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Soil physicochemical characterization of supervised and unsupervised plantations in terai region of Sub-Himalayan West Bengal, India

Sahadeb Sarkar[1], Sourav Chakraborty[1], Mainak Mukherjee[2], Arindam Ghosh[1], Soumya Majumder[1], Sumedha Saha[1], Malay Bhattacharya[1*]

[1] Molecular Biology and Tissue Culture Laboratory, Department of Tea Science, University of North Bengal, Siliguri, Darjeeling, West Bengal, India

[2] Soil analysis laboratory, Department of Tea Science, University of North Bengal, Siliguri, Darjeeling, West Bengal, India

Abstract

Terai region of sub–Himalayan West Bengal is a land of tea and plantation forests. These century old plantations are not only the socioeconomic backbone of the region but also the determinant for the environment and weather conditions. This research initiative was to determine the physico-chemical status of soil in the plantations of this region. Parameters like soil texture, bulk density, moisture content, pH, organic carbon, organic matter, total nitrogen, available phosphorus, potassium, sulphur in soil and micronutrient analysis were conducted in top and sub soil of varied plantations like *Camellia sinensis, Ficus elastica*, *Bambusa vulgaris*, *Shorea robusta*, *Lagerstroemia speciosa*, mixed forest, fallow dry land and fallow wet land areas respectively. Soil texture of the study area was witnessed to be predominantly sandy loam with bulk density of the soil ranging from 0.485 gm/cm^3 to 1.241 gm/cm^3. Good moisture content due to considerable rainfall; acidic pH; high organic carbon, organic matter; moderate nitrogen, phosphorus and potassium with low sulphur content were the overall soil nutritional status of the region. This paper highlights the pattern of nutritional demand and the present status of soil nutrition in terai land of sub–Himalayan West Bengal, providing insights with respect to ecologically sustainable management of soil quality.

Keywords: terai, plantation, soil, ph, macronutrient, micronutrient

Introduction

The origin of the Himalayas is a geological surprise that originated about 70 million years ago with the Indo-Australian plate occurring at the bottom of the Eurasian plate causing the end of Tethys Sea. The soft sedimentary soil of the Tethys Sea folded and rose upward to form the mighty Himalayas (Bhattacharya 2014) [2] while parts of northern plains adjacent to the foot hill areas formed the 'Terai' region. Soil of this region has been reported to be of alluvial type and is formed from the mixing of sand and silty loam (Mirzakhaninafchi *et al*. 2017; Mukherjee *et al*. 2020) [14, 16]. It is a well-known fact that physical and chemical properties of soil influence its behavioral characteristics affecting the type of plants growing in it; hence, the knowledge of soil property is considered very important (Sumithra *et al*. 2013) [23]. Standing crops and vegetation too influence soil quality; therefore, soil testing is of paramount importance for determining the soil nutritional status which would ascertain the amount of necessary fertilizers required to be added for mitigating the deficiency. There are no reports on comparative soil physio-chemical parameters of this region till date. To bridge this lacuna, the work is aimed to investigate physical and chemical properties of soil collected from several plantation crop fields of Terai region and make a comprehensive analysis on the nutrient demand of these crops.

Materials and methods

Study Area

The sampling area was located on the west bank of river Balasan in the southern part of Darjeeling district in the Terai region. The study area comprises plantations of *Camellia sinensis* (CS), *Ficus elastica* (FE), *Bambusa vulgaris* (BV), *Shorea robusta* (SR), *Lagerstroemia speciosa* (LS), mixed forest (MF), fallow dry land (FDL) and fallow wet land (FWL).

Sample collection and preparation

A total of 48 sets (top and sub-soil) of soil samples were collected by means of a screw type auger from plantation and fallow land respectively. The collections were made in consecutive three years (2018-2020). Sample preparation for soil analysis was conducted following the standardized protocol of Saha *et al*. (2020) [21].

Soil texture and bulk density assessment

Soil texture analysis was performed by feel method (Baruah and Barthakur 1997) [1] and bulk density examination was determined by measuring soil compaction level per unit area (Iram and Khan 2018) [9].

Soil moisture

Moisture content of the soil samples was calculated in accordance with the protocol of Mukherjee *et al*. (2020) [16].

Estimation of soil electrical conductivity (EC) and pH

Soil EC was estimated following the protocol of Jackson (1973) [10] and pH range was determined based on Barua and Barthakur (1997) [1].

Determination of organic carbon (OC) and organic matter (OM) in soil

Quantification of soil OC was conducted by Chromic acid method established by Walkley and Black (1934) [2] in addition to the percentage of OM being determined by calculation method (Nath 2015) [18].

Quantification of total nitrogen, available phosphorus, potassium and sulphur in soil

Total Nitrogen content was estimated by Kjeldahl method (Jackson 1973; Mukherjee *et al*. 2020; Saha *et al*. 2020) [10, 16, 21] and calculation was made as percentage of total Nitrogen in soil following Barua and Barthakur (1997) [1]. Available phosphorus in digested sample solution in form of phosphate was conducted by the protocol developed by Bray and Kurtz (1945) [4]; while available potassium was determined following the established methodology of ammonium acetate extraction technique (Baruah and Barthakur 1997) [1]. The amount of available sulphur was also quantified by ammonium acetate extraction procedure (Ensminger 1954) [7].

Micronutrient analysis

Micronutrient analysis of varied soil samples collected was tested through HIMEDIA Soil Testing Kit for Micronutrient (Six Test Parameters) [Kit No. K095XL-1KT] in respect of semi quantitative estimation of available Copper (Cu), Zinc (Zn), Molybdenum (Mo), Manganese (Mn), Iron (Fe) and Boron (B).

Statistical analysis

Descriptive statistics through determination of maximum and minimum value including calculation of mean and standard deviation (SD) was performed using SPSS software and Windows MS Excel.

Results and Discussions

Soil texture and bulk density

Soil texture of the study area was witnessed to be predominantly sandy loam type. Bulk density of collected soil ranged between 0.485 gm/cm^3 and 1.241 gm/cm^3 (Table 1) with highest and lowest quantity recorded in BV (1.241±0.083 gm/cm^3) plantation and FWL area (0.485±0.002 gm/cm^3) respectively. Other plantation soil except LS and FE exhibited intermediate bulk density values ranging from 1.129±0.156 gm/cm^3 to 1.221±0.003 gm/cm^3. Bulk density is a determinant of measuring soil porosity status (Blake and Hartge 1986) [3] with inversely proportional relation to each other. Iram and Khan (2018) [9] reported that soil texture too impacts bulk density, which is further regulated by the level of organic carbon present in soil. Wagner *et al*. (1994) [24] estimated bulk density utilizing soil texture parameters paralleled with organic carbon quantification and indicated a positive correlation trend in between bulk density and organic carbon content of soil. Kumar *et al*. (2009) [13] too stressed on the requirement of soil texture specific tests for correct determination of soil organic matter in order to achieve a standard bulk density and avoid problems related to excessive soil compaction.

Moisture

Soil water content is an extremely important characteristic since it regulates major physical, chemical and biological activities occurring in soil by solubilising varied minerals and nutrients that are necessary requisites for effective growth of plants. In this study, soil of LS plantation was deduced to exhibit higher level of moisture content in both top (31.55±2.459%) and sub (25.23±2.040%) soil zone (Table 1). Parallely, the moisture content of FWL area in top (31.9±3.092%) and sub (25.64±3.612%) soil surface was also determined to be comparatively higher owing to presence of shallow depressions filled with water and absence of drainage system in addition to lowest moisture content being recorded in both top (3.1±0.477%) and sub (3.32±0.173%) soil zone of BV plantation. Usually, the sub soil region has been known to have higher moisture content in comparison to top soil surface; however, our experimental findings contradict the trend with soil samples of CS, MF and LS having more moisture content in the top soil zone. Correspondingly, the soil of FDL area has more moisture content than BV plantation because there is no plant to absorb water from that soil.

pH

The study depicted pH scale ranging between 4.9 and 5.8 (Table 1). Although a slight difference could be noted in pH value of top and sub soil surface; top soil was found to be comparatively more acidic than sub soil zone in most cases. The average pH analyzed among the samples were 5.35 at soil depth 0 cm - 30 cm with highest and lowest values being recorded in SR (top soil-5.6±0.110 and sub soil-5.8±0.214) and CS (top soil-4.9±0.155±0.110 and sub soil-5.09±0.202) plantation soil respectively. In a similar work on Terai tea plantations, soil pH ranged from 4-5.3 (Mukherjee *et al*. 2020; Samanta *et al*. 2021) [16, 22] relative to Tea Board of India recommended standard pH falling between 4.5-5.5 (Mukherjee *et al*.2020) [16]; portraying the deduced value of CS plantation soil pH to be within normal range. The low pH value of CS planted soil can be related to bio-geochemical Carbon and Nitrogen cycles, which are considered as major sources of acidification within tea garden system. The breakdown of organic acids such as malic acid, citric acid, humic acid, fulvic acid and oxalic acid has been attributed to be the prime proton source in tea garden responsible for acidification of CS plantation soil (Yang 2005) through accumulation and decomposition of pruning litter and weeding phenomenon. Scientific data based comparison with respect to previously reported pH of different plantation soil *viz*. FE (5.1-5.9) (https://agris.fao.org/agris-search/search.do?recordID=IN2011000277); BV (5.38-5.65) (Kaushal *et al*. 2020) [12]; MF (5.26±0.58); SR (4.33±0.39) (Paudel and Sah 2003) [20]; LS (5.00-5.70) (Hossain *et al*. 2014); FDL (5.46-6.12) (Burdukovskii *et al*. 2019) and FWL (7.2-7.4) (Osinuga and Oyegoke 2018) area indicates the calculated pH of SR planted soil to be on the higher end (less acidic) while the deduced pH of FWL plantation soil to be much lower (more acidic) including the determined pH for all other experimental soils to be within equal range.

Electrical conductivity (EC)

EC is a quantitative measure of the charge particles present in soil. It is also an important parameter for determination of soil health status. The highest EC (279±12.133 µS/cm) was inferred in LS plantation top soil while lowest EC (65±2.608133 µS/cm) was recorded in MF sub soil (Table 1). In most cases the EC of sub soil zone was far less than that of top soil surface either due to uptake of soluble salts by plants or on account of leaching phenomenon through which minerals are gradually lost owing to excess irrigation and rainfall.

Organic Matter (OM) and Organic carbon (OC)

OM is a collective product resulting from the decomposition of prevalent soil organisms, roots and plant residues. OM and OC reserve serve as lifeblood of soil and combinedly improve the structural, physical, chemical and biological health of soil, promoting soil fertility. In the present study, BV plantation soil was found to be enriched in both OM and OC for corresponding top and sub soil zone with recorded highest OM (11.275±0.175%) and OC (6.555±0.104%) in BV sub soil surface (Table 2) while the soil sample of LS plantation possessed a minimal percentage of only 0.772±0.157% OM and 0.449±0.285% OC in top soil area. Although both plantations contained decayed leaves but soil of BV plantation contained rhizomatous parts in addition to foliage leaves, which may be the possible reason for its high OM and OC content. Noted low concentration of OM and OC in deciduous LS plantation soil was mainly due to collection of dry fallen leaves as a fire wood alternative by the local population. Except soil of FE, MF and FWL plantation; OM and OC content was generally higher in sub soil zone than top soil surface for all other experimental sites. Previously reported scientific information based comparison on OM and OC composition of different plantation soil includes CS [OM:1.72%-3.44% and OC:1.0%-2.0%] (Mukherjee *et al*. 2020) [16]; FE [OM:0.6364%-4.2656% and OC:0.37%-2.48%] (https://agris.fao.org/agris-search/search.do?recordID=IN2011000277); BV [OM:1.173%-1.183% and OC:0.682%-0.688%] (Kaushal *et al*. 2020) [12]; MF [OM:1.74±0.31% and OC:1.012±0.18%]; SR [OM:2.42±0.39% and OC:1.406±0.23%] (Paudel and Sah 2003) [20]; LS [OM:1.030%-2.920% and OC:0.598±1.698%] (Hossain *et al*. 2014)[8]; FDL [OM:15.033±0.378% and OC:8.74±0.22%] (Burdukovskii *et al*. 2019) and FWL [OM:2.84%-3.41% and OC:1.65%-1.98%] (Osinuga and Oyegoke 2018) area indicates the calculated OM and OC content of CS, FE, BV and SR planted soil to be significantly higher with FDL plantation soil depicting lower values in addition to equivalent range for soils of MF, LS and FWL regions.

Available nitrogen (N)

Nitrogen is an essential macronutrient for plants, generally up-taken in the form of nitrate and ammonium ions from soil. In our current study percentage of ‘N’ content was found to be maximum in plantation soil of BV (top soil-0.524±0.016% and sub soil-0.564±0.016%) and minimum in LS plantation top soil zone (0.042±0.022%) including sub soil surface of MF area (0.045±0.012%) (Table 2). Presence of excessive amount of dead leaves and rhizomes in BV plantation soil may be a possible reason for its elevated ‘N’ content including similar reason of dried fallen leaves removal by the people in the vicinity for decline of ‘N’ content in LS planted soil. The total nitrogen content of CS plantation soil in the study area was reported to be 0.1458% (Samanta *et al*. 2021) [22] while that for Terai region it ranged between 0.01%-0.31% quite similar to the present estimated levels (Mukherjee *et al*. 2020) [16]. Scientific data based previously described ‘N’ composition of different plantation soils like FE [0.0318%-0.2133%] (https://agris.fao.org/agris-search/search.do?recordID=IN2011000277); BV [0.073%-0.074%] (Kaushal *et al*. 2020) [12]; MF [0.111±0.01%]; SR [0.117±0.01%] (Paudel and Sah 2003) [20]; LS [0.052%-0.146%] (Hossain *et al*. 2014) [8]; FDL [0.752±0.019%] (Burdukovskii *et al*. 2019) [5] and FWL [0.21%-0.25%] (Osinuga and Oyegoke 2018) area point towards the calculated ‘N’ content of FE, BV, MF, and SR planted soil to be higher including lower values for LS, FDL and FWL plantation soils in a comparative analysis.

Available phosphorus (P)

In the biological system phosphorus is the second most important macronutrient after nitrogen. It also affects plant growth and development to a large scale. The experimental soil featured very low level of ‘P’, ranging from 0 ppm to 15.09 ppm; depicting a medium to low positive correlation coefficient in respect of all analyzed parameters excepting EC and moisture content, where mostly negative correlation values were examined. The ‘P’ content of the investigational soil was minimal because there was not even a solitary evidence of single superphosphate (SSP) or rock phosphate fertilizer application in the total area under study. Percentage of ‘P’ in the form of phosphate content was explored to be maximum in SR plantation soil (top soil-37.0±5.441 ppm and sub soil-18.0±3.033 ppm) and minimum in top soil surface of MF (2.0±1.414 ppm) including complete absence in sub soil of LS planted area (0.0±0.0 ppm) (Table 2). Lesser quantity of ‘P’ was detected in sub soil compared to top soil in all other plantations including CS, excepting MF zone with previously quantified value of 17 ppm in soils planted with CS (Samanta *et al*. 2021) [22]. Previously reported data based analysis of ‘P’ composition in different plantation soils viz. BV [6.07 ppm-6.82 ppm] (Kaushal *et al*. 2020) [12]; MF [35.397±1.75 ppm]; SR [34.214±2.209 ppm] (Paudel and Sah 2003) [20]; LS [3.910 ppm-9.810 ppm] (Hossain *et al*. 2014) [8] and FWL [5.72 ppm-5.85 ppm] (Osinuga and Oyegoke 2018) regions clearly point towards the calculated ‘P’ values of BV planted soil to be higher; MF soil samples to be lower in addition to equivalent range for LS, SR and FWL plantation soils respectively in reference to the formerly mentioned data.

Available potassium (K)

Potassium is ranked third in the essential plant macronutrient category after ‘N’ and ‘P’; required in large amounts for optimal phyto-growth, development and reproductive functions. It plays a major role in various physiological activities and is readily absorbed by plants in ionic form (K^+). The overall study area portrayed a low ‘K’ concentration in soil samples. K^+ ion possessing a small atomic size is easily leached down the soil during rainy season or on account of irrigation activities, resulting in a low concentration of ‘K’ in soil. The experimental findings of ‘K’ varied from 16 ppm to 29 ppm being estimated to be positively correlated with OM, pH and EC while negative correlation values were observed in relation to soil moisture, OC, N and P content parameters for both top and sub soil surfaces of different plantations respectively. Maximum percentage of ‘K’ in form of potash was revealed in top soil of BV (28±1.414 ppm) and sub soil of SR (29±2.098 ppm) plantation while minimum quantity was detected in soil supporting the growth of FE (top soil-23±1.414 ppm and sub soil-16±1.414 ppm) (Table 2). Excepting SR sample soil, lesser quantity of ‘K’ was noticed in sub soil zone compared to top soil surface for all other plantation soils including CS with an earlier reported ‘K’ value of 91 ppm for CS growing soil (Samanta *et al*. 2021) [22]. Earlier reports of ‘K’ composition in different plantation soils viz. BV [50.70 ppm-84.50 ppm] (Kaushal *et al*. 2020) [12]; MF [104.402±8.228 ppm]; SR [119.522±13.362 ppm] (Paudel and Sah 2003) [20]; LS [77.00 ppm-168.00 ppm] (Hossain *et al*. 2014) [8] and FWL [206.7 ppm-237.9 ppm] area (Osinuga and Oyegoke 2018) portrays the calculated ‘K’ content of BV, MF, SR, LS and FWL plantation soil to be lower in comparison to the aforementioned data.

Available Sulphur (S)

Sulphur is another important essential phyto-nutrient necessary for plant growth and development. Cysteine and methionine are the Sulphur containing amino acids involved as building block information in proteins. In our study area, ‘S’ range varied from 1.0 ppm to 23.0 ppm which is considered quite closer to the lower end in all experimental plots with respect to the standard for tea plantation for this region excepting though LS plantation soil was an exception (Table 2).

Percentage of ‘S’ was found to be maximum in top soil of LS (23.3±1.744 ppm) and sub soil of FE (17.7±0.141 ppm) while minimum quantity was detected in soil of BV (top soil- 1.5±0.126 ppm and sub soil- 6.5±0.210 ppm) plantation respectively. Apart from CS and SR plantation soil, lesser quantity of Sulphur was examined in sub soil zone compared to top soil surface for all other collection sites.

Table 1: Portrayal of Bulk density, EC, Moisture content and pH range of collected soil samples

Plantation Soil	Bulk Density (gm/cm^{3})	EC (µS/cm)		Moisture (%)		pH	
		Top Soil	Sub Soil	Top Soil	Sub Soil	Top Soil	Sub Soil
CS	1.129±0.156	215±7.906	85±7.176	10.64±0.228	9.55±0.255	4.9±0.155	5.1±0.283
FE	0.778±0.018	79±1.414	73±2.0	7.42±0.116	7.44±0.137	5.06±0.059	5.25±0.059
BV	1.241±0.083	139±1.095	89±1.789	3.1±0.477	3.32±0.173	5.4±0.141	5.66±0.154
MF	1.212±0.011	141±6.164	65±2.608	25.15±1.864	19.84±1.413	5±1.265	5.09±0.202
SR	1.154±0.013	90±2.449	93±1.414	7.4±0.717	9.16±1.847	5.6±0.110	5.8±0.214
LS	0.49±0.008	279±12.133	188±6.229	31.55±2.459	25.23±2.040	5.4±0.179	5.73±0.233
FDL	1.221±0.003	89±4.050	73±2.449	6.68±0.783	7.21±1.166	5.49±0.260	5.3±0.179
FWL	0.485±0.002	102±4.050	79±1.789	31.9±3.092	25.64±3.612	5.29±0.123	5.52±0.211

Table 2: Representation of OC, OM, N, P, K and S content of collected soil samples

Plantation	OC (%)		OM (%)		N (%)		P (ppm)		K (ppm)		S (ppm)	
	Top Soil	Sub Soil	Top Soil	Sub Soil	Top Soil	Sub Soil	Top Soil	Sub Soil	Top Soil	Sub Soil	Top Soil	Sub Soil
CS	4.563±0.210	5.49±0.234	7.848±0.149	9.443±0.154	0.37±0.016	0.464±0.038	15±0.894	11±0.632	27±1.897	23±1.549	7.7±0.210	9.6±0.167
FE	5.36±0.078	4.473±0.075	9.219±0.079	7.694±0.110	0.422±0.010	0.35±0.052	14±0.894	7±1.414	23±1.414	16±1.414	12.1±0.210	17.7±0.141
BV	6.0936±0.236	6.555±0.104	10.486±0.138	11.275±0.175	0.524±0.016	0.564±0.016	14±1.897	7±1.673	28±1.414	21±0.632	1.5±0.126	6.5±0.210
MF	1.581±0.241	0.655±0.175	2.719±0.113	1.127±0.069	0.152±0.026	0.045±0.012	2±1.414	17±4.243	24±2.098	20±2.0	16.5±3.383	12.7±0.200
SR	4.396±0.302	4.897±0.046	7.561±0.128	8.423±0.212	0.312±0.041	0.386±0.012	37±5.441	18±3.033	26±1.897	29±2.098	8.3±0.755	14±1.673
LS	0.449±0.285	0.93±0.024	0.772±0.157	1.600±0.134	0.042±0.022	0.086±0.012	4±1.414	0±0.000	25±1.789	22±2.098	23.3±1.744	14.6±1.601
FDL	4.087±0.526	4.936±0.049	7.030±0.252	8.490±0.214	0.386±0.051	0.456±0.031	5.03±0.418	1±0.894	8±2.098	20±2.366	14±3.162	17.1±1.940
FWL	1.272±0.058	0.539±0.149	2.188±0.312	0.927±0.058	0.156±0.008	0.06±0.032	0±0.000	6±2.800	22±2.608	25±2.530	9±2.608	3.3±0.488

Micronutrient analysis

Micronutrient content in soils collected from sample sites exhibited a variable scale (Table 3) of presence excepting copper and zinc. Copper was detected only in top soil of MF area while zinc was not even traced in minimal amount among all the tested soil samples. Molybdenum was detected in critical levels in top soil of LS plantation whereas in others it was deduced in lower quantities. Other microelements viz. boron, manganese, iron and molybdenum had fairly variable quantitative presence in the soil collected from plantation as well as FDL and FWL locations.

Table 3: Micronutrients analysis of collected top and sub soil from different locations of Terai region

Plantation	Region	B	Mn	Fe	Cu	Zn	Mo
CS	TOP	High	Critical	Low	Absent	Absent	Low
	SUB	Critical	Low	Absent	Absent	Absent	Low
FE	TOP	Low	Absent	Low	Absent	Absent	Low
	SUB	Critical	Absent	Absent	Absent	Absent	Low
BV	TOP	Low	Low	Low	Absent	Absent	Low
	SUB	Critical	Low	Low	Absent	Absent	Low
MF	TOP	Critical	Critical	Low	Low	Absent	Low
	SUB	High	Low	Low	Absent	Absent	Low
SR	TOP	Critical	Low	Absent	Absent	Absent	Low
	SUB	Critical	Low	Absent	Absent	Absent	Low
LS	TOP	Critical	Low	Absent	Absent	Absent	Critical
	SUB	Low	Low	Low	Absent	Absent	Low
FWL	TOP	Critical	High	Critical	Absent	Absent	High
	SUB	Low	Absent	Absent	Absent	Absent	High
FDL	TOP	Critical	Absent	Absent	Absent	Absent	Low
	SUB	Low	Absent	Absent	Absent	Absent	Low

General correlation

The soil of FWL and LS plantation possessed similar texture and moisture content. Therefore, there is minimal difference in their bulk density attributes. It is an established fact that organic carbon helps in increment of soil bulk density with LS leaves falling off during the winter season and their subsequent regular removal from ground surface by the local poor people of adjoining villages for usage in cooking purposes as substitute of fire wood is responsible behind low OC in the soil of LS plantation in addition to correspondingly reduced bulk density values. On the other hand, the leaves and rhizomes in BV plantation soil decompose naturally throughout the year; as a consequence, bulk density of soil is very high in this woody grass zone. Correlation studies were conducted to ascertain the degree of relatedness among the parameters. Top soil and subsoil was considered separately as in this study much variation was detected in the soil layers. A positive correlation was observed between OC, N, P and K with an exception to S in both and sub soil layers. The degree of correlation was detected to be closer in the top soil parameters when compared to sub soil (Table 4).

Table 4: Correlation matrix of collected top and sub soil

		OC	**N**	**P**	**K**	**S**
Top soil	OC		0.998	0.710	0.507	-0.734
	N			0.705	0.489	-0.726
	P				0.389	-0.703
	K					-0.264
	S					
		OC	N	P	K	S
Sub soil	OC		0.986	0.338	0.206	-0.657
	N			0.375	0.210	-0.691
	P				0.389	-0.703
	K					-0.264
	S					

Conclusion

The soil of terai region in sub–Himalayan West Bengal was formed by wash away soil, pebbles, rock and organic matter swept away by rain water and seasonal/perennial streams since the birth of Himalayas. Gradual mixing of organic matter by successive plant communities has developed the greenery over the region. Leaving the few inches of top soil and upper layer of sub soil the soil profile is extremely rocky infiltrated with coarse sand and pebbles. Plantation of forest plants to meet the demand of firewood and sleeper for expanding railways was the main reason for developing plantation in this region during the British period. The rest of the land unsuitable for paddy cultivation was utilized for tea cultivation. Thereafter these unmanaged and managed plantations have served as air purifier for this region. Plantation of nutrition exhaustive plants like tea, rubber, forest trees have changed the soil nutritional status due to differential physiological demand. This paper has ascertained the pattern of nutritional demand and the present status of soil nutrition in terai land of sub–Himalayan West Bengal for a better understanding and management of the plantations.

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