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Active Acidity, Reserve Acidity, Clay Content and Cation Exchange Capacity of Some Tea Soils of Bangladesh

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ABSTRACT

Some soil samples were collected from Rungicherra Tea-Estate of Moulvibazar district, Bangladesh. Active acidity, reserve acidity, cation exchange capacity and clay content of the collected soil samples were determined. The measured parameters of the soil samples were plotted and analyzed with reference to site and topography. The parameters have been found to vary with sampling sites, depths and topography.

Key Words: Soil; Active acidity; Reserve acidity; Cation exchange capacity; Clay content.

INTRODUCTION

Bangladesh is one of the leading tea exporting countries of the world. There exist about 160 tea gardens in Bangladesh with an average yield of about 835 lbs acre^{-1} which is quite low in comparison to other tea producing countries (1100-1350 lbs acre^{-1}). The cultivation of plants like tea, coffee, jute *etc.* mostly depends on soil management, physico-chemical properties and nutrient status of soil and its availability to plants (Hamblin & Davies, 1977; Curtin *et al.*, 1984; Reuss *et al.*, 1990; Aitken 1992; Curtin & Rostad, 1997; Matschonat & Vogt, 1997). Productivity as well as survival of microorganisms depend largely on active acidity, reserve acidity, buffer capacity and cation exchange capacity (CEC) of the soil (West *et al.*, 1992; Strong *et al.*, 1997; Haney *et al.*, 1999; Ghosh, 2003; Gogoi *et al.*, 2003). A through literature survey indicated that data on primary nutrient status, active acidity, CEC and other properties of the soils of different parts of Bangladesh, such as, forest, mangrove, offshore islands, flood affected areas and plain lands are abundant. But data on the properties of tea - soils of the country are scarce. Notable amongst them are the works of Chaudhury and Hasan (1974), Rashid (1978 &1985), Chaudhury and Ahsan (1979), Hossain *et al.* (1988), Hossain and Khan (2000). Unfortunately, no study available on the soil properties of Rungicherra Tea Estate. This study reports the active acidity, reserve acidity, cation exchange capacity and clay content of some soil samples of Rungicherra Tea-Estate of Moulvibazar district, Bangladesh.

MATERIALS AND METHODS

Chemicals and apparatus. The chemicals used for the investigation were: $CaCl_2.2H_2O$ (98+%), HCl (sp. Gravity 1.180), NaOH (99.99%), CH_3COOH (99.7%), KCl (99+%), Na_2CO_3 (99.5%) and H_3BO_3 (99.99%), which were procured from Aldrich and used without further purification. Ammonia free double distilled water was used during the experiments. An analytical balance of accuracy $\pm$ 0.0001 g was used for weighing. A glass electrode pH meter (Model-GPHR 1400 Digital: pH/mV, Germany) of accuracy $\pm$0.01 was used for active and reserve acidity determination. The pH meter was calibrated by using two buffer solutions (pH = 4.01 and 6.86).

Collection of soil samples. A total of 54 representative soil samples were collected from different sites of Rungicherra Tea- Estate, Kulaura, Moulvibazar, Bangladesh. The top-soils (0-9 inches), sub-soils (9-18 inches) and the substratum (18-36 inches) of three different topographic positions (T_1 = hill-top, T_2 = hill-slope and T_3 = hill-base) were collected in the month of December. Soil samples from each sites were dried in the air at room temperature, crushed to pass through 2mm sieve and analyzed.

Methods. Particle size distribution (clay, silt and sand content) was determined by the hydrometer method (Day 1965). The active acidity *i.e.*, pH in water of the soil samples was determined with digital pH meter at the soil: water ratio of 1: 2.5 (Jackson1973). The reserve acidity *i.e.*, pH in 0.1M $CaCl_2$ was measured by using the same pH meter at the soil : 0.1M $CaCl_2$ ratio of 1:2.5 (Armson 1977). Cation exchange capacity (CEC) was determined by the neutral 1N ammonium acetate method (Black 1965).

RESULTS AND DISCUSSION

Data on textural properties of soil revealed that the clay content ranged from ~16% to ~33% with an average of ~ 23% (Table I). The percentage of sand varied from ~ 55 to ~ 76 with a mean value of ~ 69, and of silt from ~ 4 to ~ 14 with a mean value of ~ 8. These properties varied with sampling sites as well as with depth and topographic positions. Based on above properties of the area under study, three different classes of soils, sandy clay loam

Table I. Physical properties of soil samples of Rungicherra Tea-Estate.

Sampling Site	Depth/ Inches	Topography	Particle size distribution Sand %	Silt %	Clay%	Sand/ Silt ratio	Silt/ Clay ratio	Textural Class
		T_1	62.16	9.67	28.17	6.43	0.343	SCL
	0-9	T_2	74.80	6.10	19.10	12.26	0.319	CL
		T_3	58.57	8.57	32.86	6.83	0.260	CL
		T_1	63.92	10.97	25.11	5.82	0.436	SCL
1	9-18	T_2	74.83	4.05	21.12	18.47	0.191	SL
		T_3	72.50	8.35	19.15	8.67	0.436	SL
		T_1	64.95	11.05	23.98	5.87	0.460	SCL
	18-36	T_2	65.11	8.79	26.10	7.40	0.336	SCL
		T_3	74.07	8.01	17.92	9.24	0.446	SL
		T_1	70.60	11.94	29.46	5.91	0.405	SL
	0-9	T_2	71.33	8.95	19.72	7.97	0.453	SL
		T_3	74.37	4.49	21.14	16.56	0.212	SL
		T_1	65.24	8.07	24.69	8.08	0.326	SCL
2	9-18	T_2	73.55	7.87	18.58	9.34	0.423	SL
		T_3	75.96	7.91	16.13	9.60	0.490	SL
		T_1	68.56	5.88	25.56	11.66	0.230	SCL
	18-36	T_2	61.98	10.05	27.97	6.16	0.359	SCL
		T_3	71.66	7.87	20.47	9.10	0.384	SL
		T_1	75.51	7.84	16.65	9.63	0.470	SL
	0-9	T_2	70.45	5.51	24.04	12.78	0.229	SCL
		T_3	72.33	9.23	18.44	7.83	0.500	SL
		T_1	76.29	6.68	17.03	11.42	0.392	SL
3	9-18	T_2	63.87	9.16	26.97	6.97	0.339	SCL
		T_3	75.04	5.92	19.04	12.67	0.310	SL
		T_1	66.59	5.73	27.48	11.62	0.208	SCL
	18-36	T_2	64.24	10.69	25.07	6.01	0.426	SCL
		T_3	73.83	8.26	17.91	8.93	0.461	SL
		T_1	70.83	7.21	22.05	9.94	0.322	SL
	0-9	T_2	72.84	9.17	17.98	7.94	0.510	SL
		T_3	55.13	13.91	26.96	3.96	0.520	SCL
		T_1	66.97	8.86	25.17	7.55	0.352	SCL
4	9-18	T_2	68.85	6.63	24.52	10.38	0.270	SCL
		T_3	72.22	4.21	23.01	17.15	0.182	SL
		T_1	65.49	7.26	27.25	9.02	0.266	SCL
	18-36	T_2	65.92	10.13	23.15	6.50	0.437	SCL
		T_3	62.46	5.53	32.01	11.29	0.172	CL
		T_1	75.35	5.50	19.15	13.7	0.287	SL
	0-9	T_2	74.44	7.29	18.27	10.21	0.399	SL
		T_3	65.28	10.75	23.97	6.07	0.440	SCL
		T_1	73.98	6.45	19.57	11.46	0.329	SL
5	9-18	T_2	76.15	8.03	15.82	9.48	0.507	SL
		T_3	65.67	8.72	25.61	7.53	0.340	SCL
		T_1	62.61	9.17	28.22	6.82	0.324	SCL
	18-36	T_2	72.54	5.46	22.09	13.28	0.247	SL
		T_3	69.49	5.51	25.37	12.61	0.217	SCL
		T_1	62.19	9.98	27.83	6.23	0.358	SCL
	0-9	T_2	65.66	9.21	25.13	7.12	0.366	SCL
		T_3	66.57	8.94	24.49	7.44	0.365	SCL
		T_1	66.62	7.05	26.13	9.44	0.269	SCL
6	9-18	T_2	63.38	11.76	24.86	5.38	0.473	SCL
		T_3	60.81	8.83	30.36	6.88	0.290	CL
		T_1	66.39	9.64	23.43	7.01	0.411	SCL
	18-36	T_2	66.30	8.74	24.96	7.58	0.350	SCL
		T_3	68.60	10.72	30.68	6.39	0.349	CL
Mean Value			68.61	8.187	23.47	9.10	0.350	
±SD (Standard deviation)			5.10	2.07	4.26	3.05	0.093	

Sandy clay loam (SCL), Sandy loam (SL), Clay loam (CL)

(SCL), sandy loam (SL) and clay loam (CL) are found to be distributed. Noticeably, maximum soils are found to be SCL in nature (Table I). High sand content of the soils, as noted here, allows good aeration and drainage, which is important for tea cultivation (Chaudhury & Hasan, 1974). It is evident from Table I that the sand: silt ratios of the soils ranged from 3.96 to 18.47, with an average of 9.10. On the other hand, ratio of silt: clay ranged from 0.17 to 0.52 with an average of 0.35.

The nature of variation of the clay contents of the soils

Fig. 1. Variation of clay content of soils of depth 0-9″.

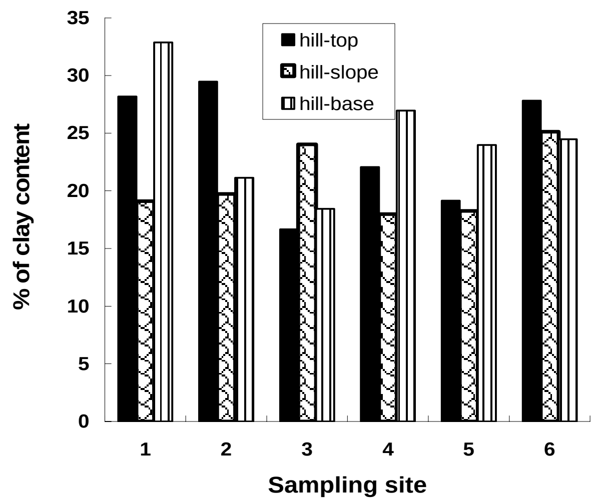
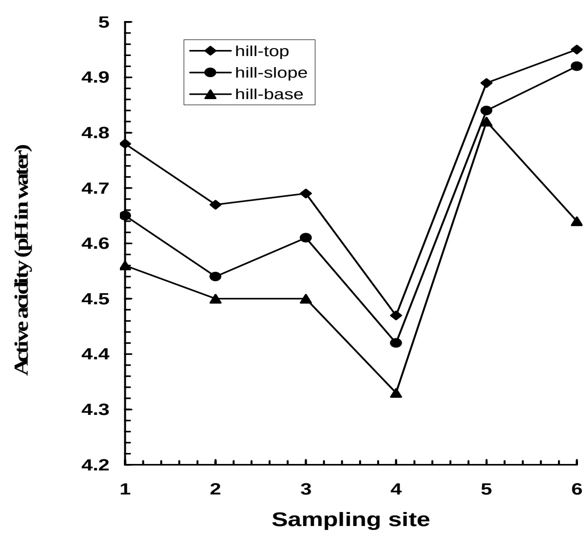


Fig. 2. Variation of active acidity (pH in water) of soils of depth 0-9″.



under study is very much irregular and does not follow any trend (Fig. 1c; Table 1). Top soils (0–9 ″) of sampling from site 1 contained the highest clay content (32.86% for hill-base), while sub-soils (9 –18″) of sampling site 5 contained the lowest clay content (15.82% for hill-slope). Active acidity of the soils was found to range from 4.33 to 5.01 with the mean value of 4.75, which indicates that the studied soils were all acidic in nature (Table II). The observed active acidity values of all the collected samples are found to lie within the optimum range 4.5 –5.8 (Chaudhury, 1978) for tea cultivation, except for the top soils of site 4. Acidity of the sampled soil from site 4 was slightly higher than the optimum range. The active acidity values of the soils of 0-9 ″depth (Fig. 2) revealed the following information:

1. Status of active acidity varies with sampling sites as well as with the topography.

Fig. 3. Variation of reserve acidity (pH in 0.1M $CaCl_2$) of soils of depth 0-9″.

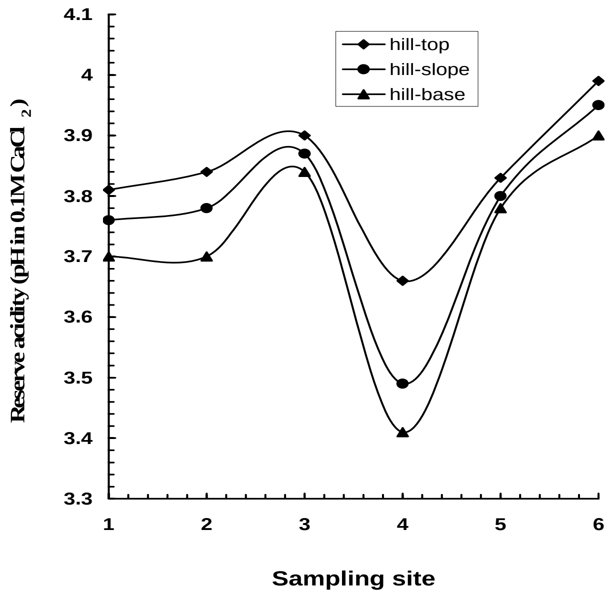


Fig. 4. Variation of cation exchange capacity, CEC, of soils of depth 0-9″.

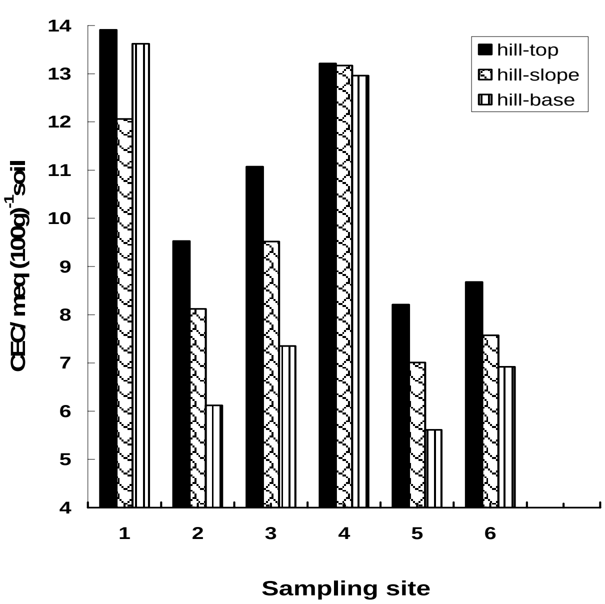


Table II. Active acidity (pH in H_2O), reserve acidity (pH in 0.1M $CaCl_2$), difference between reserve acidity and active acidity (ΔpH) and cation exchange capacity (CEC) of soil samples of Rungicherra Tea-Estate.

Sampling Site	Depth/ Inches	Topography	pH in H_2O	$CaCl_2$	ΔpH	CEC/ meq $(100g)^{-1}$
		T_1	4.78	3.81	-1.06	13.91
	0-9	T_2	4.65	3.76	-0.89	12.06
		T_3	4.56	3.70	-0.86	13.62
		T_1	4.48	3.83	-1.03	10.62
1	9-18	T_2	4.73	3.77	-0.96	8.61
		T_3	4.68	3.67	-1.01	6.99
		T_1	4.92	3.89	-1.03	11.78
	18-36	T_2	4.80	3.81	-0.99	10.13
		T_3	4.70	3.74	-0.96	7.51
		T_1	4.67	3.84	-0.83	9.53
	0-9	T_2	4.54	3.78	-0.76	8.12
		T_3	4.50	3.70	-0.8	6.12
		T_1	4.76	3.94	-0.82	10.76
2	9-18	T_2	4.69	3.82	-0.87	9.19
		T_3	4.60	3.79	-0.81	8.06
		T_1	4.81	3.96	-0.85	11.93
	18-36	T_2	4.69	3.84	-0.85	11.92
		T_3	4.55	3.80	-0.75	12.96
		T_1	4.69	3.90	-0.79	11.07
	0-9	T_2	4.61	3.87	-0.74	9.52
		T_3	4.50	3.84	-0.66	7.35
		T_1	4.85	3.96	-0.89	11.83
3	9-18	T_2	4.81	3.90	-0.91	10.36
		T_3	4.75	3.87	-0.88	8.46
		T_1	4.95	4.00	-0.95	12.12
	18-36	T_2	4.88	3.95	-0.93	11.08
		T_3	4.80	3.90	-0.9	11.72
		T_1	4.47	3.66	-0.81	13.21
	0-9	T_2	4.42	3.49	-0.93	13.17
		T_3	4.33	3.41	-0.92	12.96
		T_1	4.76	3.89	-0.87	12.79
4	9-18	T_2	4.66	3.75	-0.91	10.14
		T_3	4.62	3.74	-0.88	16.07
		T_1	4.94	3.95	-0.99	12.93
	18-36	T_2	4.70	3.93	-0.77	10.87
		T_3	4.65	3.93	-0.72	9.59
		T_1	4.89	3.83	-1.06	8.21
	0-9	T_2	4.84	3.80	-1.04	7.01
		T_3	4.86	3.78	-1.08	5.65
		T_1	4.92	3.93	-0.99	9.63
5	9-18	T_2	4.87	3.90	-0.97	8.12
		T_3	4.82	3.91	-0.91	6.43
		T_1	4.94	4.02	-0.92	10.34
	18-36	T_2	4.87	3.92	-0.95	9.14
		T_3	4.74	3.88	-0.86	7.66
		T_1	4.95	3.99	-0.95	8.68
	0-9	T_2	4.92	3.95	-0.97	7.57
		T_3	4.64	3.90	-0.74	6.92
		T_1	4.96	4.06	-0.9	9.10
6	9-18	T_2	4.93	4.02	-0.91	7.91
		T_3	4.90	3.98	-0.92	4.57
		T_1	5.01	4.10	-0.91	10.12
	18-36	T_2	4.97	4.03	-0.94	8.57
		T_3	4.79	4.00	-0.79	5.69
Mean Value			4.75	3.85	-0.89	9.82
±SD (Standard deviation)			0.16	0.13	0.09	2.45

T_1=Hill - top, T_2 =Hill – slope, T_3 = Hill – base

2. The observed active hydrogen ion concentrations for different topographic positions have been found in the order: hill - base > hill – slope > hill – top. Similar types of curves as well as trends have also been observed at other depths (curves not shown).

Reserve acidity of the soil samples was found to range from 3.66 to 4.06 with the mean value of 3.85 (Table II). In an acid soil, most of the H^+ present are absorbed by the soil (reserve acidity). The reserve acidity of soil is always higher than the active acidity. The difference between reserve and active acidity, ΔpH, of the studied soils was negative and found to range from – 0.72 to – 1.08 with a mean of – 0.89. This indicated that the studied soil samples had considerable reserve acidity. Hossain and Khan (2000) reported ΔpH values for Modupur rubber plantation area of Bangladesh, which are to be in the range of – 0.8 to – 1.3 with a mean of – 1.0. The reserve acidity values of the soils of 0-9″ depth were plotted in Fig 3. An examination of the curves revealed: a) the reserve acidity value changes with sampling sites as well as with the topographic positions as observed for the case of active acidity and b) the observed reserve acidity for different topographic positions have been found to follow the same sequence as is observed for active acidity.

Cation exchange capacity (CEC) of the studied soils varied widely. It was found to range from 4.57 to 16.07 meq $100g^{-1}$ soil with an average of 9.82 (Table II). Hossain *et al.* (1988) reported CEC of soils of Satgoan, Baraora and Kurmah Tea Estates and observed a wider range of variation in CEC (5.15 to 33.25 meq $100g^{-1}$). CEC of the soils of 0–9″ depth indicated that it varied with sampling sites as well as with topography (Table II & Fig. 4). The variation of CEC amongst the topography was significant and generally followed a sequence: hill-top > hill-slope > hill-base.

CONCLUSIONS

Textural class of the maximum soil samples is sandy clay loam. Clay content and the cation exchange capacity of the soils are satisfactory. Active acidity of the maximum soils is within the optimum range for tea cultivation. Top soils of sampling site 4 need more lime treatment for improving the active acidity level.

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