Predictive Assessment of Topographical Survey and Soil Nutrient Properties for Sustainable Crop Planning in a Hilly Terrain of Assam

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Abstract—*Assam state of North Eastern Region of India is surrounded by many hilly terrains which are lying barren throughout the year. In order to achieve sustainable crop production in hilly terrain with humid climate, more appropriate approach is the assessment of soil nutrient properties as well as soil fertility. So, the present study describes the details of topographical survey, soil sampling and analysis of nutrient status at different soil profiles and find out the status of suitability of land for crop planning in the hilly terrain. The topographical survey revealed the sloppy nature of the top land surface varying the slope from 3 to 7%. And the average depth of soil on the top land was found to be only 60 cm and below which hard pan layer was encountered. So, the soil nutrient parameter analysis were carried out at four depth of soil profiles (0-15, 15-30, 30-45 and 45-60 cm). The soil profile analysis revealed that the average o***rganic Carbon (OC) content was 1.12, 0.80, 0.61, 0.26 % in the soil profile*** at 0-15, 15-30, 30-45 and 45-60 cm profile, respectively***. Average total Nitrogen, Phosphorous and Potassium content observed in the soil profile*** at 0-15, 15-30, 30-45 and 45-60 cm profile ***were found to be 4.20, 5.60, 2.80 and 2.45g/kg; 0.02, 0.02, 0.14 and 0.01g/kg; 0.47, 0.48, 0.47 and 0.57g/kg, respectively.*** *The predictive assessment of topographical survey and soil nutrient properties at a generic level revealed the scope for growing vegetables and horticultural crops in the hilly terrains.*

Keywords*: Hilly terrain, nutrient status and agricultural planning.*

1. INTRODUCTION

Maintenance of soil quality is essential to sustain crop yields even under harsh environments like the humid tropics where high soil erosion, landslides and nutrient losses generally occur. Soil quality assessment has also been suggested as a tool for evaluating sustainability of soil and crop management practices [9]. Soil fertility refers to the ability of the soil to support organic life. It also refers to the inherent capacity of the soil to supply nutrient in adequate amount and in suitable proportions for crop growth and crop yield.

The trend in increasing the yield by adopting high yielding varieties has resulted in deficiency of nutrients in soils and has reflected as deficiency symptoms in plants. Hence, it is required to know the fertility (NPK) status of the soils of the state for applying the required dosage of fertilizers and planning the regional distribution of fertilizers. Micronutrient deficiencies are reported to be the main cause for stagnant or declining yields in India [7]. While little attention has been paid to assess micronutrient deficiency in soils of the humid areas, large scale yield benefits with the application of Zn and B along with S have been reported [11]. Extensive Zn, B and S deficiencies were reported due to poor organic C status of soil [13]. It was also reported that 43 out of 57 districts in India were Zn deficient, with the deficiency being more prevalent in the surface horizons of Alfisols, Vertisols, Inceptisols and Aridisols [6].

Soils in the hilly areas like Karbi-Anglong, adjoining Arunachal Pradesh have high organic matter status (2.3-2.94%). Nitrogen content in the soil varies from 0.013-0.217% in Brahmaputra Valley. Available Phosphorus status is low in the plains and high in hilly districts. Available Potassium is higher in 20% of the Cachar district.

Since, the soil quality status of the hilly terrain of Assam University, Silchar has not been monitored for sustainable crop planning. So, the present study has been carried out to assess the aforementioned soil physical and chemical properties at different soil profiles of the hilly terrain which is among the non-irrigated land of the Assam state in India.

2. MATERIALS AND METHODS

2.1 Study area

One of the hilly terrains situated in the Assam University, Silchar of Cachar district and in the southern part of the Assam was considered for the study area. The study area hilly terrain of Assam University, Silchar covered total hill top area of about 10000m^2. The climate of the Silchar is warm and humid during summer where average relative humidity is 85% and in winter it is about 78%. The area receives an average of 2196 mm rainfall during the year. Soils of the zone vary from sandy type to clay soil mostly suitable for field crops including horticultural crops. The soil pH ranges from 4.6 to 5.7.

2.2 Topographic survey and soil sampling

In order to assess the suitability of land for agriculture and classification of soils, topographical land survey was carried out using standard surveying instruments such as Global Positioning System (GPS) and Automatic Level. The total area of the hilly terrain was found about 9682.8m^2. Because of dense jungle, it was not possible to make demarcation in to different sections of the land. However, randomly, total of 16 (8 numbers in left side and 8 numbers in right side) observation points were considered for the assessment of soil parameters of the terrain. The topographical view of the study site is shown in Figure1.

Fig. 1: A topographical view of the hilly terrain

The topographic characteristics such as land area, soil depth, slope and elevation of each observation points were determined using standard guidelines of land capability classification [10].

Three main factors such as depth, sampling intensity per unit area of site sampled, and the sampling design are usually considered when developing soil-sampling protocols to monitor change in major soil fertility parameters. It is noted that sampling by fixed depths, rather than by generic horizon, underestimated soil carbon losses due to cultivation [6]. So, the sampling by fixed depth was considered and collected using a soil core cutter and sampler. During collection of samples; dead plants, old manures and areas near trees were excluded.

2.3 Analysis of soil nutrient status

2.3.1. Soil organic Carbon content

Soils contain Carbon (C) in both organic and inorganic forms. The majority of C is held as soil organic carbon. The term soil organic matter (SOM) is used to describe the organic constituents in the soil (tissues from dead plants and animals, products produced as these decompose and the soil microbial biomass). SOM is defined as any living or dead plant and animal materials in the soil and it comprises a wide range of organic species such as humic substances, carbohydrates, proteins, and plant residues [3]and [4] For testing soil Organic Carbon, Walkley and Black’s rapid titration method .

2.3.2. Total Nitrogen

Nitrogen (N) is the forth plant nutrient taken up by plants in greatest quantity next to carbon, oxygen and hydrogen, but it is one of the most deficient elements in the tropics for crop production [12],[9]and [10]. The total N content of a soil is directly associated with its OC content and its amount on cultivated soils is between 0.03% and 0.04% by weight [9] and [14]. Total nitrogen in soil were determined by Micro Kjeldahl method (Jackson, 1973).

2.3.3. Total Phosphorous

Phosphorus (P) is known as the master key to agriculture because lack of available P in the soils limits the growth of both cultivated and uncultivated plants [4]. Following N, P has more wide spread influence on both natural and agricultural ecosystems than any other essential elements. The main sources of plant available P are the weathering of soil minerals, the decomposition and mineralization of soil OM and commercial fertilizers. Phosphorus in soil was estimated by Olsen’s method as described by Jackson.

2.3.4. Total Potassium

Potassium is the third most important essential element next to N and P that limit plant productivity. Its behavior in the soil is influenced primarily by soil cation exchange properties and mineral weathering rather than by microbiological processes. Unlike N and P, K causes no off-site environmental problems when it leaves the soil system. It is not toxic and does not cause eutrophication in aquatic systems [1]. It was reported that the variation in the distribution of K depends on the mineral present, particles size distribution, degree of weathering, soil management practices, climatic conditions, degree of soil development, the intensity of cultivation and the parent material from which the soil is formed [15]. Total potassium in young leaf, mature leaf, stem, root and soil were determined by Flame photometer method.

3. RESULTS AND DISCUSSION

3.1 Topographic and land characteristics

The topography and land characteristics of the study site are presented in Table 1. The topographical survey revealed that the top land surface is sloppy and undulating.

Table 1: Topography and land characteristics of the study site

Sites	Obser-vation points	Elevation (m) w.r.t. MSL	Slope (%)	Range of soil depth (cm)	Topography and class	Drainage type and class
Left Side	(A)	36.5	2.85		Gently sloping to gently undulating B2	Moderately well drained C3
	(B)	36.27	2.04			
	(C)	35.85	4.17			
	(D)	35.77	3.53	25-50		
	(E)	35.72	3.31			
	(F)	35.81	2.60			
	(G)	35.83	2.22			
	(H)	35.84	1.98			
Right Side	(A)	36.32	2.57		Moderately sloping to gently undulating B3	Moderately well drained C3
	(B)	35.59	8.67			
	(C)	35.37	7.96			
	(D)	34.87	9.11	50-90		
	(E)	34.24	10.00			
	(F)	34.27	7.91			
	(G)	34.67	5.67			
	(H)	34.59	5.31			

It was observed that left side of terrain has an average land slope of about 3% and so the land is gently sloping to undulating (class B_2 type). However, average land slope of right side of terrain was found to be 7% and which is moderately sloping to gently undulating (Class B_3 type). The drainage systems of both the sides were found to be moderately well drained which indicates that it is a class C_3 type (Land Capability Classification, Agriculture Handbook, United States Department of Agriculture, 1958). The average soil depth in the study area was found 60 cm. So, further sampling and analysis were carried out using the individual samples from four profile depths (0-15, 15-30, 30-45 and 45-60cm).

3.2 Soil nutrient status

Soil samples collected from average 8 locations and 4 depths of profile in the study site were used to determine the soil nutrient status ie.soil organic Carbon, total Nitrogen, total Phosphorous and total Pottasium.

The OC content of the profiles varies from 0.14-1.23% in the left side and 0.38-1.01% in the right side indicating low OC content in both the sites. In both the sites, the highest amount was found at the depth of 0-15cm and lowest at the depth of 45-60cm. The trend of total organic carbon was found to be decreasing with increase in soil depth. Total Nitrogen content varies from 2.8-5.6g/kg in the left side whereas in the right side it varies from 2.1-5.6g/kg. The amount is the highest at a depth of 0-15cm and 15-30cm and it is lowest at a depth of 30-45cm and 45-60cm in the left side. In the right side, the amount is the highest at the depth of 15-30cm and lowest at the depth of 0-15cm, 30-45cm and 45-60cm.

Table 2: Depth wise average soil nutrients observed in the study site

SITES	Depths (cm)	Total Organic carbon (%)	Total Nitrogen (g/kg)	Total Phosphorus (g/kg)	Total Potassium (g/kg)
Left side	0-15	1.23	5.6	0.01	0.47
	15-30	0.65	5.6	0.01	0.47
	30-45	0.43	2.8	0.25	0.47
	45-60cm	0.14	2.8	0.001	0.50
Right side	0-15cm	1.01	2.8	0.03	0.47
	15-30cm	0.94	5.6	0.02	0.49
	30-45cm	0.79	2.8	0.02	0.47
	45-60cm	0.38	2.1	0.01	0.64

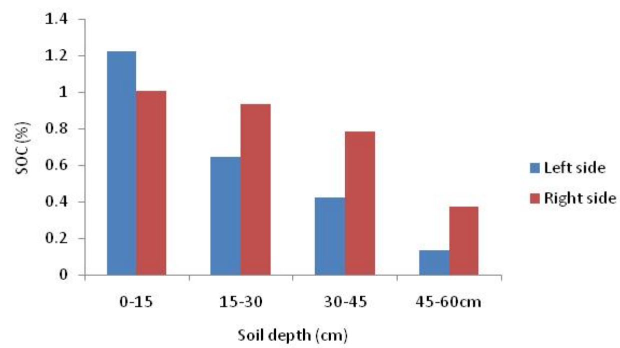

Fig. 2: Depthwise variation of Soil Organic Carbon in the study site

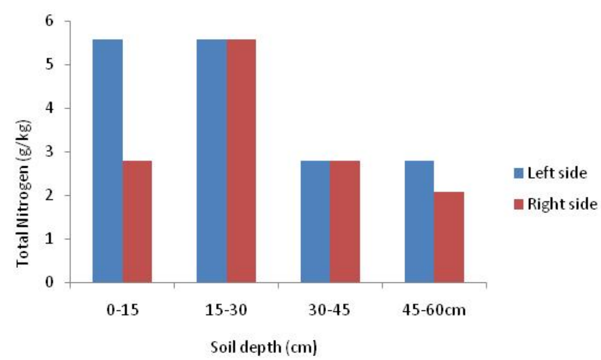

Fig. 3: Depthwise variation of total Nitrogen in the study site

Total Phosphorous content varies from 0.001-0.2g/kg in the left side and 0.01-0.2g/kg in the right side. The amount is the highest at a depth of 30-45cm and lowest at a depth of 45-60cm in the left side and the amount is found to be decreasing with the increase in the depth of soil in the right side of the study site. Total Potassium content in both the sides of the study site is about 0.4g/kg. The amount of total Potassium in the left side is found to be comparatively lower than in the right side of the study site (Table 2). The variation of the soil Organic Carbon content, total Nitrogen content, total

Phosphorous content and total Potassium content with the various depth of the soil sample is given in Fig. 2, 3, 4 and 5 respectively.

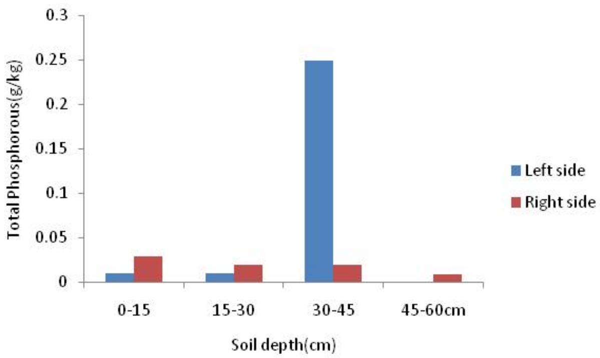

Fig. 4: Depthwise variation of total Phosphorous in the study site

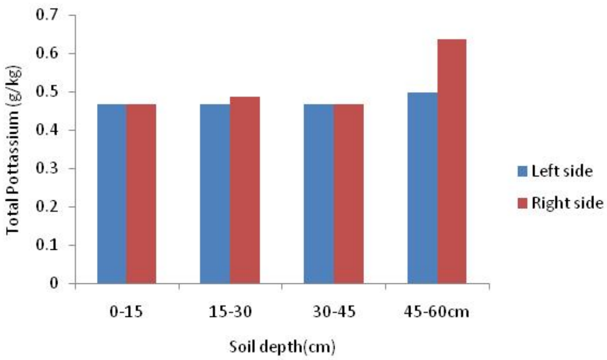

Fig. 5: Depthwise variation of total Pottassium in the study site

4. AGRICULTURAL PLANNING

The development of plants and measures to achieve greater and more efficient output from agriculture; a sound agriculture policy should be able to reconcile three basic needs: the production of food and agricultural products, protection of the environment and the maintenance of the agricultural farm. The hilly terrain is not suitable for the cultivation of rice as it is a well drained land and rice requires lot of water during its plantation period. However, low water requirement crops like carrot, maize, tomato, sweet potato, peas and flowers like roses, cosmos, marigold, hibiscus and calendula are suitable for cultivation. Based on the basic research with the specific parameters of soil, the crop planning for sustainable agriculture in a hilly terrain is proposed and presented in the Table 3.

Agricultural intensification without adequate restoration of soil fertility may threaten the sustainability of agriculture. Quantitative estimation of plant nutrient depletion from soils is useful for comprehending the state of soil degradation and for devising corrective measures.

Table 3: Sustainable agricultural planning of the study site

Sites	Soil					Crop
	Type	Soil OC% (Avg.)	Soil N(g/kg) (Avg.)	Soil P(g/kg) (Avg.)	Soil K(g/kg) (Avg.)	
Left side	2-4 % slope, gently sloping to gently undulating, moderately well drained	0.61	4.2	0.07	0.48	Tomato, Maize, Sweet Potatoes, Radish, rose, calendula, cosmos, marigold, pineapple etc.
Right side	3-10 % slope, Moderately sloping to gently undulating, well drained	0.78	3.33	0.02	0.52	Tomato, Maize, Sweet Potatoes, Radish, rose, calendula, cosmos, marigold, pineapple etc.

5. CONCLUSIONS

The soil nutrient status largely determines the soil's water and air supplying capacity to plants. Many soil nutrient status change with changes in land use system and its management such as intensity of cultivation, application of fertilizers, amount of irrigation. So, the present study was carried out to assess soil nutrient status of a hilly terrain situated in Assam University, Silchar and surrounded by many low hills of Assam state. The nutrient status of the soil samples were determined using standard methods.

The land topographical survey and soil characteristics study revealed that the study site is coming under sloppy (3-7%) land. Average organic carbon (OC) content was found to be 1.12, 0.80, 0.61, 0.26 % in the soil profile at 0-15, 15-30, 30-45 and 45-60 cm profile. Total Nitrogen, Phosphorous and Potassium content observed in the soil profile at 0-15, 15-30, 30-45 and 45-60 cm profile were found to be 4.20, 5.60, 2.80 and 2.45g/kg; 0.02, 0.02, 0.14 and 0.01g/kg; 0.47, 0.48, 0.47 and 0.57g/kg, respectively. The findings provide the logistic and basic information for a sustainable agricultural planning in the study site. However, for increasing the yield of the crops to be grown in the hilly terrain a detailed fertility status with other physic-chemical properties are also to be studied.

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