The Pharma Innovation Journal 2021; 10(11): 1040-1047

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2021; 10(11): 1040-1047
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www.thepharmajournal.com
Received: 17-09-2021
Accepted: 26-10-2021

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Assessment of soil health parameters from different blocks of West Tripura District, Tripura, India

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Abstract
An experiment was conducted in the Department of Soil Science and Agricultural Chemistry, Naini Agricultural Institute, SHUATS, Prayagraj during 2020-21 to assess the physical and chemical properties of soils in the West Tripura district of Tripura. Soil samples were collected from nine different Villages of West Tripura District at three profile depths, *viz.* 0-15cm, 15-30cm and 30-45cm. Twenty-seven sampling points were selected for the analysis. The results revealed that the soil colour varied from yellowish brown to Reddish brown colour in the dry condition while Pale brown to Dark yellowish brown colour predominated in the wet condition. The texture in Mohanpur and Dhukli was mostly clay loam while in Jirania, the texture was Sandy clay loam. The water holding capacity varied from 42.85 to 65.65% and pore space percentage from 42.69 to 94.45%. The bulk density values ranged from 0.95 to 1.27 Mg m^{-3}, particle density from 2.5 to 4.0 Mg m^{-3}, specific gravity from 1.57 to 2.73. The pH ranged from 3.1 to 7.1, electrical conductivity from 0.01 to 0.12 dS m^{-1}. High organic carbon values were obtained which ranged from 0.6 to 1.65% as a result of decades of organic farming practices adopted by the farmers. Available nitrogen ranged from 105.52 to 538.50 kg ha^{-1}, available phosphorus from 20.33 to 55.65 kg ha^{-1} and available potassium content ranged from 71.33 to 233 kg ha^{-1}. Exchangeable calcium varied from 0.06 to 2.68 cmol (p+) kg^{-1}, exchangeable magnesium from 0.04 to 2.6 [cmol (p+) kg^{-1}], and the available sulphur ranged from 7.38 to 65.47 kg h^{-1}.

Keywords: Physical and chemical properties of soil, soil health card, West Tripura

Introduction
Soil may be defined as "A dynamic natural body on the surface of the earth in which plants grow, composed of mineral and organic materials and living forms" (Buckman and Brady *et al.*, 1969) [3]. West Tripura District is located on the north and west of Khowai district by the sepahijala district on east and south east and south. After the formation of four new districts of Tripura state, the total area of the district is 983.63sq km. The climate of Tripura is humid sub-tropical characterized by high rainfall. The annual rainfall ranges from 2,000 to 3,000 mm. The soils of Tripura state belong to five orders, such as Inceptisols, Entisols, Ultisols, Alfisols, and Histosols. Bulk density, particle density, porosity, water holding capacity, soil color, texture, and specific gravity were all evaluated as physical attributes of soil (Beutler *et al.*, 2002) [4]. Soil testing is one of the best available tools, to ascertain the physical characteristics & nutrient status of a field so as to assess the fertilizer requirements for a crop or a cropping system or for knowing the reclamation requirements if the soil is saline/sodic in nature. Fertilizer application based on soil tests is the best available approach for harvesting the economically viable potential yields of crops by increasing input use efficiency and maintaining soil health. (Joshi *et al.*, 2013) [17].

Materials and methods
Study site: Hilly Tripura is one of northern eastern state among the seven sister in which West Tripura district located. The location of West Tripura district lies between 23°8'to 24° north latitude and 91°25'to 92°1'east longitude. It covers geographical area of 2997 km^2 which is bounded by Bangladesh in the north and west by Khowai district in the east and by sepahijala district in the south.

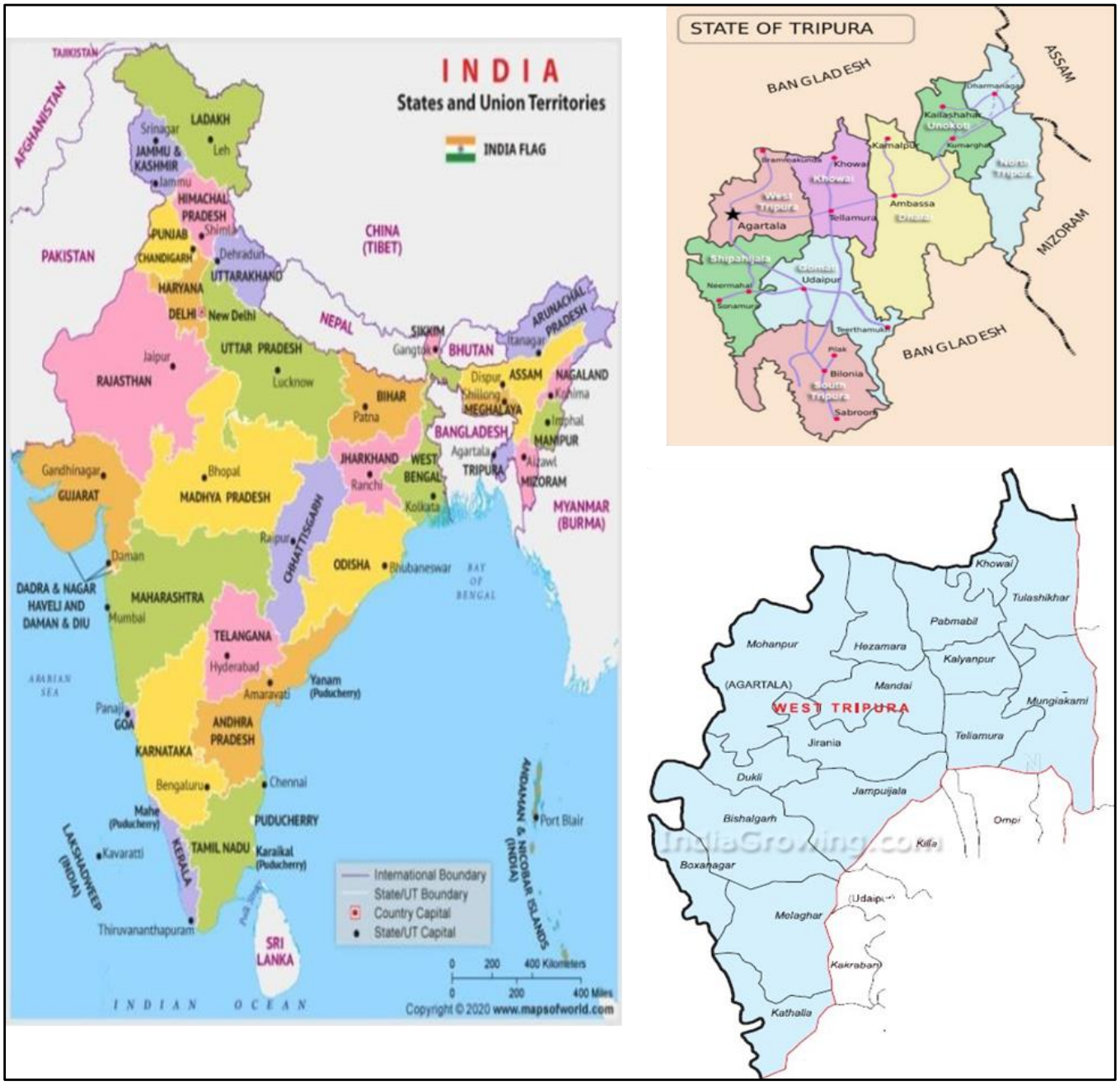

Fig 1: Map of Study sites

Collection of soil sample from study site

Soil Samples were collected from different areas of West Tripura district. They are Mohanpur, Jirania and Dukli, having variation in colour, slope/topography and cropping pattern to a depth of 0-15cm, 15-30cm and 30-45cm. The samples were analysed for physical and chemical properties. Soil samples were collected with the help of Khurpi, spade and meter scale. In each block three villages were selected for sampling and samples were obtained from three different depths 0-15cm, 15-30cm, and 30-45cm. A total of twenty-seven soil samples were collected from three different village in agricultural fields of farmers after harvest or before sowing. In view of this, 27samples were collected in totality with 3 sample representing one village each with three profile depths. Soil sample collection from the edges of the field was omitted.

Method of sampling

Samples were collected using Khurpi by random selection of sites by cutting a V-shaped slice of about 45 cm depth. The sample was then lifted using Khurpi from the sides of the slice and collected in plastic bag, tagged with representative labels such as sample number, depth of profile, GPS coordinates, Date of sampling and then taken to the laboratory. Also, after the final preparation of sample, experiments were carried out as early as possible in the laboratory to avoid adsorption of gases in the laboratory. The size of the sample depends on factors such as coarseness of the material, objective of analysis and the desired accuracy. About 1.5kg of soil sample was collected every time. After the collection of samples, precaution was taken to avoid further chemical reactions. The soil samples were air dried in shade. After drying of sample, all the unwanted materials such as roots, stones, etc. were removed. Large clods were crushed by wooden mallet and then ground using wooden mortar and pestle without crushing the ultimate particles. Grinding was followed by sieving for which 2.0mm sieve was used. Sieved soil samples were stored in air-tight plastic bags

and tagged for estimation of physico-chemical properties. Sieved soil samples were determined for physical properties of soil like its soil textural class by Bouyoucos hydrometer method soil colour by using Munsell soil colour chart bulk density, particle density, percent pore space and water holding capacity was determined by 100 ml graduated measuring cylinder method and specific gravity was determined by Pycnometer/Relative density bottle method. For determined the chemical properties of soil like its pH was determined by digital pH meter by making 1:2 soil-water suspension (Jackson, 1958) [16] whereas EC was measured by digital EC meter (Wilcox, 1950) [39], Organic carbon was determined by wet-oxidation method (Walkley and Black, 1947), available nitrogen was determined by alkaline potassium permanganate method by 800ml kjeldahl flask (Subbiah and Asija, 1956) [30], available potassium was determined by flame photometer using 1 N NH_4OAC (pH 7.0) (Toth and Prince, 1949) [34], available phosphorus was determined by photoelectric colorimetric method by using spectrophotometer (Olsen *et al.*,1954) [28], exchangeable calcium Ca^{2+} and magnesium Mg^{2+} were estimated by EDTA titration method available Sulphur was estimated by Turbidimetric method (Bardsley and Lancaster, 1960). The data was recorded during the course of investigation were subjected to statistical analysis of Completely Randomized Design (CRD) as per the method of "Analysis of Variance" (ANOVA) technique (Fisher, 1957) [12]. The type of ANOVA adopted for the experiment was two-way factor analysis without replication.

Results and discussion

Physical Properties

1. Soil Color

The results of the study site revealed that most of the soils of West Tripura district in dry condition, reflected yellowish brown (10YR5/4) to Reddish Brown (2.5YR 4/4) color and in wet condition, reflected Very Pale Brown (10YR 7/3) color to Dark yellowish brown (10YR 4/4) color mentioned in (Table 1.). Same work was done by Nayak *et al.*, (2002) [27].

Table 1: Evaluation of physical properties of soil from different villages of West Tripura district at 0-15cm, 15-30cm, 30-45cm depths

Soil Colour							
Blocks	**Villages Name**	**Dry condition**			**Wet condition**		
		0-15cm	**15-30cm**	**30-45cm**	**0-15cm**	**15-30cm**	**30-45cm**
Mohanpur (B1)	Bamutiya (V_1)	Yellowish brown	Yellowish brown	Yellowish brown	Very Pale brown	Pale brown	Pale Brown
	Barjala (V_2)	Brown	Brown	Brown	Reddish Yellow	Reddish yellow	Reddish yellow
	Debendrachandranagar (V_3)	Dark reddish brown	Dark reddish brown	Dark reddish brown	Reddish Yellow	Light Reddish yellow	Light Reddish yellow
Jirania (B2)	Radhamohanpur(V_4)	Dark brown	Dark yellowish brown	Dark Yellowish brown	Yellowish Brown	Yellowish brown	Yellowish red
	Jirania (V_5)	Dark reddish brown	Dark reddish brown	Dark reddish brown	Yellowish Red	Yellowish red	Yellowish red
	PurbaDebendranagar (V_6)	Dark reddish brown	Reddish brown	Reddish brown	Dark Brown	Brown	Dark grayish brown
Dukli (B3)	Ishanchandra Nagar (V_7)	Brownish yellow	Light yellowish brown	Pale brown	Dark Reddish	Reddish brown	Reddish brown
	Rabindra Nagar (V_8)	Light brownish gray	Pale brown	Light yellowish brown	Reddish Yellow	Reddish yellow	Reddish yellow
	Badharghat (V_9)	Yellowish brown	Yellowish brown	Yellowish brown	Dark Yellowish brown	Brown	Dark Yellowish brown

2. Soil Texture (%)

Soil texture of soil samples was fall under clay loam (Table 2). A similar result has also been identified by Majumder *et al.*, (2014).

3. Bulk Density (Mg m^{-3})

The bulk density in soil from different villages varied from 1.27 to 0.95 Mg m^{-3}. The bulk density increases with the increase in soil depth (Table 2). The bulk density decreased due to high organic matter content or vice versa. A similar result has also been identified by Wankhade *et al.*, (2015) [37].

4. Particle density (Mg m^{-3})

The particle density of soil varied from 2.5 Mg m^{-3} to 4.0 Mg m^{-3}. The particle density increased due to increase in soil depth (Table 2). Particle density of soils considers only the mineral solids present in soil. Same analysis has been done by Barthwal *et al.*, (2019) [6].

5. Water holding capacity (%)

The water holding capacity (%) of soil varied from 42.85 to 65.65%. The variations in water holding capacity is attributed to variation in sand, silt and clay content and organic carbon content. These findings were in line with that of Deb *et al.*, (2013).

Table 2: Evaluation of Soil texture, Bulk Density, Particle Density, Water holding capacity, Specific Gravity, Pore Space in soil from different villages of West Tripura district at 0-15cm, 15-30 cm and 30-45cm depths

Blocks	**Villages Name**	**Soil Texture**	**Bulk Density (Mg m^{-3})**	**Particle Density (Mg m^{-3})**	**Water holding capacity (%)**	**Specific Gravity**	**Pore Space (%)**
Mean							
Mohanpur	Bamutiya	Clay loam	1.12	2.85	53.26	2.31	91.66
	Barjala	Clay loam	1.206	2.5	56.09	2.27	52.53

(B1)	Debendrachandranagar	Loam	1.176	3.11	58.83	2.44	64.85
Jirania (B2)	Radhamohanpur	Sandy clay loam	1	2.5	54.793	2.03	59.83
	Jirania	Sandy clay loam	1.056	2.85	43.816	2	64.60
	Purba Debendranagar	Clay loam	1.063	2.783	50.8	2.39	62.16
Dukli (B3)	Ishanchandranagar	Clay loam	1.26	2.22	64.006	2.11	43.02
	Rabindra Nagar	Clay loam	0.95	4.0	65.29	2	75.25
	Badharghat	Sandy clay loam	1.053	2.85	64.223	2.01	71.91

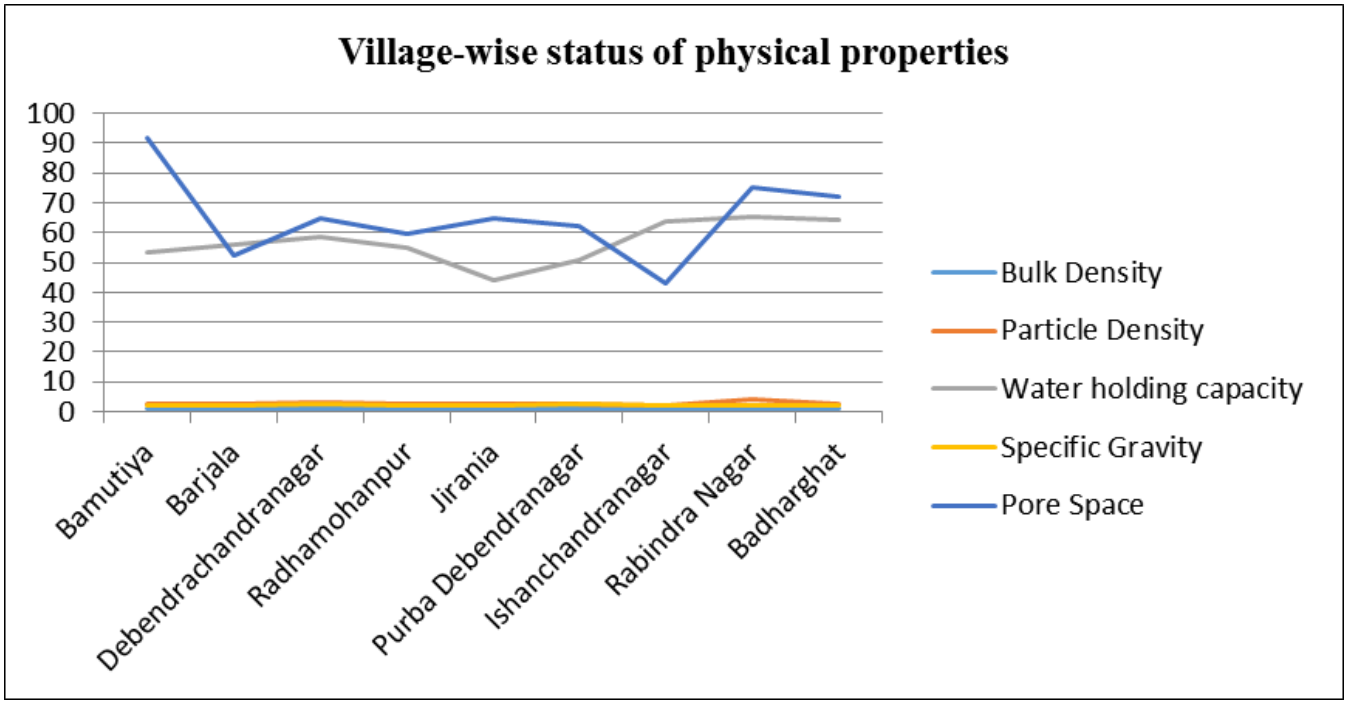

Fig 2: Village-wise status of Bulk Density (Mg m^{-3}), Particle Density (Mg m^{-3}), Water holding capacity (%), Specific Gravity, Pore Space (%)

6. Specific Gravity

Specific gravity in soils of different sites varied between 1.57 to 2.73 in the soils of study area which is indicative of porous particle and high organic matter content. The highest mean soil-specific gravity was found at V_3–Debendrachandranagar (2.44) and lowest mean soil-specific gravity was found at V_5 – Jirania and V_8–Rabindra Nagar. These findings where line with that of Sujatha *et al.*, (2016) [31].

7. Pore Space (%)

The percentage of soil pore space (Table) of different sites varied between at the different depth 0-15cm, 15-30 cm, 30-45cm. The highest mean soil pore space was found at V_1 – Bamutiya (91.66%) and lowest mean soil pore space were found at V_2 –Barjala (52.53%). Similar finding results were in line with that of Pandey *et al.*, (2018) [29].

Chemical properties

1. Soil pH and EC (DS m^{-1}): Soil pH is a measure of alkalinity and acidity in soil. The soil of West Tripura district are suitable for most of the crops as they are neutral to acidic with pH range of 3.1-7.1 as the district receives a good amount of precipitation at different depth of variations 0-15cm, 15-30cm, 30-45cm. The range and mean of pH and Electrical conductivity values of different villages are given in Table 3. Soil pH influences the availability of essential nutrients. The Electrical conductivity of soil samples ranges between 0.01-0.12 DS m^{-1} which indicates that soils are suitable for cultivation of almost all crops. Similar finding analysis has been noticed earlier by Belwal *et al.*, (2014) [5].

2. Organic Carbon (%): The Soils of West Tripura district were found to be rich in % Organic Carbon with mean value range of 0.8-1.65% with highest percent Organic Carbon found in villages of Jirania (B2) block. The range and mean values of different Chemical properties are given in Table 3. Similar finding analysis has been noticed earlier by Santhi *et al.*, (2017) [32].

Table 3: Evaluation of chemical properties in soil from different villages of West Tripura district at 0-15cm, 15-30 cm and 30-45cm depths

Blocks	Villages Name	Soil pH		Electrical Conductivity (dS m^{-1})		Organic Carbon (%)	
		Range	Mean	Range	Mean	Range	Mean
Mohanpur	Bamutiya	4.3-5.6	5.03	0.05-0.11	0.093	1.4-1.65	1.5
	Barjala	5.1-5.5	5.26	0.01-0.06	0.04	0.93-1.4	1.1
	Debendrachandranagar	5.1-5-5	4.96	0.08-01	0.09	1.57-1.58	1.5
Jirania	Radhamohanpur	4.3-5.2	4.83	0.08-0.12	0.103	1.57-1.60	1.6
	Jirania	4.9-5.6	5.13	0.03-0.05	0.04	0.96-0.99	0.97
	Purba Debendranagar	3.1-4.9	4.2	0.1-0.12	0.11	1.33-1.38	1.36
Dukli	Ishanchandranagar	4.8-5.5	5.1	0.05-0.08	0.066	1.50-1.54	1.53
	Rabindra Nagar	4.9-6.3	5.4	0.1-0.11	0.103	0.80-0.98	0.92
	Badharghat	5.5-7-1	6.03	0.07-0.09	0.08	0.67-0.88	0.78

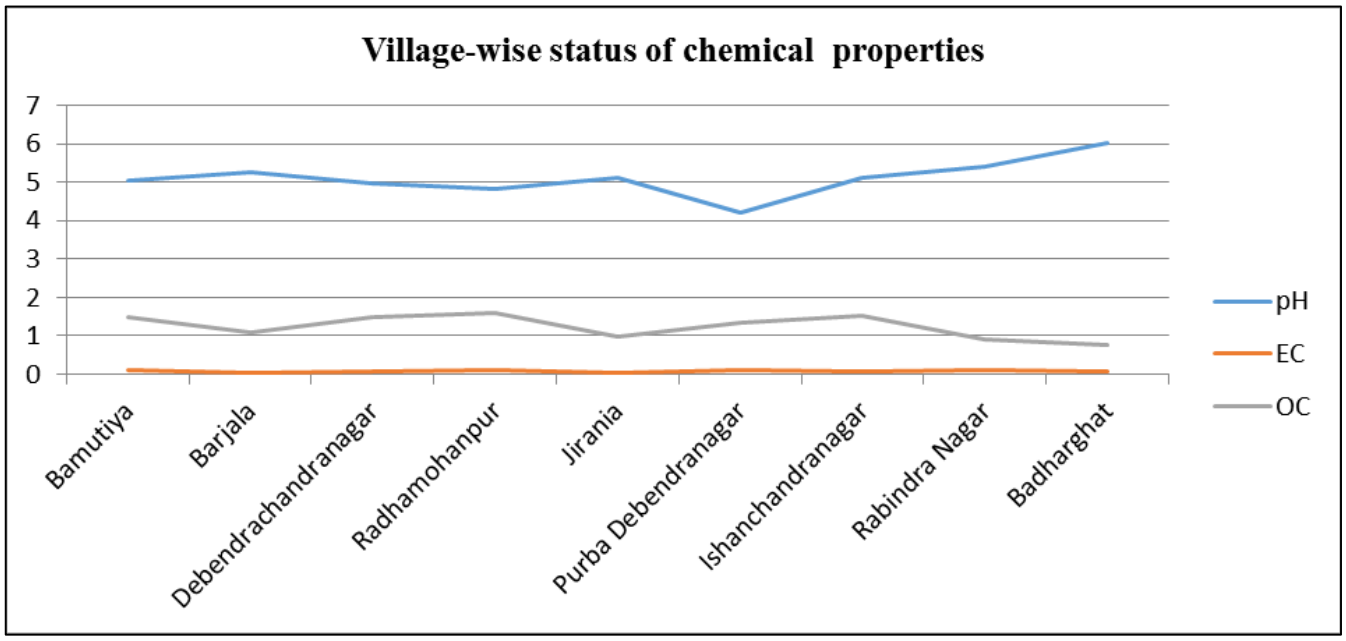

Fig 3: Village-wise status of pH, EC (DS m^{-1}), OC (%)

3. Available Nitrogen (kg ha^{-1}): Nitrogen is important for plant growth, metabolism and the creation of chlorophyll**.** The available Nitrogen content of the three blocks of West Tripura district ranges between 105.52-538.50 (kg ha^{-1}) which reflects that it is in low range according to the limits suggested by Muhr *et al.,* (1965) and also indicating that % Organic Carbon is correlated with Nitrogen content of soil. The available nitrogen decreased with the increased in soil depth. Similar finding analysis has been noticed earlier by Mishra *et al.,* (2000).

4. Available Phosphorus (kg ha^{-1}): It plays important functions like energy transfer, photosynthesis and nutrient movement within the plant. But excessive soil Phosphorus reduces the Plant's ability to take up required micronutrients, particularly Iron and Zinc, even if they are adequate. Available Phosphorus of soils of West Tripura district was found in the range of 20.33-55.65 kg ha^{-1} which is medium in Jirania and which is very high in Dhukli.

5. Potassium (kg ha^{-1}): Potassium is important for ensuring optimal plant growth. It is an activator of dozens of important enzymes, such as protein synthesis, sugar transport, etc. It is vital to the retention and absorption of water in crop soil. Available Potassium content of all three blocks of West Tripura district was found in the medium range i.e. 71.33-233.00 kg ha^{-1}. The range and mean values of Primary nutrients are given in Table 4.

Table 4: Evaluation of primary nutrients in soils from different villages of West Tripura district at 0-15cm, 15-30cm and 30-45cm depths

Blocks	Villages Name	Available Nitrogen (kg ha^{-1})		Available Phosphorus(kg ha^{-1})		Available Potassium (kg ha^{-1})	
		Range	Mean	Range	Mean	Range	Mean
Mohanpur	Bamutiya	250.05-518.43	363.57	32.23-55.20	43.94	107.44-233.00	173.71
	Barjala	222.87-507.00	395.04	23.45-44.87	33.94	103.66-141.40	125.80
	Debendrachandranagar	240.55-538.50	362.02	23.60-33.33	27.94	106.50-210.50	171.92
Jirania	Radhamohanpur	105.52-389.50	264.86	29.78-44.79	37.75	121.55-223.70	174.58
	Jirania	180.75-494.02	324.77	31.45-45.76	36.40	89.58-130.70	114.21
	Purba Debendranagar	150.55-487.55	312.52	20.33-35.37	27.05	71.33-92.35	83.12
Dukli	Ishanchandranagar	250.55-500.68	355.59	38.25-55.65	45.37	90.28-133.00	109.98
	Rabindra Nagar	212.50-412.50	316.88	40.56-54.66	45.63	87.55-108.44	98.15
	Badharghat	250.55-388.10	313.51	35.34-42.33	39.34	97.24-210.50	162.81

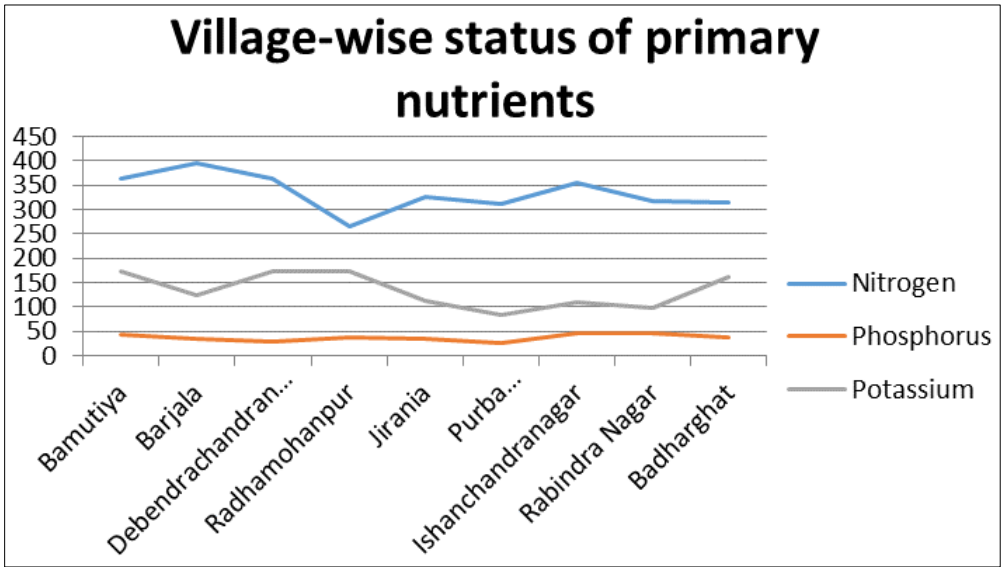

Fig 4: Village-wise status of available nitrogen (kg h^{-1}), phosphorus (kg h^{-1}), potassium (kg h^{-1})

6. Exchangeable Ca and Mg [cmol (p+) kg^{-1}]: Calcium is an essential plant nutrient required by plants in relatively large amounts for healthy growth. Calcium improves the absorption of other nutrients by roots and their translocation within the plant whereas Magnesium is the center molecule of chlorophyll, improves the utilization and mobility of phosphorus. Exchangeable Ca and Mg in Soils were found to be high in the range of 0.06-2.68 [cmol (p+) kg^{-1}] and 0.04–2.6 [cmol (p+) kg^{-1}] respectively which is due to the high clay content in soil.

7. Available Sulphur (kg ha^{-1}): Sulphur is used in the formation of amino acids, proteins, and oils. The available Sulphur content of three blocks of West Tripura district was found sufficient in range of 7.38-65.47 kg ha^{-1}.

Table 5: Evaluation of secondary nutrients in soils from different villages of West Tripura districts at 0-15cm, 15-30cm, 30-45cm depths

Blocks	Villages Name	Exchangeable Ca [cmol(p^+) kg^{-1}]		Exchangeable Mg [cmol(p^+) kg^{-1}]		Available Sulphur (kg ha^{-1})	
		Range	Mean	Range	Mean	Range	Mean
Mohanpur	Bamutiya	0.42-1.35	0.933	0.4-1	0.9	8.16-10.11	9.14
	Barjala	0.58-1.02	0.81	0.55-1.02	0.79	13.11-25.11	19.77
	Debendrachandranagar	0.89-1.35	1.096	0.8-1.04	1.04	50.11-74.13	65.47
Jirania	Radhamohanpur	1.35-2.6	1.81	1.3-2.55	1.75	11.41-33.43	21.72
	Jirania	1.31-2.55	1.753	1.3-2.5	1.71	29.31-32.91	30.85
	Purba Debendranagar	1.95-2.68	2.403	1.9-2.6	2.35	25.26-28.23	26.92
Dukli	Ishanchandranagar	1.66-2.05	1.863	1.6-2	1.8	8.61-29.33	18.05
	Rabindra Nagar	0.06-0.29	0.19	0.04-0.25	0.163	7.38-10.11	8.99
	Badharghat	0.87-1.86	1.343	0.8-1.25	1.28	12.39-15.89	14.16

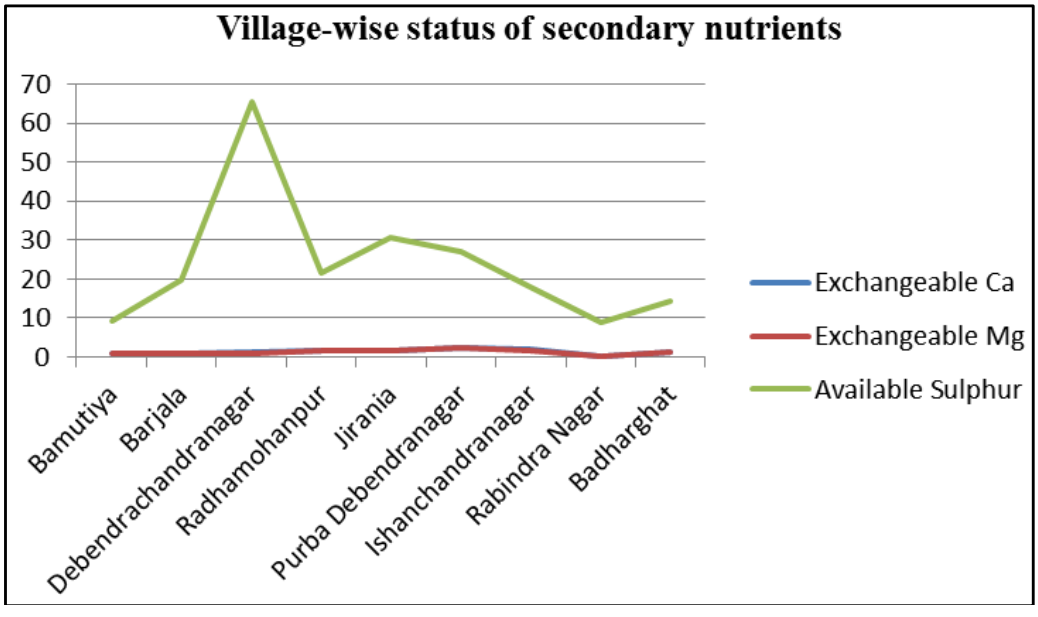

Fig 5: Village-wise status of Exchangeable Ca [cmol (p^+) kg^{-1}], Exchangeable Mg [cmol (p^+) kg^{-1}], Available Sulphur (kg ha^{-1})

Conclusion

It is concluded that soil parameters were studied during the course of investigation responded good physical properties and pH is acidic. EC, Organic Carbon are in adequate range and Nitrogen (N), Phosphorus (P) and Potassium (K) in medium range, having good amount of Ca-Mg and Sulphur (S) range. Cultivation is mainly confined to *Kharif* season but on availability of irrigation. Rabi crops are also grown. Rice, maize, cotton, jute, pigeon pea, black gram, green gram, cowpea, groundnut, sesame, and Mesta are the major *kharif* crops of the hilly west Tripura. Different crops taken during Rabi season are rice, wheat, pea, green gram, lentil, rapeseed-mustard, potato. The main crops grown in West Tripura region are paddy, tea and oilseed. Paddy is grown in 55% of gross cropped area in three season's *viz*. Aush (*pre Kharif*), Aman (*Kharif*) and Boro (*Summer*). Soybean cultivation has also picked up in these regions especially and lentil is the major pulse crops of the regions. The results thus show that in totality, organic farming not only improves the physical condition of the soil but also enrich the soil with essential plant nutrients at low costs of production, substantially benefiting the farmer. West Tripura soils also need improvement in drainage for successful production of crops like maize, soybean, arhar etc.

Acknowledgement

The author would like to avail the opportunity to thank the Hon'ble Chairman, Advisor, HoD of the Department of Soil Science and Agricultural Chemistry, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, U.P. for providing necessary support and desired equipments for this research work.

Conflict of Interest

As a Corresponding Author, I Samadrita Paul, confirm that none of the others have any conflicts of interest associated with this publication.

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