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Organic Carbon, Nitrogen and Phosphorus Contents of Some Tea Soils

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Abstract

Soil samples were collected from Rungicherra Tea-Estate of Moulvibazar district, Bangladesh. Organic carbon, organic matter, total nitrogen and available phosphorus content of the collected soil samples of different profiles and of different topographic positions have been determined. The experimental data have been analyzed statistically and plotted against topography and soil depth. Organic carbon and organic matter content varied from 0.79 to 1.24% and 1.37 to 2.14%, respectively. Total nitrogen and available phosphorus content of these soils varied respectively from 0.095 to 0.13% and 2.31 to 4.02 ppm.

Keywords: Soil; organic carbon; organic matter; total nitrogen; available phosphorus

Introduction

Bangladesh is one of the tea exporting countries of the world. There exist about 160 tea gardens in Bangladesh. The average yield of tea in Bangladesh is about 378 kg (840 lbs) $acre^{-1}$, which is quite low in comparison to other tea producing countries of the world, on an average each producing 500-600 kg (1137-1333 lbs) $acre^{-1}$. The growth of plants, like tea, jute, coffee *etc.* largely depends on the availability of nutrients. Literature survey indicates that works on both primary and secondary nutrient status of soils of different parts of Bangladesh, such as forest [1-3], mangrove [4], flood affected areas [5, 6], off-shore islands [7] and Madhupur tract area [8-10] are available. Unfortunately, works on nutrient status of the tea soils of Bangladesh is very scarce. Notably the works of Chaudhury and coworkers [11-15] on the fertility status of some tea estates of Bangladesh are important. As a part of our ongoing project on soil properties of the tea estates of Bangladesh, recently, we have reported on the physico-chemical properties of the soils of Rungicherra Tea- Estate of Moulvibazar District, Bangladesh [16]. Now, we are reporting on the organic carbon, organic matter, total nitrogen and available phosphorus content of the soils of the same tea - estate.

Experimental

Chemicals

The chemicals have been used for the investigation are: HCl (sp. gr. 1.180), H_2SO_4 (98%), NaOH (99.99%), Na_2CO_3 (99.5%), H_3BO_3 (99.99%), $FeSO_4.7H_2O$ (99+%), $K_2Cr_2O_7$ (99%), ammonium molybdate (99.98%), $SnCl_2$ (99.99%), KH_2PO_4 (99+%). All the chemicals were procured from Aldrich. Ammonia free double distilled water was used during the experiments.

Equipments

An analytical balance of accuracy $\pm$ 0.0001 g was used for weighing. Kjeldahl digestion and distillation apparatus were used in the determination of total nitrogen. A Shimadzu (Model-160) double beam UV- visible spectrophotometer was used for estimating the available phosphorus content.

Collection of soil samples

54 representative soil samples were collected from different sites of Rungicherra Tea-Estate, Kulaura, Moulvibazar, Bangladesh. The topsoil (0-9″), subsoil (9-18″) and the substratum soil (18-36″) 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. The collected soil samples from each sampling sites were dried in the air at room temperature, crushed to pass through 2mm sieve and then analyzed.

Methods

Soil organic carbon content was determined by wet oxidation method as described elsewhere [17]. Organic matter content of the soil samples was calculated by multiplying the percent of organic carbon by Van Bemmelon factor of 1.73 [18]. Total nitrogen was estimated by using micro-Kjeldahl digestion and distillation procedure [17]. Available phosphorus was extracted from the soil by using Bray and Kurtz No. 2 solution (0.1N HCL and 0.03N NH_4F) [19]. Phosphorus in the extract was determined by the chlorostannous reduced molybdophosphoric blue color method in a sulphuric acid medium [17]. The absorbance of the solution were recorded within 20-30 minutes of preparation by using the double beam UV- visible spectrophotometer and these values were used in the phosphorus calibration curve to determine the amounts of phosphorus in ppm present in the soil.

Results and discussion

The organic carbon (OC), organic matter (OM), total nitrogen (TN), available phosphorus (AP) and carbon - nitrogen ratio (C/N) of the soils are listed in Table 1 along with the standard deviations. Each data is the mean of six measurements. Organic carbon contents of the soils are found to be low to medium and ranged from 0.79 to 1.24 %. This poor status of organic carbon content is thought to be due to its rapid decomposition caused by high rainfall and temperature. The values of organic carbon content for hill top soils of all depths are slightly higher than that of the critical value (1%) for the cultivation of tea [20], while the soils of the other topography have lower values.

Organic matters are often called the life of the soil and play a key role in the maintenance of soil fertility. It affects the physical as well as biological properties of the soil largely. The observed OM content varied with the topographic positions and soil depths. OM content was found to range from 1.37 to 2.14 % (Table 1). Hill top soils of all depths contain higher percentage of OM than those observed for the other topographic positions. The highest OM content (2.14%) amongst the studied soils was recorded for the hill top soils of 0-9″ depth. Chaudhury and Shome [12] reported the highest value (2.58 %) of organic matter content for Udnacherra Tea Estate of the same district, whereas, Islam *et al* [8] reported the highest value of 2.28 % for the Chandra soils of Madhupur Tract.

Of the plant nutrients, nitrogen plays an important role in increasing the yield of tea. Total nitrogen (TN) of the studied soils ranges from 0.095 to 0.13 percent (Table 1). Chaudhury and Ahsan [14] observed a similar range (0.09 to 0.12%) of TN for Bilashcherra experimental farm of Bangladesh Tea Research Institute. Most of our soil samples contain slightly higher values of TN than that of the critical value (0.1%) for tea cultivation [20].

C/N ratio plays an important role in the synthesis of new microbial cells, which in turn die and are decomposed by other microorganisms. The C/N ratio of the studied soils ranges from 8.25 to 9.38 (Table 1) and is lower than the critical value, 10, for tea cultivations [20]. This narrow C/N ratio indicates that the organic matter fraction of the soils is highly oxidized and the associated microbes are quite active. The distribution pattern of C/N ratio amongst different topographic positions and depths is irregular. For some rubber plantation area of Bangladesh Zaman *et al.* [2], Anam *et al.* [3], and Hossain and Khan [9] have also reported similar kind of variations for C/N ratio with depths.

Phosphorus is an important plant nutrient. It plays a decisive role in the normal growth of tea and also stimulates the development of roots. It

was found that the available phosphorus (AP) of Rungicherra tea estate varied from 2.31 to 4.02 ppm (Table 1). It should be noted here that the hill top soils of 0-9″ depth contain the highest value for AP. The experimental data indicate that the soils are deficient in AP and the values are significantly lower than that of the critical value (10 ppm) for the cultivation of tea [20]. This low content of AP may be due to the conversion of AP into unavailable form by microorganisms and / or phosphate fixation by aluminum in the prevailing acidic conditions. Moreover, AP content of soil may be varied due to the difference in formation of organic phosphorus compounds by decomposition of organic matter and other vegetations.

The experimental data for OC, OM, TN, C/N and AP have been analyzed by using Two-way ANOVA to see the effect of topography as well as depth on the measured parameters. The values of F statistics, probability (applicability of null hypothesis) and least significant difference at 95% confidence level (LSD 0.05) are tabulated in (Table 2) and (Table 3). F values for OC, OM, TN and AP due to topographic variations are found to be 13.814, 13.808, 47.391 and 27.035 respectively (Table 2). These values of F are significant at 0.00 level *i e.* topographic variations have a significant effect on OC, OM, TN and AP content of the studied soils. On the other hand, value of F (0.062) with a high probability value (0.9403) indicate that the variation of topography has almost no effect on C/N *i.e.* null hypothesis is valid for this parameter. While working for different soil depths it has been found that F values for OC, OM and TN are 7.661, 7.726 and 7.090 respectively (Table 3). These values of F are significant at less than 0.25 % level. These indicate that OC, OM and TN values also vary significantly with soil depths. F statistics for C/N and AP are 1.453 and 2.206, respectively, which are not significant at more than 10% level and indicate that C/N and AP do not vary significantly with soil depths.

The influence of variations of topography and soil depth on OC, OM, TN, C/N and AP are shown graphically in Figs.1-3. Examination of these Figures reveals the following:

(a) OC and OM are found to vary significantly with topographic position and soil depth. These variations may be due to difference in washing, air oxidation and decay of plant residues etc.

(b) The variation of TN with topography as well as depths is not so remarkable as those observed for OC and OM.

(c) OC, OM, TN, C/N and AP values are found to follow the following sequences amongst the topographic positions and soil depths irrespective of their magnitudes of variations:

(i) Hill top > Hill slope > Hill base and

(ii) Top soil (0-9″) > Sub soil (9-18″) > Substratum soil (18-36″).

Conclusion

Organic carbon, total nitrogen and available phosphorus content of the studied soils are poor. Some soil samples are found to show slightly higher organic carbon and total nitrogen contents than those of the critical values for tea cultivation, but their available phosphorus content is lower than that of the critical value. To improve the quality and yield of tea of Rungicherra Tea-estate of Bangladesh, nutrient status of soils should be maintained above the optimum range with proper drainage condition and shade.

Table - 1. Total nitrogen (TN), available phosphorus (AP), organic carbon (OC), organic matter (OM) and carbon/nitrogen ratio (C/N) of soils of Rungicherra Tea-estate.

Depth	Topography	OC	OM	TN	CN	AP
0-9”	Hill top	1.24±0.18	2.14±0.32	0.13±0.01	9.28±2.21	4.02±0.75
	Hill slope	1.1±0.18	1.9±0.32	0.11±0.007	9.38±2.12	3.63±0.45
	Hill base	0.94±0.15	1.62±0.26	0.10±0.005	8.85±1.75	2.72±0.42
9-18”	Hill top	1.09±0.11	1.88±0.19	0.12±0.12	8.58±1.25	3.80±0.80
	Hill slope	0.95±0.17	1.6±0.29	0.11±0.005	8.41±1.61	3.43±0.42
	Hill base	0.83±0.23	1.43±0.39	0.1±0.006	8.39±2.57	2.51±0.38
18-36”	Hill top	1.01±0.07	1.75±0.12	0.12±0.01	8.28±1.04	3.65±0.82
	Hill slope	0.90±0.08	1.5±0.14	0.11±0.006	8.25±0.83	3.26±0.40
	Hill base	0.79±0.11	1.37±0.19	0.095±0.005	8.36±0.98	2.31±0.41

Table – 2 . Effect of topography on total nitrogen (TN), available phosphorus (AP), organic carbon (OC), organic matter (OM) and carbon/nitrogen ratio(C/N) of soils of Rungicherra Tea-estate.

Parameter	Topography			F-statistics @ df=2	LSD0.05	Probability
	Hill top	Hill slope	Hill base			
OC%	1.11a	0.98b	0.85c	13.814	0.09985	0.0000
OM%	1.92a	1.70 b	1.47c	13.808	0.17255	0.0000
TN%	0.12a	0.11b	0.10c	47.391	0.00597	0.0000
C/N	8.71a	8.68a	8.53a	0.062	--	0.9403
AP (ppm)	3.82a	3.44b	2.51c	27.035	0.36856	0.0000

Note: Values followed by same letter are not significant at 0.05 LSD

Table – 3. Effect of depth on Total nitrogen (TN), available phosphorus (AP), organic carbon (OC), organic matter (OM) and carbon/nitrogen (C/N) of soils of Rungicherra Tea-estate.

Parameter	Depth			F-statistics @ df=2	LSD0.05	Probability
	0-9”	9-18”	18-36”			
OC%	1.09a	0.96b	0.90b	7.661	0.09985	0.0013
OM%	1.89a	1.65b	1.56b	7.726	0.17255	0.0012
TN%	0.12a	0.11b	0.11b	7.090	0.00597	0.0020
C/N	9.17a	8.46a	8.30a	1.453	--	0.2438
AP (ppm)	3.46a	3.25a	3.07a	2.206	--	0.1209

Note: Values followed by same letter are not significant at 0.05 LSD.

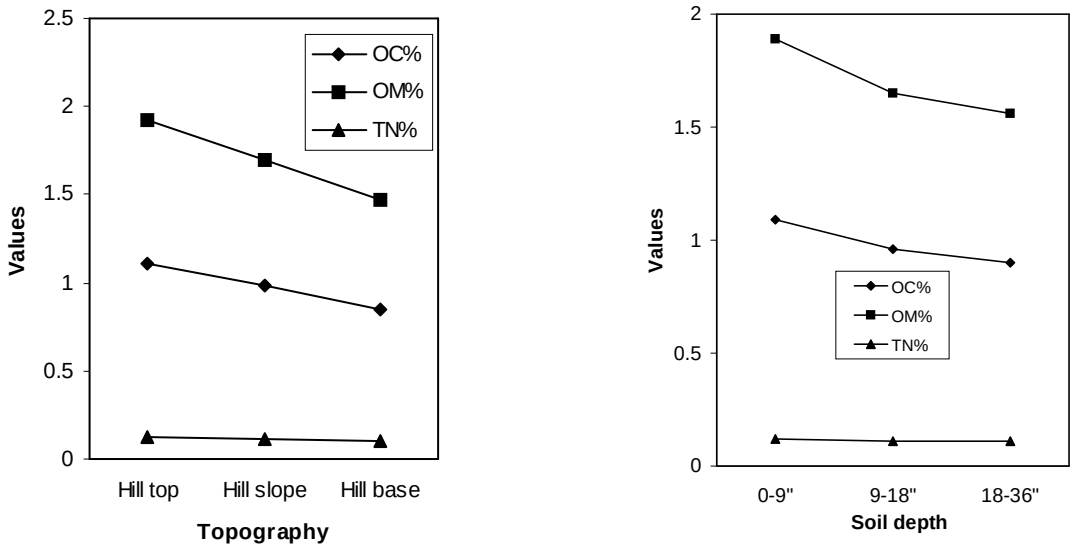

Fig.1. Total nitrogen (TN), organic carbon (OC) and organic matter (OM) influenced by topography and depth of soils of Rungicherra Tea-estate.

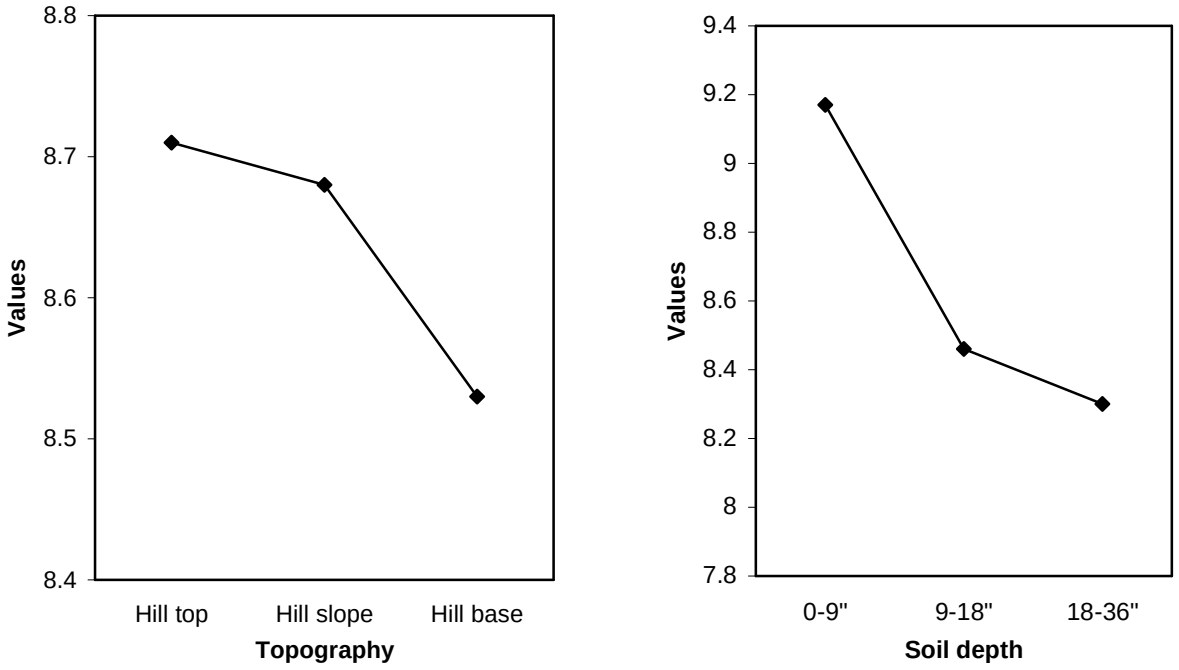

Fig. 2. Carbon/nitrogen (C/N) influenced by topography and depth of soils of Rungicherra Tea-estate.

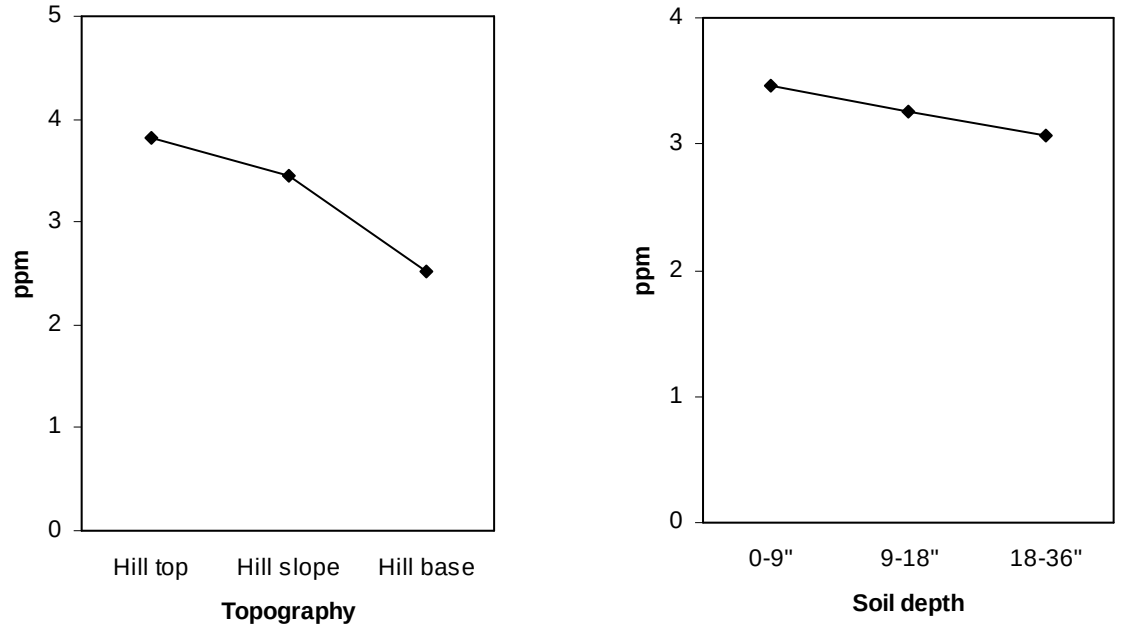

Fig. 3. Available phosphorus (AP) influenced by topography and depth of soils of Rungicherra Tea-estate.

References

1. M.M. Hassan and A.T.M.N. Islam, *Ind. J. For.*, 7 (1984) 217.
2. M.B. Zaman, A.R. Mazumder, N. Ahmed, M.S. Hussain and S. Rahman, *Bang. J. Soil Sci*., 20 (1984) 7.
3. K. Anam, S.M.I. Huq, A. Aziz and M. Ahmed, *Bang. J. Soil Sci*., 14 (1978)161.
4. M.M. Hassan and A.H. Mazumder, *Ind. J. For.*, 13 (1990) 281.
5. Z.H. Khan, A.R. Mazumder, M.S. Hussain and S.M. Saheed, *J. Ind. Soc. Soil Sci*., 45 (1997) 89.
6. Z.H. Khan, A.R. Mazumder, M.S. Hussain and S.M. Saheed, *J. Ind. Soc. Soil Sci*., 46 (1998) 485.
7. Z.H. Khan, M.S. Hussain and A.R. Mazumder, *Bang. J. For. Sci*, 27 (1998)114
8. A.K.M.N. Islam, A.J.M.S. Karim, M.A. Rahman, M.M. Begum and K.M. Khalequzzaman, *Bang. J. Agr. Res*., 27 (2002) 553.
9. A. T.M.E. Hossain and Z.H. Khan, *Bang. J. For. Sci.*, 29 (2000)112.
10. M.A. Zaman, A.S.M. Mohiuddin, A.R. Mazumder and M. S. Hussain, *Bang. J. Soil Sci.*, 23 (1992) 15.
11. S.H. Chaudhury, *Tea J. Bang*., 14 (1978) 2.
12. S.H. Chaudhury and K.M. Shome, *Tea J. Bang.*, 14 (1978) 12.
13. S.H. Chaudhury, A. K. M. G. Kibria and K. A. Hasan, *Tea J. Bang*., 11 (1975) 20.
14. S.H. Chaudhury and Q. Ahsan, *Tea J. Bang.*, 15 (1979) 13.
15. S.H. Chaudhury, K. A. Hasan and M. Molla, *Tea J. Bang.*, 7 (1969) 9.
16. M. Shamsuddin Ahmed, M.R. Zamir and A. F.M. Sanaullah, *Int. J. Agr. Biol*., (2005) *in press*.
17. M.L. Jackson,. *Soil Chemical Analysis* (Prentice Hall of India, Pvt. Ltd., New Delhi) 1/e (1973) 498.
18. C.S. Piper, *Soil and Plant Analysis* (Interscience, New York) (1942) 221-222.
19. R.H. Bray and L.T. Kurtz, *Soil Sci*., 59 (1945) 39.
20. A.K.M.G. Kibria and M.A. Rashid, *Fertilizer Recommendation for matures Tea*, Bang. Tea Res. Inst. Pamphlet No.21, Srimangal, Moulvibazar, (1994) 7