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Primary nutrient status and some related physical properties of the soils of Karnaphuli tea estate, Chittagong

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ABSTRACT

The soil samples were collected from six different sections and three topographic positions having different depths from Karnaphuli Tea Estate of Chittagong district, Bangladesh. Active acidity, reserve acidity, buffer capacity, cation exchange capacity (CEC), organic carbon (OC), organic matter (OM), total nitrogen (TN), available phosphorous (AP) and potassium (K) were determined. The parameters have been found to vary with sampling sites, depths and topography. Soils of this studied area were acidic (pH= 4.88) in nature and reserve acidity was 4.19. Most of the soil samples showed high buffer capacity with a few exceptions. The clay content and the cation exchange capacity (CEC) values of the studied soils were found 21.78% and 19.39 meq/100g respectively. Organic carbon and organic matter contents of the soils were found 0.59% and 0.94% respectively. Average value of TN, K and AP of the soils are 0.09%, 0.11meq/100g and 0.02ppm sequentially. Maximum values are quite lower than that of the critical value for tea cultivation.

KEYWORDS

Active acidity;
Reserve acidity;
Buffer action capacity;
Organic carbon;
Organic matter;
Nitrogen;
Phosphorus;
Potassium.

INTRODUCTION

Soil is a natural body comprised of solids (minerals and organic matter), liquid, and gases that occurs on the land surface, occupies space and is characterized by one or both of the following: horizons, or layers, that are distinguishable from the initial material as a result of additions, losses, transfers, and transformations of energy and matter or the ability to support rooted plants in a natural environment[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[2-5]. Productivity as well as survival of microorganisms[6,7] depend largely on active acidity, reserve acidity, buffer capacity and cation exchange capacity (CEC) of the soil. Tea has been grown in the soils of various types (loam, sandy-loam, clay-loam, sandy clay-loam) but sandy-loam and sandy clay-loam is considered to be excellent[8]. Soil organic carbon (SOC) is a significant soil characteristic, affecting many processes such as soil degradation, surface crusting, runoff, and erosion in soil[9]. It increases the cohesion of aggregates, stabilizes, holds soil particles together against disruption upon rainfall, and reduces erosion hazard[9]. Accurate and detailed mapping of SOC can also be used in

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precision farming to optimize the crop production inputs such as fertilizers and chemicals[10]. Moreover, the average yield variability was very significantly and negatively correlated with the cropland soil organic matter (SOM) level[11]. Nitrogen, Phosporous and potassium are three major nutrients usually are lacking from the soil first because plants use large amounts for their growth and survival. There are not always enough of these nutrients in the soil for a plant to grow healthy. This is why many farmers and gardeners use fertilizers to add the nutrients to the soil. Tea estate authority cultivates tea by trivial system as like as any other tea estate of Bangladesh. They use lime to control acidity of the soil without measuring pH of the soil and buffer action capacity lack of proper knowledge. Again they use NPK fertilizer though have no data of nutrient status of the soil. Tea production decrease with excess and missing fertilizing program[12]. Keeping this view in mind we taking step to investigate physicochemical properties and nutrient status of tea soil of Chittagong region as there is no available data found.

SAMPLE COLLECTION AND PROCESSING

To study the general physico-chemical as well as nutritional properties of soil a total 54 soil samples for this study were collected in May 2007 from throughout the Kharnaphuli tea estate, Chittagong for three depths i.e. 0-23, 23-46 and 46-91 cm and six different hills by auger[13]. The samples were air dried ground at room temperature and sieved through 2 mm diameter and 325 mesh sieve. The fine soils of each sample were stored in sample bottle with proper label.

MATERIALS AND METHODS

The active acidity (pH in water) and reserve acidity (pH in 0.1M $CaCl_2$) of the soil samples was determined with the pH meter (model HI 8424, HANNA Instruments, Romania[14]. Soil texture (percentage of sand, silt and clay content) and CEC were measured by the hydrometer (Model ERTCO 544416, ASTM, USA)[15] and ammonium acetate method[16] respectively. The organic carbon was analysed by Walkey and Black method[17] and organic matter by wet dichromate acid oxidation method[17]. Soil total nitrogen was by the macro–Kjeldhal method[18]. Available Phosphorus was determined by UV- spectroscopic method according to the stannous chloride reduced molybdophosphoric blue color method and the K was determined on an atomic absorption spectrophotometer[19].

RESULT AND DISCUSSION

The experimental data of all the parameters are shown in TABLE 1 and TABLE 2 according to three different depth (0-23, 23-46 and 46-91 cm) and three different topographic position (hill top, hill slope and hill base). Each value of both the TABLES is average of six different hills. The observed data for OC, OM, CEC, TN, K, TN, AP have been analyzed statistically to see the effect of topography as well as soil depth on the measured parameter given in TABLE 3 and TABLE 4

TABLE 1 : Active acidity (pH in water), reserve acidity (pH in $CaCl_2$), percentage of sand, silt, clay content and textural class of the soil

Depth cm	Topography	pH in H_20	pH in $CaCl_2$	Sand %	Silt %	Clay content	Texture Class
	Hill Top	4.91	4.12	53.20	23.63	23.58	Sandy clay loam
0-23	Hill Slope	4.73	4.17	52.25	24.88	22.88	Sandy clay loam
	Hill Base	4.84	4.25	58.08	22.54	19.38	Sandy loam
	Hill Top	4.93	4.22	52.79	23.60	23.58	Sandy clay loam
23-46	Hill Slope	4.99	4.29	52.27	24.88	22.88	Sandy clay loam
	Hill Base	4.95	4.20	59.33	22.54	19.33	Sandy loam
	Hill Top	4.93	4.23	52.21	20.46	28.33	Sandy clay loam
46-91	Hill Slope	4.87	4.14	48.00	22.29	29.71	Sandy clay loam
	Hill Base	4.73	4.12	63.45	16.17	20.86	Sandy clay loam
Overall mean value		4.88	4.19	54.62	22.33	23.39	Sandy clay loam

TABLE 2 : Organic carbon (OC), organic matter (OM), total nitrogen (TN), available phosphorus (AP), potassium (K), cation exchange capacity (CEC) and carbon/nitrogen ratio (C/N) status

Depth cm	Topography	OC %	OM %	TN %	C/N	AP ppm	K meq/100g	CEC meq/100g
	Hill Top	0.61	1.04	0.09	13.06	3.17	0.15	14.92
0-23	Hill Slope	1.17	1.31	0.12	13.99	2.33	0.11	15.74
	Hill Base	0.71	1.22	0.09	12.84	4.33	0.15	12.92
	Hill Top	0.54	0.94	0.08	7.60	1.50	0.11	19.9
23-46	Hill Slope	0.49	0.84	0.11	12.81	1.00	0.11	18.36
	Hill Base	0.45	0.78	0.11	4.40	1.67	0.11	12.79
	Hill Top	0.44	0.76	0.05	12.53	1.17	0.08	26.25
46-91	Hill Slope	0.43	0.74	0.11	4.19	1.83	0.10	23.58
	Hill Base	0.46	0.79	0.07	6.75	1.17	0.09	30.02
Overall mean value		0.59	0.94	0.09	9.80	2.02	0.11	19.39

TABLE 3 : Effect of topography on total nitrogen (TN), available phosphorous (AP), organic carbon (OC), organic matter (OM), carbon/nitrogen (C/N), potassium (K), cation exchange capacity (CEC) of soils of Karnaphuli tea estate.

Parameter	Topography			F-statiscs@		
	Hill-Top	Hill-Slope	Hill-Base	df=2	LSD0.05	Probability
OC%	0.53	0.56	0.54	0.13584	--	0.87331
OM%	0.91	0.96	0.93	0.13697	--	0.87233
TN%	0.07	0.11	0.09	3.60003	0.03087	0.03477
C/N	11.06	9.58	7.99	0.36391	--	0.69682
AP	1.94	1.72	2.39	1.95372	--	0.15263
K	0.11	0.10	0.12	1.39063	--	0.25857
CEC	20.36	19.23	18.58	7.41610	_3.64453	0.00154

TABLE 4 : Effect of depth on total nitrogen (TN), available phosphorous (AP), organic carbon (OC), organic matter (OM), carbon/nitrogen (C/N), potassium (K), cation exchange capacity (CEC) of soils of Karnaphuli tea estate.

Parameter	Depth(cm)			F-statiscs@		
	0-23	23-46	46-91	df=2	LSD0.05	Probability
OC%	0.69	0.49	0.44	10.67758	0.11438	0.00014
OM%	1.19	0.85	0.76	10.66201	0.19727	0.00014
TN%	0.10	0.10	0.08	1.25713	--	0.29348
C/N	12.33	8.27	7.92	0.89480	--	0.14526
AP	3.28	1.39	1.39	20.16519	0.69033	0.00000
K	0.14	0.11	0.09	7.12530	0.02367	0.00192
CEC	14.53	17.02	26.25	0.16099	--	0.85175

sequentially. The values of F statistics, probability and least significant difference at 95% confidence level (LSD 0.05) are also listed in same TABLES.

The active acidity is determined by the number of hydrogen ions, which dissociate from the adsorptive complex and exist in the solution[20]. Active acidity is found to vary from 4.30 to 5.80 with the mean value 4.88, which indicates that the studied soil samples are all acidic in nature. This value is similar (pH=3.22-5.37) of the tea soil of eastern black sea reason of Turkey[21]. Active acidity of maximum soil samples are within optimum range 4.5-5.8 for tea cultivation[22]. The pH in $CaCl_2$ (0.01M) or in KCl (0.01M) solution is termed as reserve acidity. The determined reserve acidity is 4.19 and varies with sampling site as well as with topographic positions and profiles within the same section (TABLE 1). These observed variations of the active acidity and reserve acidity might be due to the variation

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of lime treatments and difference in the nature of clay surface of the studied soils. Buffer capacity of a soil helps to maintain a constant pH of soil and ensures consistent ionic condition of the soil, which is essential for both the plants and microorganisms[22]. Buffer capacity[23] measurement data of a section are represented graphically in Figure 1. The measurements indicate that maximum soil samples have good buffer capacity.

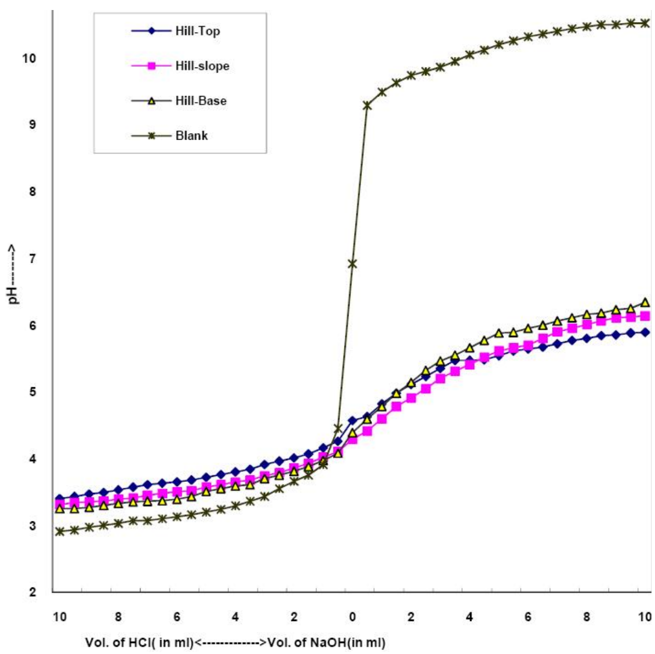

Figure 1: Buffer action capacity of section number 4 of 0-23 cm depth with reagent blank

Most of the soils are found to be sandy loam and clay loam in nature but sandy-loam and sandy clay-loam are considered to be the best for tea cultivation[8]. The Clay content of the studied soils are ranged from 9.75 to 40% with mean value 23.39%. However, percentage sand and clay of the soil shown in TABLE 1. The cation exchange capacity (CEC)[24] were found to range from 10.1 to 34.53 meq/100g. Average value of CEC was found 19.39 which is higher than Rangapani tea estate[25] of same district. The variation of cation exchange capacity due to the difference in nature and amount of clay content and percentage of organic matter content and pH in the soil[25]. In fact both clay content and acidic condition of Karnaphuli tea estate is better than Rangapani tea estate[25].

The observed value of organic carbon and organic matter content of the studied soils is ranged from 0.191 to 1.268% and 0.329 to 2.185% with the mean value of 0.59% and 0.94% respectively. The values for maximum soil samples (TABLE 2) are even lower than the critical value (1%)[22] for the cultivation of tea. Rungicherra[26], Kaliti[27] tea estates of Bangladesh also contain lower organic carbon than critical value. This low status of organic carbon and organic matter content is thought to be due to its rapid decomposition caused by high rainfall and temperature. Shading, irrigation and drainage system have to improve and organic fertilizer (compost) can use to keep up optimum level of organic carbon and organic matter of the tea soil.

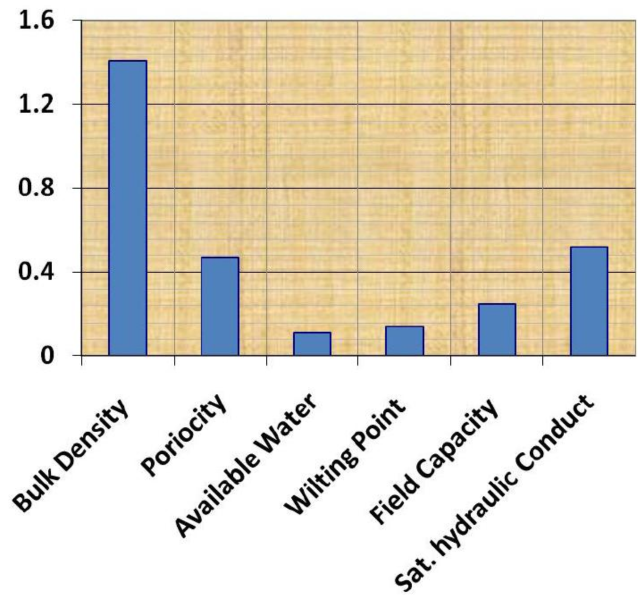

Figure 2 : Bulk properties of the soil samples

Total nitrogen (TN) content of the studied soils are 0.09, 0.12 and 0.09% for hill top, hill slope and hill base of 0-23 cm depth; 0.08, 0.11 and 0.11 % for hill top, hill slope and hill base of 23-46 cm depth ; 0.05, 0.11 and 0.07% for hill top, hill slope and hill base of 46-91 cm depth (TABLE 2). The minimum requirement[28] of total nitrogen for tea cultivation is 0.8 to 0.9% in the non-sandy part of the soil. Recently Ahmed et al.[26] reported 0.095 to 0.13 % TN for the soils of Rungicherra tea estate.

C/N ratio plays a vital role in the synthesis of new microbial cells. The C/N ratio of the studied soils ranges from 4.19 to 13.99 with the mean value of 9.80. Most of the studied soil samples have closest C/N ratio to the critical value (10) for tea cultivations, with some exceptions. This low C/N ratio indicates that the organic matter of the soils is extremely oxidized and the associated microbes are active. The variation of C/N ratio amongst the topographic positions and depths is irregular. Ahmed et. al. recently reported 8.25 to 9.38 C/N ratio for Rungicherra tea estate[26].

The observed data for Phosporous (P) and Potassium (K) of the studied soils indicate that the values varied with the sampling sites as well as with topography and soil depths. The values of available phosphorus content for studied soil samples are 2.33 to 4.33 ppm for 0-23 cm depth, 1.00 to 1.50 ppm for 23-46 cm depth and 1.17 to 1.83 ppm for 46-91 cm depth. Potassium content of the studied soil samples is found to range from 0.11 to 0.15 meq/100g for 0-23 cm depth, 0.11 to 0.11 meq/100g for 23-46 depth and 0.08 to 0.10 meq/100g for 46-91cm depth. Maximum values of Phosporous and Potassium are quite lower than that of the critical value (10ppm and 80ppm or 0.20 meq/100g) for tea cultivation and similar as reported Ahmed et al[27]. These low contents of AP may be caused by the conversion of available phosphorus into unavailable form by microorganisms and or phosphorus fixation by Aluminium in the prevailing acidic conditions. Furthermore, AP content of soils may be varied due to the difference in formation of organic phosphorus compounds by decomposition and other vegetations.

The value of F for different soil depths is significant at 0.00 levels, *i.e.*, soil depths have a significant effect on OC and CEC. On the other hand, the values of F for topographic variation with a high probability value indicate that the topography has almost no effect on OC, CEC, i.e., null hypothesis is valid for both the parameter. F value for TN due to topographic positions is 3.60003 (TABLE 3) with a probability value of 0.03477, indicates that the topographic variations is significant at 3% level. For different soil depths F value for TN is 1.25713 (TABLE 4). Thus this value of F with a high probability value (0.29348) indicates from the statistical point of view that the different soil depth has almost no effect on TN, *i.e.*, null hypothesis is valid in case of soil depth for this parameter. This F value with a higher probability value (0.25857) indicates that the topographic variations have almost no effect on potassium (K). On the other hand, F value for K in case of different soil depths is 7.12530 (TABLE 4). This value of F is significant at 0.00 levels, *i.e.*, this parameter varies significantly with soil depth. This value of F on AP is significant at 0.00 levels, *i.e.*, soil depth has a significant effect on AP.

CONCLUSION

Active acidity of maximum soil samples of Karnaphuli tea estate is found within the optimum range (4.5 to 5.8) for tea cultivation. The buffer capacity status of maximum soil samples of the studied areas is good. Organic carbon and organic matter content of the soils is sufficiently low but the cation exchange capacity and clay contents are satisfactory. To increase the organic carbon content in the soil, the tea estate authority should give more emphasis on using more organic fertilizers (as cow-dung) and plant residues instead of using artificial fertilizers. Total nitrogen (TN), available phosphorus (AP) and potassium (K) content of the studied soils are also very poor. The yield of tea widely depends on TN, AP and K in soil. To improve the yield and quality of tea, it is important to keep up the above parameters within the optimum range in addition to proper drainage and shade condition.

REFERENCES

[1] H.D.Foth, L.M.Turk; Fundamental of soil science, 5th Edition, John Wiley and Sons. New York, **(1983)**.
[2] A.P.Hamblin, D.B.Davies; Soil Sci., **28**, 11–22 **(1977)**.
[3] D.Curtin, H.P.W.Rostad; Canadian J.Soil Sci., **77**, 621–626 **(1997)**.
[4] G.Matschonat, R.Vogt; European J.Soil Sci., **48**, 163–71 **(1997)**.
[5] J.O.Reuss, P.M.Walthall, E.C.Roswall, R.W.E.Hopper; Soil Sci.Soc.American J., **54**, 374-380 **(1990)**.
[6] A.W.West, G.P.Sparling, C.W.Feltham, J.Reynolds; Australian J.Soil Res., **30**, 209–222 **(1992)**.
[7] S.Gogoi, M.K.Bhuyan, R.M.Karmakar; J.Indian Soc.Soil Sci., **51**, 252–257 **(2003)**.
[8] S.H.Chaudhury; K.A.Hasan; Tea J.of Bang., **10(2)**, 3-6 **(1974)**.
[9] Y.Bissonnais, D.Arrouays; European J.Soil Sci., **48(1)**, 39-48 **(1997)**.
[10] G.Esteban, Jobbágy, R.B.Jackson; Ecological Applications, **10(2)**, 423–436 **(2000)**.
[11] P.Genxing, P.Smith, P.Weinan; Agriculture, Ecosystems and Environment, http://www.ireea.cn/upfiles/200941616209871.pdf; **129**, 344-348 **(2009)**.

[12] Anonymous; Annual of Trabzon Province, Trabzon Government Publ. No. 125, **(2000)**.

[13] M.L.Jackson; Soil Chemical Analysis, Prentice Hall of India Pvt.Ltd., New Delhi–India, **(1973)**.

[14] K.A.Armson; Forest soils, University of Toronto Press, **(1977)**.

[15] P.R.Day; Particle Size Distribution and Particle Size Analysis.In: C.A.Black, (Ed); Methods of Soil Analysis (American Society of Agronomy, Madison, Wisconsin, USA, **(1965)**.

[16] C.A.Black, Methods of Soil Analysis, American Society of Agronomy. Madison, Wisconsin–USA, **2**, 1022 **(1965)**.

[17] D.W.Nelson, L.E.Sommers, Sparks, et al. (Ed); Methods of soil analysis, Part 3, Chemical methods (Book Series No. 5, SSSA and ASA, Madison, 961-1010 **(1996)**.

[18] J.M.Bremner, C.S.Mulvaney; Agronomy Monograph, 2nd Edition. American Society of Agronomy, Madison, WI, **9(2)**, 595-624 **(1982)**.

[19] J.Dewis, F.Freitas; Soil Bulletin Number 10. Food and Agriculture Organization of the United Nations, Rome, **(1970)**.

[20] G.D.Martin; Laboratory Manual, Department of Chemistry, Lakehead University, Canada, 22 **(1988)**.

[21] A.Aydin, A.Sevinc; Pakistan Journal of Biological Sciences, **9(3)**, 365-370 **(2006)**.

[22] K.M.G.Kibria, M.A.Rashid; Pamphlet, Bangladesh Tea Research Institute, **21**, **(1994)**.

[23] F.Turner, W.W.Mccall; Mech.arg, Exp.Sta.Quart Bull, **40**, 268-281 **(1957)**.

[24] G.P.Gillman, E.A.Sumpter; Australian J. of Soil Res., **24**, 61-66 **(1986)**.

[25] M.N.Islam, A.F.M.Sanaullah; J.of Sci.Res., **3(3)**, 683-688 **(2011)**.

[26] M.S.Ahmed, M.R.Z.Hasan, A.F.M.Sanaullah; Pak.J.Anal.Chem., **6(1)**, 10-15 **(2005)**.

[27] M.S.Ahmed, M.M.S.Hasan, A.F.M.Sanaullah; Pak.J.Anal.Chem., **6(2)**, 59-64 **(2005)**.