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CATIONIC ENVIRONMENT IN SOME SELECTED TEA SOILS OF BANGLADESH

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The cationic status of soils of Rashidpur, Nurjahan, Jagcherra, Daragaon and Udnacherra tea estates was determined. These soils contained between 310 and 700 mg K per 100 g soil but its available form was not proportionately high. Magnesium content varied between 100 and 210 mg per 100 g soil with a ratio between exchangeble form and total less than 1.7×10^{-2}. They contained small amounts of Ca but half of the total Ca was present in the exchangeable form. Manganese content varied between 10 and 37 mg per 100 soil with trace amounts of Cu and Zn. Potassium, Mg and trace elements were intimately associated with the clay-size fractions in the different depths of the soil profiles.

The exchangeable basic cations had been depleted from these soils. Most of the soils contained over 85% Al in the exchange sites. Hydrogen ion concentration had considerably increased with the pH between 4.0 and 4.8. The degradation of clay minerals in these soils was propably due to acid weathering; the adsorbed H^+ ions caused instability of the clay lattices with the ultimate disintegration of part of its structure and subsequent release of Al^{3+} ions in solution.

INTRODUCTION

The tea plant is a perennial and remains on the same land for several years. Its nutrient needs are met by the soils inherent nutrient supplying capacity as well as by the application of fertilizers. The traditional methods for increasing the yield of old tea plantations including manuring were found to be inadequate. Many of the tea soils were depleted of the essential elements, where considerable amounts of clay-size fraction were also removed over years of tea cultivation (Hasan *et al.*, 1974). This results in soils with low cation exchange capacities and an imbalance of cations.

It is, therefore, pertinent to study the cationic status of some old tea soils, whose detailed mineralogy is known (Karim *et al.*, 1978) so as to better understand their fertility status. This might also help in understanding the processes of soil mineralogical destruction. The above will help to preserve the soils' productivity potential by adopting suitable methods and controlling the rate of degradation of soil minerals.

This study is aimed at analysing the cations of some selected tea soils of Balisera circle and giving the probable causes of their current status. Knowledge of soil properties will thereby aid to evaluate the yield potential of old tea soils and develop rational soil management practices, including soil amendment and a balanced fertilizer programme.

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MATERIALS AND METHODS

Five brown hill old tea soils from Rashidpur, Nurjahan, Jagcherra, Daragoan and Udnacherra tea estates of Balisera Circle of Bangladesh were used in this study. Soil samples were collected from 0—9," 9—18" and 18—36" depths of the profile. 0.2 g of finely ground oven-dried soil was digested in analar 60% perchloric acid, which was used for the determination of K, Mg, Ca, Mn, Cu and Zn. Exchangeable bases were displaced by leaching with ammonium acetate solution and exchangeable Al was removed by leaching with an unbuffered 1N KCl solution. Active fractions of iron and aluminium were extracted by acidified ammonium oxalate dissolution procedure (Tamm, 1922; Schwertmann, 1964). Sodium, K, Mg, Ca, Mn, Cu, Zn, Fe and Al in different extracts were determined by atomic absorption spectrophotometer. For Al N_2O was used as oxidising gas and all other elements were determined in the air-acetylene flame.

RESULTS AND DISCUSSION

Basic Cations in Soils

It appeared from Table 1 that all these soils contained considerable amounts of total K, ranging between 310 and 700 mg/100 g soil and the content gradually decreased down the profile. Daragoan and Udnacherra tea estate soils contained maximum amount of total K and it is more than double at 18—36" layer than at the surface layer in Daragaon soil. Magnesium content varied between 100 and 210 mg per 100g soil and this also increased down the profile. All these soils contained small amounts of Ca ranging from 3.7 to 11.8 mg per 100 g soil, being maximum at the surface. Exchangeable K and Mg for all these soils are very low but they vary widely amongst different soils and in various profile depths (Table 2). Exchangeable Ca varied between 0.10 and 0.33 m eq. per 100 g soil.

TABLE 1 — *Total cation content of different tea estate soils (mg per 100 g oven-dried soil)*

Soil	*Depth* (inch)	*K*	*Ca*	*Mg*	*Mn*	*Cu*	*Zn*
Rashidpur	0—9	310.0	7.7	120.0	10.0	1.2	2.5
	9—18	310.0	6.0	120.0	11.0	1.0	2.2
	18—36	490.0	4.8	170.0	15.0	1.8	3.2
Nurjahan	0—9	420.0	6.7	140.0	25.0	1.1	3.5
	9—18	450.0	5.0	150.0	28.0	1.2	3.7
	18—36	440.0	4.2	130.0	37.0	1.0	2.6
Jagcherra	0—9	330.0	11.8	120.0	16.0	0.5	2.6
	9—18	350.0	8.8	140.0	14.0	0.7	3.1
	18—36	360.0	6.0	130.0	13.0	0.8	3.2
Daragoan	0—9	320.0	8.3	100.0	10.1	1.1	2.3
	9—18	590.0	3.7	180.0	14.0	2.2	3.1
	18—36	680.0	4.4	210.0	16.0	2.6	4.2
Udnacherra	0—9	450.0	6.5	140.0	16.0	1.4	2.4
	9—18	480.0	5.3	150.0	14.0	1.5	2.7
	18—36	700.0	6.5	200.0	14.0	2.6	3.5

Sodium, K, Mg and Ca occur in soils as constituents of silicates composing the mineral fraction of the soils, as exchangeable cations and as simple inorganic salts. The increasing K and Mg content down the profile is consistent with the increased clay content in all these soils (Table 1 and 3). All these soils were dominated by kaolinite with some mica and trace of smectite and vermiculite. The kaolinite present was largely altered and deformed with irregular broken edges (Karim *et al.*, 1978). The potash content of these soils (Table 1) in general was reasonably good but its available from (Table 2) was not proportionately high. This might be due to the presence of variable amounts of smaller weather resistant K-Silicates in these soils as evidenced by X-ray diffraction and electron microscopic examinations (Karim *et al.*, 1978). In such soils application of potash manure may benefit.

In these soils over half of the total Ca was present in the exchangeable form (Table 1 and 2). For successful tea cultivation soils should contain Ca within the range of 0.07 to 0.14% (Hasan *et al.*, 1974). Total Ca content in all these soils was between 0.004 and 0.012% ,indicating that these soils were severaly depleted of Ca due to cultivation of tea over the years. The idea that tea is a calcifuge was not supported (Eden, 1967), since Ca is the most abundant mineral constituent in the tea plant with a concentration of 0.5 to 0.7% (TRIEA, 1954). Thus, addition of Ca to the soil may benefit tea plantations. All these soils had large amounts of total Mg but its exchangeable form constituted only a small portion. The ratio between the exchangeble and total Mg. was less than 1.7 x 10^2 in all the soils,. The tea plant is very sensitive to excess Mg in soils (Hasan *et al.*, 1974). The above ratio indicated that the Mg content was within the safe limit for tea cultivation and the total reserve in these soils ensured continued supply for plant uptake over several years.

TABLE 2 — *The exchangeable cations and CEC of different tea estate soils. (m eq. per 100 g oven-dried soil)*

Soil	*Depth (inch)*	*Na*	*K*	*Ca*	*Mg*	*Al*	*TEB*	*CEC*	*% Salt*
Rashidpur	0—9	0.04	0.08	0.18	0.17	3.00	3.66	3.66	18.03
	9—18	0.04	0.05	0.10	0.02	0.88	0.88	3.19	9.80
	18—36	0.03	0.05	0.16	0.05	0.77	0.39	5.16	7.63
Nurjahan	0—9	0.01	0.12	0.11	0.30	4.18	0.27	4.45	6.10
	9—18	0.01	0.40	0.11	0.02	4.19	0.55	4.47	11.58
	18—36	0.01	0.90	0.17	0.04	3.96	0.31	4.29	7.19
Jagcherra	0—9	0.07	0.10	0.29	0.06	2.89	0.51	3.40	15.00
	9—18	0.07	0.05	0.26	0.04	3.38	0.43	3.81	11.21
	18—36	0.04	0.04	0.21	0.09	3.27	0.41	3.68	11.14
Daragoan	0—9	0.06	0.07	0.27	0.06	0.70	0.44	3.14	14.04
	9—18	0.09	0.08	0.10	0.03	4.65	0.29	4.95	5.98
	18—36	0.10	0.07	0.11	0.09	4.99	0.38	5.37	7.19
Udnacherra	0—9	0.02	0.13	0.14	0.03	4.50	0.33	4.83	6.85
	9—18	0.02	0.12	0.16	0.02	4.52	0.32	4.48	6.65
	18—36	0.02	0.12	0.33	0.10	4.82	0.57	5.39	10.57

Manganese, Cu and Zn in Soils

Manganese content varied between 10 and 37 mg. per 100 g in all the soils, except in soils of Jagcherra and Udnacherra where it decreased down the profiles. All the tea soils studied contained only small amounts of Cu and Zn which progresssively increased in the sub-surface layers (Table 1).

Manganese, Cu and Zn in the soil are largely present as impurities in compounds of other elements (Forbes *et al.*, 1976; Hodgson, 1963). Many of them may have isomorphously replaced a very small proportion of the major ions constituting clay silicates and others are absorbed when precipitates such as iron, aluminium and manganese oxides are formed (Le Riche and Weir, 1963). The trace elements were intimately associated with the clay and active fraction of aluminium, since trace elements increased with increasing amounts of clay and active A1 fraction down the soil profiles (Table 1 and 3). These elements may be chemically bonded with the above-mentioned compounds and this may limit the uptake of trace elements by the tea plant.

TABLE 3 — *The pH and active fractions of various tea estate soils.*

Soil	*Depth (in.)*	*pH*	*% Clay*	*% Active Fe*	*% Active Al*
Rashidpur	0—9	4.7	15	0.16	0.21
	9—18	4.8	16	0.17	0.21
	18—36	4.5	29	0.22	0.27
Nurjahan	0—9	3.3	21	0.15	0.24
	9—18	4.2	22	0.12	0.25
	18—36	3.4	23	0.08	0.25
Jagcherra	0—9	4.4	15	0.10	0.21
	9—18	4.4	17	0.11	0.22
	18—36	4.4	17	0.09	0.22
Daragoan	0—9	4.4	14	0.16	0.21
	9—18	4.4	31	0.19	0.29
	18—36	4.4	36	6.16	0.33
Udnacherra	0—9	4.1	23	0.24	0.25
	9—18	4.0	25	0.20	0.25
	18—36	4.4	35	0.16	0.31

Exchangeable Acidity

All these soils contained very small amounts of exchangeable bases but a large amount of exchangeable acidity. Aluminium was the principal cation in all these soils but it did not follow any regular distribution pattern in the soil profiles. It increased down the profiles in Jagcherra, Daragaon and Udnacherra soils but decreased in Nurjahan soil profile (Table 2). The percentage base saturation in these soils varied between 18 and 6. This indicated that the exchangeable basic cations had been removed from the soils and replaced by exchangeable acidity. All the tea soils had remarkably large amounts of exchangeable aluminium ion, varying between

2.70 and 4.99 m eq. per 100 g soil (Table 2). These soils may be suitable for tea since tea is an Al accumulator (Chenery, 1955) but the accumulation of such large amounts of Al may lead to the deformation of soil minerals by shuttling of aluminium from clay lattices to hydrous oxides via exchange sites.

Most of the tea soils studied contained over 85% of Al in the exchange sites. Soil mineralogical data reported elsewhere (Karim *et al.*, 1978) reveal that the clay minerals in the tea soils studied are largely altered. Hasan *et al.*, (1974) reported that over a period of thirty years of tea cultivation the clay minerals had disappeared from the soil profiles. In all these soils $(NH_4)_2SO_4$ is being used for a consecutive number of years. Hydrogen ion concentration had considerably built up in these soils, which had pH values between 4.0 and 4.8, while the best range of pH for tea cultivation is reckoned to be 5 — 5.5 (Hasan *et al.*, 1974). Such low values of soil pH may also hinder the availability of some nutrient elements.

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REFERENCES

CHENERY, E. M. (1955). A preliminary study of aluminium and the tea bush. *Plant and Soil.* 6, 174.

EDEN, T. (1976). Tropical Agricultural Series. Tea 3rd ed. London: Longman.

FORBES E. A., Posner, A. M. and Quirk, J. P. (1976). The specific adsorption of divalent Cd, Co, Cu, Pb and Zn on goethite. *J. Soil Sci.* 27, 154.

HASAN, K. A, Chaudhury, S. H., Shome, K. M. and Rahman, M. A. (1974). Nutrient status of the tea soils of Balisera Circle, sylhet. Pamphlet No. 2. Notes on Soil survey. Bangladesh Tea Research Institute, Srimangal, Sylhet.

HODGSON, J. F. (1963). *Adv. Agron.* 15, 119.

KARIM, Z., Rahman, M.A. and Chaudhury, S. H. (1978). Mineralogy of some selected tea and rice soils of Bangladesh. *Bangl. J. Sci. Res.* 4.

LE RICHE, H. H. and WEIR, A. H. (1963). Methods of studying trace elements in soil fractions. *J. Soil Sci.* 14, 225.

SCHWERTMANN, U. (1964). Differenzierung der Eisenoxide des Bodens durch Extraktion mit Ammonium — Oxalat — Losung. A. PfL. Ernahr. Dung. Boodenk. 105, 194.

TAMM, O. (1922). Um bestamning ow de organisk komponenterna i merkens gelkomplex. Medd. Statens. Skogsforsokanst. 19, 384.

TRIEA, (1954). Tea Research Institute of East Africa.