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EVALUATING SOILS FERTILITY OF TEA GARDENS OF NORTH EAST BANGLADESH

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Abstract: Soils from tea garden in Sylhet and Moulovibazar, North East Bangladesh were analyzed for texture, organic matter, loss of moisture, pH, N, C/N ratio, Na, K, Ca, Mg, S, Fe, and Al. The soils are loamy to sandy loam, extremely acidic to acidic. They were very low in organic matter (0.87-1.60%), nitrogen content (0.051-0.121%) and pH (3.75-4.90). The exchangeable bases – Ca, Mg, Na and K - are also very low due to their leaching under existing acidic conditions. The C/N ratio is very low. The studied soils contain higher concentration of Fe, Al, and S. These soils are not ideal for tea cultivation because of low pH, organic matter, nitrogen, Na, Ca, Mg, and K contents. The data were statistically analyzed by LSD at 5% level of significance.

Key words: Tea soil, tea garden, Bangladesh, physico-chemical characters and nutrient status

Introduction

Human civilization has discovered so far three non-alcoholic stimulating beverage namely, coffee, tea and cola. Among these tea is to be considered as the most popular and cheapest temperate drink in the world. An abundant supply of nitrogen and organic matter is essential for the vegetative growth of tea plants. The present nutritional condition of Bangladesh old tea soil indicates that the nitrogen level is satisfactory but the level of organic matter is poor to marginal (Gerzabek and Ullah, 1989). Organic matter in the form of cow dung, compost or green manuring crops may be *added* to the soil in order to improve the fertility of the soils (Ali and Faizullah, 1973). This will also increase the cation exchange capacity and activity of microorganisms in the soil. Very high aluminium, which is the main problem of strong acidity and decline in crop yield, must be brought to a safe level by the application of lime (Chaudhury, 1983).

This study analyzed the status of soil texture, Soil moisture, Particle size, Organic Carbon, Total nitrogen, pH, Na^{+}, K^{+}, Ca^{2+}, Mg^{2+} Al, Fe P and S from five old tea gardens situated in the North East Bangladesh.

Materials and Methods

Sampling sites: The sites selected for collecting the samples were five old (1857-1920) tea gardens in Sylhet and Moulavibazar districts for the experiments. The gardens were Sona Rupa

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Tea Estate, Pulchara Tea Estate, Zareen Tea Estate, Nurjahan Tea Estate and Malnichara Tea Estate.

Collection of soil sample: Soil samples were collected from the soil profiles at a depth of 0-5, 5-10, 10-15, 15-20 cm respectively from five tea estates during the month of May, 2005. Three pits were dug in each of the tea estates and five soil samples were collected from each depth segment of the profile. Samples from respective depths were well mixed to prepare composite samples were prepared. The physical and chemical properties analyzed are Loss of moisture, Particle size, Textural class, Organic carbon (OC) and organic matter (OM), pH, total N, C/N ratio, Exchangeable K^+, Ca^{2+}, Mg^{2+}, Na^+, available Al^{3+}, Fe^{2+}, S and P – following standard methods as presented in Table 1.

Table 1. Standard methods used in the laboratory for analyze physical and chemical properties of soil.

Parameters	Methods	References
Loss of moisture	Oven dry method	Black (1965)
Particle size	Hydrometer method	Black (1968)
Textural class	Using Marshall's triangular coordinates	USDA (1951)
Organic carbon	Volumetric method	Black (1965)
Total nitrogen	Micro-kjeldhal's method	Jackson (1962)
pH	pH meter (model-7)	Jackson (1962)
Na^+, K^+, Ca^{2+}, Mg^{2+}	Ammonium acetate method	Piper (1950)
Al, Fe and P	Acid digestion method	Vdlufa (1975)
S	Turbidimetric method	Jackson (1962)

Results

The loss of moisture is 3.19 to 5.10% in the investigated soils. For locations, the F value of moisture loss is 17.20 so, there is significant difference among the 5 tea estates with respect to soil moisture contents at 5% level of significance. Vertically the F value is 0.698, so, there is insignificant difference among depths. The soils of the tillah are loamy and sandy loam (Table 2).

The soils of high flat and medium flat are sandy clay loam. The contents of sand, silt and clay in the 5 different tea estates varied widely among themselves. The F value of sand, silt and clay was 36.04, 27.66 and 24.46 respectively indicating that there was significant difference among tea estates at 5% level of significance. However, vertically value is less 2.20, 2.81 and 2.31 so there is no significant difference in sand, silt and clay contents at different depths of the soil profile. The Organic matter contents of the soils were generally low (0.87-1.60%) (Table 2). The F value of organic carbon is 0.081 for locations and 0.001 for depths and does not show significant statistical difference both spatially and vertically among the stations. Soil pH is an important parameter for tea cultivation. The pH of the surface soil is slightly higher than the subsurface soil in almost all the samples (Table 3).The F value of pH is 3.21 for locations and 0.72 for depths and does not show significant statistical difference both spatially and vertically among the stations. The tea estates are very poor in nitrogen contents (0.051-1.121%) (Table 3). The F value of total nitrogen is 7.78 for locations and 0.73 for depths so there was no spatial variation however, vertical variation is statistically significant at 5% level of significance. The C/N ratio of the five tea estates ranges 5.31-11.90. (Table 3). The amount of available phosphorus was high (11to 39 mg Kg^{-1}) in the soils. (Table 3). The tea soils did not differ significantly in available P contents and also P is uniformly distributed at different depths. The soils varied widely in exchangeable K^+, Ca^{2+}, Mg2+, and Na^+ contents both spatially and vertically. The exchangeable cations of the soils in all places are generally low (Table 4). The F value of K^+, Ca^{2+}, Mg^{2+}, and Na^+ was 27.67, 33.69, 78.75 and 1.99 for locations and 2.48, 3.33, 0.75 and 1.71 for depths so tea estates varied significantly among themselves in exchangeable K^+, Ca^{2+}, Mg^{2+}, and Na^+ contents, but no significant difference was observed in exchangeable K^+, Ca^{2+}, Mg^{2+}, and Na^+ at different depths of the soil profiles.

Aluminium concentrations were generally high (1.2-8.47 $mg.Kg^{-1}$) and varied widely among the tea estates (Table 3).The highest concentration of Al was found in soils of Nurjahan tea estate (3-8 $mg.Kg^{-1}$ soil) and the lowest in Zareen and Malnichara tea estates (1.2-3.1 $mg.Kg^{-1}$ soil) (Table 3). The F value of Al is 10.11 for locations and 1.91 for depths so tea estates varied significantly in their Al contents in soils; while there was no difference in Al distribution in the profile of the tea estates. The results showed that there was an appreciable amount of the soluble iron in the soil of tea estates which ranges 12-43 $mg.Kg^{-1}$ (Table 3).

The results further showed that the tea estates differed widely in their iron contents. The F value of Fe^{2+} is 8.03 for locations and 3.38 for depths so soils of the tea estates varied significantly from each other, but differenceis relatively less significant at various depths. Soils are very rich in available S, ranging from 85 to 198 $mg.Kg^{-1}$ soil (Table 3). The F value of S contents was 0.73 for locations and 0.15 for depths so statistically no significant difference in available S contents was observed among the tea estates both spatially and vertically.

Table 2. OM, loss of moisture and textural classes in the sampled soils.

Name of tea garden	Depth (inch)	%OM	Loss of Moisture %	%Sand	%Silt	%Clay	Textural class
1.Sona Rupa Tea Estate (SRTE)	0-5	1.06	4.71	39.82	35.72	24.46	L
	5-10	1.17	4.22	40.17	34.87	24.96	L
	10-15	1.05	4.40	38.95	35.17	25.88	L
	15-20	1.04	4.12	40.76	34.52	24.72	L
2.Pulchara Tea Estate (PTE)	0-5	1.20	3.19	58.72	20.44	20.84	SCL
	5-10	1.22	3.22	54.89	22.32	22.75	SCL
	10-15	1.24	3.71	55.33	21.18	23.49	SCL
	15-20	1.16	3.54	57.81	21.79	20.40	SCL
3.Zareen Tea Estate (ZTE)	0-5	1.22	4.14	57.71	20.71	21.58	SCL
	5-10	1.12	4.10	79.10	19.31	21.59	SCL
	10-15	1.15	4.10	60.52	18.89	20.59	SCL
	15-20	1.32	4.90	58.18	19.52	22.30	SCL
4.Nurjahan Tea Estate (NTE)	0-5	1.08	5.10	55.40	22.40	22.2	SCL
	5-10	0.87	4.98	42.50	33.00	24.50	L
	10-15	0.98	4.80	50.20	26.50	23.30	SCL
	15-20	0.92	5.0	54.00	24.60	21.4	SCL
5.Malnichara Tea Estate (MTE)	0-5	1.60	3.90	63.49	24.45	11.98	SL
	5-10	1.58	4.10	57.22	24.18	18.57	SL
	10-15	1.54	3.75	59.07	25.44	15.55	SL
	15-20	1.48	4.17	58.77	24.79	16.44	SL

SCL=Sandy clay loam, SL=Sandy loam, L=Loam

Table 3. pH, N, C/N Ratio, Al^{3+}, Fe^{2+},S and P contents in theS soils.

Name of Garden	Depth (Inch)	pH	%N	C/N Ratio	Al^{3+}	**Fe^{2+}**	S	p
					mg Kg^{-1}			
STE	0-5	4.30	0.072	8.61	3.5	33	110	18
	5-10	4.20	0.059	11.50	2.8	24	134	22
	10-15	4.05	0.067	9.11	3.3	37	98	30
	15-20	4.00	0.051	11.85	3.8	27	153	21
PTE	0-5	4.00	0.090	7.45	6.11	16	191	11
	5-10	3.90	0.083	8.58	4.44	28	90	19
	10-15	3.75	0.098	7.38	3.89	31	142	27
	15-20	3.60	0.091	7.45	5.10	12	108	18
ZTE	0-5	4.25	0.068	10.38	2.5	16	128	21
	5-10	4.40	0.061	10.57	2.7	19	154	17
	10-15	4.05	0.060	11.25	1..2	24	85	31
	15-20	4.25	0.064	11.98	1..9	12	180	19
NTE	0-5	4.50	0.121	5.22	8.47	38	198	33
	5-10	4.40	0.095	5.31	8.27	27	172	31
	10-15	4.00	0.11	5.20	6.58	41	196	20
	15-20	4.10	0.09	5.92	3.33	43	95	17
MTE	0-5	4.90	0.064	11.90	3.0	30	103	22
	5-10	4.30	0.078	11.82	3.5	28	132	39
	10-15	4.20	0.066	11.54	2.7	36	141	25
	15-20	3.90	0.064	11.53	1.8	25	114	38

Table 4. Exchangeable Na^+, K^+, Ca^{2+}, Mg^{2+} contents in the sampled soils.

Name of Garden	Depth (Inch)	Na^+	K^+	Ca^{2+}	Mg^{2+}
		meq/100g soil			
STE	0-5	0.31	0.50	0.52	0.16
	5-10	0.24	0.41	0.39	0.13
	10-15	0.39	0.54	0.48	0.21
	15-20	0.33	0.39	0.43	0.11
PTE	0-5	0.66	0.14	0.73	0.23
	5-10	0.42	0.13	0.81	0.19
	10-15	0.35	0.23	0.76	0.20
	15-20	0.48	0.17	0.86	0.18
ZTE	0-5	0.72	0.32	0.62	0.22
	5-10	0.49	0.25	0.61	0.15
	10-15	0.80	0.42	0.60	0.35
	15-20	0.85	0.40	0.58	0.27
NTE	0-5	0.95	0.18	0.12	0.26
	5-10	0.65	0.19	0.16	0.31
	10-15	0.72	0.21	0.11	0.32
	15-20	0.93	0.14	0.17	0.38
MTE	0-5	0.14	0.11	0.14	0.11
	5-10	0.18	0.09	0.10	0.12
	10-15	0.16	0.14	0.32	0.30
	15-20	0.13	0.21	0.16	0.28

Discussion

The moisture was more or less evenly distributed in the same profile of soil. Probably the tea roots absorbed water uniformly from all the investigated depths of soil profiles (Ranganathan and Natasan, 1987). Tea grows on soils of various textural classes, the sandy loam is considered to be the best (Hasan and Chawdhury, 1966), because it can pass water through the pores and water stagnancy is harmful for tea cultivation (Sana, 1989). Tillahs are suitable for the tea cultivation. The increase of clay content with depth restrict the percolation of water to reach the tea roots thus top soil is more suitable than subsoil for tea cultivation (Sarma, 1960). Organic matter is low in the investigated soil (<2%) which influencing the contents of soil nitrogen. None of the authorities recommends the growing of tea where pH is greater than 6.0.(Chaudhury, 1983).

For many years North East India and Bangladesh relied on ammonium sulphate application during the 1930,s (Cooper, 1939) but 15 to 20 years of continuous ammonium sulphate application was enough to exhaust the Bangladesh tea soils of most of their bases (Moinuddin, 2005). The old tea soil of Bangladesh has been suffering from strong acidity resulting from the continuous application of ammonium sulphate and high leaching. A soil consisting less than 0.1% N is considered poor for tea cultivation (Hasan *et al.*, 1974). C/N ratio in the soil is also considered to be important because it is helpful in assessing the influence of OM on plant growth. Lower the C/N ratio, the more rapid is the decomposition and hence the greater is the mineralization of organic nitrogen (Harler, 1956). Higher C/N ratio lowers the decomposition because they have no sufficient nitrogen to sustain the microorganisms responsible for decomposition (Islam and Hossain, 1974). The C/N ratio of the soils of five tea estates is much less than 12 in most cases indicating that the organic matter present in the soils are well decomposed and in the forms of brown and gray humic acids rather than undecomposed or fulvic acid form. (Gerzabek and Ullah, 1989).The mineralogy of the soils is responsible for available phosphorus. The contents of K, Ca, Mg and Na were very low in the soils probably because of leaching of these cations under acidic conditions (pH=4). Such low contents of these exchangeable bases might influence the CEC of the soils that affect nutrient retention in the soil profile. Generally the values of exchangeable cations are higher in the top soil, as a result of higher organic matter (Harrison, 1932). The pH of most of the soils was around 4.0. The concentration of Al in the investigated soils is very high. The high concentrations of Al in the tea soils might have contributed to high acidity of the soils (Eden, 1928) and its high content in the soils might be associated with the mineralogical composition of the soil (Eden, 1952). The high concentrations of Fe were due to low pH of the soils (Ali,1999; Cooper, 1946). The results further showed that the tea estates differed widely in their iron contents. The results also indicated that soils are very rich in available S, which ranged from 85-198 mg/kg soil (Table 3).

Conclusion

The soils are very poor in OM and nitrogen contents both at the surface and at various depths. The pH of the soils (4.0) are at low critical level for tea cultivation compared to those of the other tea soils of the world (Child,1953). The exchangeable bases of the soils are also very low due to leaching of Ca, Mg, K and Na under acidic conditions. The investigated tea estates are generally poor in plant nutrients. Malnichara tea estate is particularly very different in nutrient elements.

Soluble alumunium and iron in the soils are very high and may be in toxic concentrations. The available phosphate content in the soils is very low.

The application of soluble phosphate fertilizer may be preceded by the application of lime (Anonymous,1935). It may further be concluded that a project development programme should be established based on the soil properties. Such research should have priority in relation to soil management techniques concerned mainly with soil acidity neutralization, increased fertility and organic matter conservation.

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