs	7.5YR 3/4	-	cl	m 2 sbk	ss ps				
South Tripura	Bt3	0.66-0.90		7.5YR 4/6	-	c	m 2 sbk	s p				
	R	0.90+	Hard Rock									
Pedon 6	Ap	0 - 0.11	gs	2.5Y 4/4	2.5YR 3/4	sl	m1 sbk	ss ps	3-8	Undulating	Alluvium	Paddy
Harina,	Bw1	0.11-0.45	gs	2.5Y 5/4	2.5YR 3/4	sl	m 2 sbk	ss ps		plain with		
South Tripura	Bw2	0.45-0.95	gs	2.5Y 5/4	2.5YR 3/4	scl	m 2 sbk	s p		low mounds		
	BC1	0.95-1.25	gs	2.5Y 5/4	2.5YR 3/4	sl	m 2 sbk	ss ps				
	BC2	1.25-1.50		2.5Y 5/4	2.5YR 3/4	sl	m 2 sbk	ss ps				
Pedon 7	Ap	0-0.10	gs	10YR 3/3	-	sil	m 1 sbk	ss ps	1-3	Flood plain	-do-	Paddy and
Kakrabon	Bw1	0.10-0.35	gs	10YR 3/3	-	sil	m2 sbk	ss ps				vegetables
South Tripura	Bw2	0.35-0.77	gs	2.5Y 4/2	7.5YR 4/4	sil	m2 sbk	sp				
	Bw3	0.77-1.05	gs	10YR 3/4	7.5YR 4/4	sil	m 2 sbk	sp				
	Bw4	1.05-1.25	gs	10YR 3/3	7.5YR 4/4	sicl	m 2 sbk	sp				
	Bw5	1.25-1.40		10YR 3/4	7.5YR4/4	sicl	m2 sbk	sp				

Table 2. Physical and chemical properties of soil

Horizon	Sand	Silt	Clay	Org.C (g kg^{-1})	C E C c mol (p+) kg^{-1}	BS (%)	Free iron oxide g kg^{-1}
	-------	%	-------				
Peodn 1(Typic Dystrudept)							
A	69.2	11.3	19.5	11.4	5.2	47	10.7
Bw1	67.1	10.4	22.5	9.4	4.0	60	12.8
Bw2	63.5	12.0	24.5	5.0	3.8	58	17.1
BC	67.0	13.5	19.5	2.3	2.8	66	14.2
Pedon 2 (Typic Dystrudept)							
A	64.3	14.2	21.5	11.1	5.4	36	17.1
Bw1	58.4	12.1	29.5	7.4	6.7	13	34.2
Bw2	52.8	11.7	35.5	5.8	7.0	20	39.9
BC	50.1	13.4	36.5	5.3	7.5	18	42.8
Pedon 3 (Humic Dystrudept)							
A	56.2	23.3	20.5	9.1	4.9	34	7.1
Bw1	53.1	22.4	24.5	7.0	5.5	34	13.5
Bw2	46.9	21.6	31.5	5.6	5.9	29	13.5
Bw3	41.9	18.6	39.5	4.3	7.1	22	9.3
Bw4	45.8	18.2	36.0	3.4	5.8	29	9.3
Pedon 4 (Typic Dystrudept)							
A	54.7	20.8	24.5	12.6	7.4	37	17.1
Bw1	40.9	24.1	35.0	4.8	8.9	17	24.2
Bw2	39.8	25.7	34.5	4.3	9.7	23	22.8
Bw3	42.0	25.0	33.0	2.8	9.4	36	32.8
2C1	42.8	18.7	38.5	1.3	10.6	65	5.7
2C2	44.1	21.4	37.5	1.3	10.2	42	18.5
Pedon 5 (Typic Kandiudult)							
Ap	49.1	26.4	24.5	9.8	6.0	26	18.5
Bt1	38.5	25.0	36.5	9.8	5.3	23	28.5
Bt2	33.0	28.0	39.0	7.4	6.9	22	31.4
Bt3	28.9	28.1	43.0	5.6	7.4	25	37.1
Pedon 6 (Oxyaquic Dystrudept)							
Ap	64.1	23.9	12.0	5.7	3.9	53	13.5
Bw1	58.8	22.7	18.5	3.8	6.1	34	18.5
Bw2	54.3	23.7	22.0	4.5	7.1	30	22.8
BC1	71.7	12.8	15.5	2.0	3.9	41	28.5
BC2	71.6	11.9	16.5	1.5	3.0	64	25.7
Pedon 7 (Flavaquentic Eutrudept)							
Ap	13.5	63.5	23.0	6.8	12.2	90	18.5
Bw1	23.1	53.9	23.0	5.3	11.2	96	19.2
Bw2	11.9	65.6	22.5	5.4	12.5	97	31.4
Bw3	11.3	65.7	23.0	4.5	12.5	97	31.4
Bw4	9.1	58.9	32.0	4.2	15.4	50	38.5
Bw5	6.6	57.9	35.5	4.4	14.5	50	38.5

Table 3. Nature of soil acidity

Horizon	pH (H_2O)	pH KCl	Exchange acidity H^+	Al^{3+}	Total	pH dependent acidity	Total potential acidity
			---------c mol (p^+) kg^{-1}			----------------->	---->
			Pedon 1 (Foot hill slope)				
A	4.4	3.9	0.4	0.7	1.1(16.9)	5.4(83.1)	6.5
Bw1	4.2	3.9	0.1	1.3	1.4(24.1)	4.4(75.9)	5.8
Bw2	4.5	4.0	0.8	1.1	1.9(45.2)	2.3(54.8)	4.2
BC	4.3	3.8	0.3	0.8	1.1(57.9	0.8(42.1)	1.9
			Pedon 2 (Flat-topped denuded hills)				
A	4.2	3.7	0.7	2.1	2.8(31.8)	6.0 (68.2)	8.8
Bw1	4.4	3.7	0.6	3.4	4.0(40.4)	5.9 (59.6)	9.9
Bw2	4.5	3.8	0.7	3.2	3.9(39.4)	6.0 (60.6)	9.9
BC	4.2	3.9	0.7	3.0	3.7(35.6)	6.7 (64.4)	10.4
			Pedon 3 (Flat-topped denuded hills)				
A	4.4	3.8	0.4	1.2	1.6(21.9)	5.7(78.1)	7.3
Bw1	4.2	3.9	0.9	1.8	2.7(31.8)	5.8(68.2)	8.5
Bw2	4.3	3.9	0.7	2.6	3.3(34.4)	6.3(65.6)	9.6
Bw3	4.6	4.0	0.5	3.0	3.5(32.7)	7.2(67.3)	10.7
Bw4	4.5	3.9	0.8	2.9	3.7(37.0)	6.3(63.0)	10.0
			Pedon 4 (Flat-topped denuded hills)				
A	4.8	3.8	0.9	2.1	3.0(30.9)	6.7(69.1)	9.7
Bw1	4.8	3.7	2.6	4.1	6.7(57.3)	5.0(42.7)	11.7
Bw2	5.0	3.6	2.4	4.1	6.5(55.5)	5.2(44.4)	11.7
Bw3	5.2	3.6	2.1	3.3	5.4(55.7)	4.3(44.3)	9.7
BC1	5.0	3.6	1.0	2.6	3.6(34.3)	6.9(65.7)	10.5
BC2	5.1	3.6	1.9	3.6	5.5(58.5)	3.9(41.5)	9.4
			Pedon 5 (Undulating upland)				
Ap	4.2	3.0	0.7	2.7	3.4(34.7)	6.4(65.3)	9.8
Bt1	4.3	3.2	0.7	3.4	4.1(32.8)	8.4(67.2)	12.5
Bt2	4.2	3.3	0.7	3.4	4.1(33.9)	8.0(66.1)	12.1
Bt3	4.4	3.4	1.2	2.8	4.0(32.0)	8.5(68.0)	12.5
			Pedon 6 (Undulating plains)				
Ap	4.4	3.8	0.4	1.2	1.6(18.2)	7.2(81.8)	8.8
Bw1	4.2	3.9	0.9	1.8	2.7(37.0)	4.6(63.0)	7.3
Bw2	4.3	3.9	0.7	2.6	3.3(39.3)	5.1(60.7)	8.4
BC1	4.6	4.0	0.5	3.0	3.5(70.0)	1.5(30.0)	5.0
BC2	4.5	3.9	0.8	2.9	3.7(63.8)	2.1(36.2)	5.8
			Peodn 7 (Flood plain)				
Ap	5.3	4.3	0.3	-	0.3(3.3)	8.7(96.7)	9.0
Bw1	5.7	4.3	0.2	-	0.2(2.7)	7.2(97.3)	7.4
Bw2	5.9	4.3	0.2	-	0.2(2.3)	8.4(97.7)	8.6
BW3	5.9	4.4	0.2	-	0.2(2.4)	8.0(97.6)	8.2
BW4	5.2	3.9	1.0	-	1.0(7.3)	12.7(92.7)	13.7
BW5	5.1	3.9	0.6	3.0	3.6(22.4)	12.5(77.6)	16.1

Figures in the parentheses indicate the percentage contribution of total potential acidity

Table 4. Coefficients of correlation between different forms of acidity and soil properties

Soil acidity	Soil properties					
	pH	Org.C	CEC	Exch. Al	Clay	Free iron oxide
Exchange acidity	-0.6958**	-0.225	0.084	0.982**	0.591**	0.506**
pH dependent acidity	0.321	0.226	0.711**	-0.190	0.397*	0.696**
Total potential acidity	0.11	0.069	0.600**	0.414**	0.584**	0.575**

** Significant at 1 per cent level

* Significant at 5 per cent level

increases with depth except in pedons 1, 4 and 6. The pH dependent acidity shows significant positive correlation with CEC (r = 0.71), clay (r=0.33) and free iron oxide (r=0.69). The contribution of pH dependent acidity to total potential acidity ranges from 30.0 to 97.7 per cent. The pH dependent acidity increased significantly with increasing free iron oxides and organic carbon in the soils. Since the amount of organic carbon is low in this soil, the pH dependent acidity of the soil may be described mainly to inorganic components in soil.

Relation between pH and Al saturation

The presence of appreciable amount of H^+ in acid soils are due to the permanent charge on mineral soil surfaces. The humic substances also contribute to some extent towards the soil acidity by ionization of phenolic –OH and carboxylic- COOH groups or by hydrolysis of aluminium or aluminium hydroxy cations. In Tripura, the soil acidity is mainly due to Al^{3+} ions and the relationship between Al saturation and pH will provide a quantitative assessment of Al-toxicity level at a defined pH. .

Al-saturation (%) was calculated considering effective CEC (Table 5). The effective cation exchange capacity (ECEC) is the sum of exchangeable Ca, Mg, Na and K extracted by 1*M* NH_4OAc (pH 7.0) and exchangeable Al^{3+} from 1*M* KCl extract of the soil and was taken as the permanent charge components of the soils (Coleman *et al.* 1959; Mishra *et al.* 1989). The percentage Al- saturation of Tripura soils based on the effective CEC shows that the exchangeable Al^{3+} was practically zero at pH 5.3 or more (Table 5). This relationship for soils of Orissa was reported to be zero per cent at pH 5.0 (Mishra *et al.* 1989) and higher Al-saturation in Meghalaya soils was observed around pH 5.6 (Nair and Chamuah 1993). Thus it is seen that in Tripura soils, where the acidity of soil is mainly due to Al^{3+} ions, the management of the soils of pH 5.0 will be done either by liming to neutralize exchangeable Al^{3+} or selection of Al tolerant crops such as tea, coffee, pineapple and upland rice. The lime requirement of these soils was calculated based on exchangeable Al^{+3} (Kamprath 1970) and presented in table 5.

The lime requirement values generally increase in the flat-topped denuded hills and become negligible in the soils in the floodplains. The commonly grown horticultural and plantation crops may be benefitted by application of lime in the flat-topped hills in south Tripura. The study shows that the upland soils of Tripura has significant problem of soil acidity which can be managed by liming to neutralize or reduce the Al^{3+} level to tolerable limits for better crop production.

References

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Table 5. Aluminium saturation in relation to pH and lime requirement

Horizon	pH (H_2O)	Exch. Bases	Exch. Al^{3+}	ECEC	Al saturation (%)	Lime requirement ($Mg\ ha^{-1}$)
			Pedon 1(Foot hill slope)			
A	4.4	2.5	0.7	3.2	22	1.16
Bw1	4.2	2.4	1.3	3.7	35	2.15
Bw2	4.5	2.2	1.1	3.3	33	1.82
BC	4.3	1.9	0.8	2.7	30	1.32
			Pedon 2 (Flat-topped denuded hills)			
A	4.2	1.9	2.1	4.0	52	3.47
BW1	4.4	0.9	3.4	4.3	79	5.61
Bw2	4.5	1.4	3.2	4.6	70	5.28
BC	4.2	1.3	3.0	4.3	70	4.95
			Pedon 3 (Flat-topped denuded hills)			
A	4.4	1.7	1.2	2.9	41	1.98
BW1	4.2	1.8	1.8	3.6	50	2.97
Bw2	4.3	1.7	2.6	4.3	60	4.29
Bw3	4.6	1.6	3.0	4.6	65	4.95
Bw4	4.5	1.7	2.9	4.6	63	4.79
			Pedon 4 (Flat-topped denuded hills)			
A	4.8	2.7	2.1	4.8	44	3.47
BW1	4.8	1.5	4.1	5.6	73	6.77
Bw2	5.0	2.2	4.1	6.3	65	6.77
Bw3	5.2	3.4	3.3	6.7	49	5.45
BC1	5.0	6.9	2.6	9.5	27	4.29
BC2	5.1	4.2	3.6	7.8	46	5.94
			Pedon 5 (Undulating upland)			
Ap	4.2	1.6	2.7	4.3	63	4.46
Bt1	4.2	1.6	3.4	5.0	68	5.61
Bt2	4.2	1.6	3.4	5.0	68	5.61
Bt3	4.4	1.9	2.8	4.7	60	4.62
			Pedon 6 (Undulating plain)			
Ap	4.4	2.1	1.2	3.3	36	1.98
Bw1	4.2	2.1	1.8	3.9	46	2.97
Bw2	4.3	2.1	2.6	4.7	55	4.29
BC1	4.6	1.7	3.0	4.7	64	4.95
BC2	4.5	1.9	2.9	4.8	60	4.79
			Pedon 7 (Flood plains)			
Ap	5.3	11.1	-*	11.1	-	-
BW1	5.7	10.8	-	10.8	-	-
Bw2	5.7	12.1	-	12.1	-	-
Bw3	5.9	12.1	-	12.1	-	-
Bw4	5.2	7.7	-	7.7	-	-
Bw5	5.1	7.3	3.0	10.3	29	4.95

* - = Nil

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