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ESTIMATION OF NITROGEN TRANSFORMING MICROORGANISMS IN SOILS OF DIFFERENT TEA VALLEYS OF BANGLADESH

MA GAFUR AND AFROZA SULTANA

Department of Botany, University of Chittagong, Chittagong-4331, Bangladesh

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Abstract

Physico-chemical properties of soils and quantitative estimation and distribution of population of *Azotobacter*, ammonifying, nitrifying and denitrifying bacteria in soils under tea plants of tea valleys of Bangladesh were studied. Soil texture ranged from loam to clay loam, pH ranged from 4.84 - 5.65 and organic carbon varied between 0.18 and 2.12%. Population of *Azotobacter*, ammonifying bacteria, *Nitrosomonas*, *Nitrobacter* and denitrifying bacteria ranged from 18.0×10^9/g - 88.4×10^9cfu/g soil, 0.20×10^9/g - 0.24×10^9/g soil, 0.20×10^9/g - 0.24×10^9/g soil, 0.20×10^9/g - 0.24×10^9/g soil and 0.17×10^9/g - 0.24×10^9/g soil, respectively. The populations of microorganisms were not related with soil pH and organic carbon. Ammonifying bacteria was positively and significantly correlated with *Nitrosomonas* and *Nitrobacter* and *Nitrosomonas* with *Nitrobacter* at 0.01% level.

Introduction

Tea *Camellia sinensis* (L.) O. Kuntze belongs to Theaceae and its leaves provide worldwide the cheapest and the most popular beverage (Amarakoon 2004). There are 163 tea estates in Bangladesh distributed in Moulovibazar, Habiganj, Chittagong, Sylhet and Panchagar. Small areas in Brahmanbaria and Rangamati have also been planted with tea (Sana 1989).

For a healthy growth and economic production of tea, soil quality determined by its physico-chemical properties and biological activities is of primary concern. Soil texture, organic matter and nutrient status are important criteria. Low organic matter and presence of appreciable amount of iron and aluminium in most tea soils of Bangladesh reduce the availability of phosphate to plants (Kibria 1981). Tea soils are usually acidic due to the prolonged use of nitrogenous fertilizer such as urea and ammonium sulphate to obtain high crop production (Ishaque and Cornfield 1974).

For many nutrients poor ecosystems, nutrient cycling brought about by rhizosphere and non-rhizosphere organisms play a vital role. The cycling of organic matter and nutrients in soil provide healthy biochemical environment around roots of tea plants. Coarse to medium textured acidic soils with low fertility status may affect the rate of nitrification, by *Nitrosomonas* and *Nitrobacter*. Since a few reports are available on microbial activities in soils under tea plants of Bangladesh and little is known about their nitrogen transforming microbial population of soil under tea plantation, the present investigation was undertaken to study the properties of soil and the population and distribution of *Azotobacter*, ammonifying, nitrifying and denitrifying bacteria in soils under tea plantations of seven different circles of Sylhet and Chittagong divisions.

Materials and Methods

Soil samples were collected from different circles with a representative in each circle, namely Balisera, Mono-Doloi, Juri, Lungla, Luskerpure, North-Sylhet and Chittagong (Table 1). Each site was divided into three sub-sites, namely tillah, flat and kunchi. A number of soil samples were collected from each sub-site with an auger at 0 - 15 cm depths and mixed in equal proportion to form a composite sample in May, 2011. There were a total of 21 samples. Soil samples were used for physico-chemical analyses and estimation of the nitrogen transforming microorganisms.

Soil texture was determined by Bouyoucos hydrometer method. Soil pH (1 : 2 soil water ratios) was measured with a digital pH meter (TOA Japan). Soil organic carbon was determined by Walkley and Black (1934) wet oxidation method. For the estimation of microbial population soil samples were diluted for a series of dilutions up to 10^9. *Azotobacter* was cultured in nitrogen free sucrose medium, and ammonifying bacteria in nutrient broth solution (Alexander 1965), *Nitrosomonas* in ammonium-calcium carbonate medium, *Nitrobacter* in nitrite-calcium carbonate medium (Alexander and Clark 1965) and denitrifying bacteria in medium for denitrification test. The population was calculated with the help of MPN chart according to Alexander (1965).

Results and Discussion

The values of the physico-chemical properties of soils appear in Table 1. Soil texture ranged from loam to clay loam in all sampling sites. Clay loam was present in 7 sites, sandy loam in 5 sites, loam in 7 sites, sandy clayey loam and loamy sand in 1 site in each. Sandy loam was maximum in tillah and clay loam in kunchi and flat. Akter (2002) reported similar results of soil texture. The soils were all acidic in reaction. The pH values ranged from 4.84 - 5.65 which agreed with the reports of Chowdhury (1978), Akter (2002) and Adhikari (2003). Generally the pH of the

Table 1. Physico-chemical properties of soils under different circles of tea plantations in Bangladesh.

Circle	Sampling site	Position	Soil texture	pH	Org. C (%)
Balisera	Kalighat Tea Estate	Flat	CL	5.10	0.33
Balisera	Kalighat Tea Estate	Kunchi	SL	5.17	1.30
Balisera	Kalighat Tea Estate	Tillah	SL	5.15	2.12
Chittagong	Oodaleah Tea Estate	Flat	L	4.97	0.94
Chittagong	Oodaleah Tea Estate	Kunchi	L	5.07	0.33
Chittagong	Oodaleah Tea Estate	Tillah	SL	5.33	0.68
Juri	New Sumonbag Tea Estate	Flat	CL	5.17	2.04
Juri	New Sumonbag Tea Estate	Kunchi	CL	5.20	0.32
Juri	New Sumonbag Tea Estate	Tillah	SCL	5.17	1.86
Lungla	Gazipur Tea Estate	Flat	L	5.65	1.91
Lungla	Gazipur Tea Estate	Kunchi	CL	5.19	1.57
Lungla	Gazipur Tea Estate	Tillah	CL	5.32	0.72
Luskerpure	Luskerpure Tea Estate	Flat	L	5.30	1.06
Luskerpure	Luskerpure Tea Estate	Kunchi	CL	5.34	1.25
Luskerpure	Luskerpure Tea Estate	Tillah	CL	5.19	0.19
Mono-Doloi	Mono-Doloi Tea Estate	Flat	L	5.05	1.56
Mono-Doloi	Mono-Doloi Tea Estate	Kunchi	L	5.20	1.23
Mono-Doloi	Mono-Doloi Tea Estate	Tillah	SL	4.84	1.95
North-Sylhet	Malnichara Tea Estate	Flat	LS	5.04	0.18
North-Sylhet	Malnichara Tea Estate	Kunchi	L	5.40	1.57
North-Sylhet	Malnichara Tea Estate	Tillah	SL	5.32	1.29

L = Loam, SL = Sandy loam, SCL = Sandy clayey loam, LS = Loamy sand, CL = Clayey loam.

soils in tea growing countries of the world varies from 3.3 - 6.0, and a soil pH 4.5 - 5.5 is considered to be the optimum for the utilization of nutrients especially nitrogen by tea plants (Natesan 1999). The maximum organic carbon was 2.12% in the tillah of Kalighat Tea Estate followed by 2.04% in flat of New Sumonbag Tea Estate. The lowest was 0.18% in flat of

Malnichara Tea Estate. Organic carbon ranged from 0.18 - 0.94% in 8 sites, 1.06 - 1.57% in 8 sites and 1.86 - 2.12% in 5 sites. BARC (1989) categorized organic matter in agricultural soils of Bangladesh. According to them, 8 sites fall in the very low, 8 sites fall in low and 5 sites fall in the medium category.

Quantitative estimation of populations of *Azotobacter*, ammonifying bacteria, *Nitrosomonas*, *Nitrobacter* and denitrifying bacteria in surface soils under different selected circles were estimated and are shown in Table 2. The highest *Azotobacter* population was 88.4×10^9 cfu/g soil found in kunchi of Monu-Doloi and the lowest 18.0×10^9 cfu/g soil in flat of Monu-Doloi and kunchi of Gazipur Tea Estates. It was observed that *Azotobacter* population was better in tillah. The present findings corroborate well with Zhang *et al*. (1988), Hegazi *et al.* (1979), Ranjana and Nagaraj (1989), Khan and Rahman (2003) and Akond *et al*. (2006).

Table 2. Population of *Azotobacter*, ammonifying bacteria (AB), *Nitrosomonas* (NM), *Nitrobacter* (NB) and denitrifying bacteria (DB) in soils under different circles of tea plantations in Bangladesh.

Circle	Position	*Azotobacter*	AB	NM	NB	DB
		No. of total cfu $\times 10^9$/g soil	MPN $\times$ 10^9 g soil	MPN $\pm$ 10^9/g soil	MPN $\pm$ 10^9/g soil	MPN $\times$ 10^9/g soil
Balisera	Flat	60.5	0.24	0.24	0.24	0.24
Balisera	Kunchi	82.1	0.20	0.20	0.20	0.17
Balisera	Tillah	20.2	0.24	0.24	0.24	0.24
Monu-Doloi	Flat	18.0	0.20	0.20	0.20	0.24
Monu-Doloi	Kunchi	88.4	0.24	0.24	0.24	0.24
Monu-Doloi	Tillah	47.4	0.24	0.24	0.24	0.20
Juri	Flat	40.6	0.24	0.24	0.24	0.20
Juri	Kunchi	34.5	0.24	0.24	0.24	0.24
Juri	Tillah	53.2	0.24	0.24	0.24	0.20
Lungla	Flat	23.5	0.24	0.24	0.24	0.20
Lungla	Kunchi	18.0	0.24	0.24	0.24	0.24
Lungla	Tillah	35.2	0.24	0.24	0.24	0.24
Luskerpur	Flat	25.3	0.24	0.24	0.24	0.20
Luskerpur	Kunchi	38.5	0.24	0.24	0.24	0.20
Luskerpur	Tillah	73.3	0.24	0.24	0.24	0.24
North-Sylhet	Flat	49.5	0.24	0.24	0.24	0.17
North-Sylhet	Kunchi	52.8	0.24	0.24	0.24	0.24
North-Sylhet	Tillah	55.0	0.24	0.24	0.24	0.24
Chittagong	Flat	77.0	0.24	0.24	0.24	0.24
Chittagong	Kunchi	30.1	0.24	0.24	0.24	0.24
Chittagong	Tillah	40.3	0.24	0.24	0.24	0.20

The maximum population of ammonifying bacteria was 0.24×10^9/g soil observed in 19 sites and the minimum 0.20×10^9/g soil in two sites. The findings of the present study agree with Adhikari (2003).

The population of *Nitrosomonas* varied from 0.20×10^9/g - 0.24×10^9/g soil. Nineteen sites had the same population of *Nitrosomonas***.** The range of *Nitrobacter* was similar to that of *Nitrosomonas*. The highest population of denitrifying bacteria was 0.24×10^9/g soil and the lowest was 0.17×10^9/g soil. The above findings agreed with Begum (2001) and Adhikari (2003).

Statistical analyses showed (Table 3) that a significant variation existed between population of ammonifying bacteria and that of *Nitrosomonas*, ammonifying bacteria and *Nitrobacter*, and *Nitrosomonas* and *Nitrobacter*. Ammonifying bacteria was positively and significantly correlated with *Nitrosomonas* and *Nitrobacter* at 0.1% level. Again *Nitrosomonas* was positively and significantly correlated with *Nitrobacter* at 0.1% level. These findings conform well with Mai (1988) and Jha *et al*. (1996). No variation was observed among soil and microbial population but Martyniuk *et al*. (2002) reported that significant correlation between numbers of *Azotobacter* spp. and the contents of organic C in the Polish soils indicated that soil fertility is an important factor for colonization of soils by *Azotobacter*.

Table 3. Relationships among soil properties and microorganisms of soils under different circles of tea plantations in Bangladesh.

	Organic carbon	*Azoto-bacter*	Ammonifying bacteria	*Nitroso-monas*	*Nitro-bacter*	Denitrifying bacteria
pH	0.128	–0.175	0.251	0.251	0.251	0.134
Organic carbon	-	–0.72	0.022	0.022	0.022	–0.091
Azotobacter	-	-	–0.065	–0.065	–0.065	–0.065
Ammonifying bacteria	-	-	-	1.000**	1.000**	0.199
Nitrosomonas	-	-	-	-	1.000**	0.199
Nitrobacter	-	-	-	-	-	0.199

**Correlation is significant at the 0.01% level (1-tailed).

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