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Effect of Landform on some Physical and Chemical Properties of Soil under Rice cultivation in North East Region of India

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ABSTRACT

Detailed knowledge about important soil properties is essential for developing site specific nutrient management practices for sustainable crop production system. Landform is one of the key factors defining the soil properties of a landscape. In the present study soil pH, electrical conductivity (EC), texture, available NPK and cationic micronutrients (Zn, Fe, Cu and Mn) were analysed in soil samples (0-20 cm depth) collected from five different landforms (upper piedmont, lower piedmont, foothills, old alluvial plain and young alluvial plain) under rice cultivation in Baska block of Baksa district in Lower Brahmaputra Valley agroclimatic zone of Assam in the North Eastern India. Results indicated that studied soils were loam to clay loam in texture and medium to high in organic carbon (OC) (0.72-0.97%). Soils were acidic in reaction (pH 5.2-5.7) and effect of landform on pH was non-significant at $p<0.05$. Effect of landform on OC, available NPK and micronutrients were found significant at $p<0.05$. Among the landforms significantly higher values of clay (35.6%), OC (0.97%) and available N (269 kg ha^{-1}) were found in young alluvial plain whereas old alluvial plain was having highest P (P_2O_5 59.6 kg ha^{-1}) and K (K_2O 138.2 kg ha^{-1}). Studied soils were low to medium in available N; low in available K; medium in available P; sufficient in Fe, Mn and Cu and deficient in Zn across the landforms.

1. Introduction

Soils are well-known as the essential portion of the landscape and their features are largely controlled by the landforms on which they developed. The physiographic influence on soil properties is recognized and ultimately leads to evolution of the soil–landform relationship (Ali and Moghanm, 2013). Landform is one of the 5 fundamental elements of the soil-forming factor theory (Amundsen *et al.*, 1994) and is central to the catena concept of soil development (Hook and Burke, 2000), which is characterized by leaching and redistribution of elements and soil material along landscape. Landform exerts significant effect on soil biological and chemical processes through its influence on soil moisture conditions and flow patterns, solar radiation and temperature regime, plant structure and erosion and sediment redistribution. Many researchers have related the soil properties with landform (Shao *et al.*, 2007; Zhao and Shao, 2008). Brubaker *et al.* (1993) observed increases of sand and silt, organic matter, pH, $CaCO_3$, Ca and Mg, and base saturation but decreases in clay, cation exchange capacity and available K in low position of landforms in Nebraska, USA. McKenzie and Ryan (1999) observed terrain, together with climate and parent material, to explain as much as 78% of total phosphorus variation and 54% of total Carbon variation in a catchment in South-Eastern Australia. Chen *et al.* (1997) found aspect and slope to be

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controlling factors for soil pH in a mountainous area of eastern Taiwan. Johnson *et al.* (2000) found that landforms were able to explain 4 - 25% of the variation of soil chemical parameters in the Catskill watershed in New York, USA.

Rice is grown in different landform situations and rice, mono-cropping is the dominant system in Assam, but the productivity (2000 kg ha^{-1}) is much below the national average (2596 kg ha^{-1} as on 2019-20). Among many factors, improper nutrient management is the key factor for low productivity. Nutrient deficiencies of N, P, K, and Zn are considered as major nutrient limiting factors for the low productivity of rice in the North-Eastern part of India (Baishya *et al.*, 2017). The information on variation of soil properties across varied landforms is limited thus the present study was undertaken to examine the soil reaction (pH), EC, texture and contents of macro- (NPK) and micronutrients (Zn, Fe, Cu and Mn) in five landforms in Baska block of Baksa district of Assam. The area falls in Lower Brahmaputra Valley Agroclimatic zone of Assam. The climate of the area is hot humid to subhumid with annual average rainfall of 2300 mm (of which 52% received during monsoon season). This study is likely to help in fertilizer management to improve rice yield and maintain soil fertility.

2. Materials and Methods

Present study was conducted in the year 2019 in the Baska block lies between 26° 33' 35.7" N to 26° 47' 20.16" N latitude and 91° 14' 0.39" E to 91° 25' 32.83" E longitude of Baksa district, Assam. The study area is characterized by mixed topography of plains and foothills and falls within Lower Brahmaputra Valley zone of Assam. There were five different landforms in our study area, *viz.*, Upper Piedmont, Lower Piedmont, Foot Hills, Old Alluvial Plain and Young Alluvial Plain. The composite soil samples (0-20 cm depth) were collected in six replications from each landform under rice cultivation to study the variation in soil texture and major soil chemical properties and comparison amongst them. Collected soil samples were air-dried and grounded to pass through a 2 mm sieve and part of the 2 mm soil sample (approximately 10 g) finely grounded using porcelain pastel mortar and passed completely through a 0.2 mm sieve and used for organic carbon analysis.

Soil pH and electrical conductivity (EC) were determined in 1:2.5 soil: water ratio following standard methods (Jackson, 1973). Soil textural analysis was done by International pipette method (Piper, 1996). Soil organic carbon (OC) was determined by wet oxidation method (Walkley and Black, 1934). Available nitrogen (N) was determined by the alkaline $KMnO_4$ method (Subbiah and Asija, 1956). Available phosphorus (P) was determined by following standard procedure (Bray and Kurtz, 1945). Available potassium (K) was determined by extraction with neutral normal ammonium acetate method (Jackson, 1973).Cationic micronutrients (Zn, Fe, Cu and Mn) were extracted by diethylene triamine penta acetic acid (DTPA) (Lindsay and Norvell, 1978) and determined by using atomic absorption spectrophotometer (AAS).

Experimental data obtained were subjected to analysis of variance (one way ANOVA) in completely randomized block design (RBD) using window based statistical software, SPSS version 16.0. Least significant difference (LSD) and Duncan's multiple range test (DMRT) at ($p = 0.05$) were used to determine whether the means differed significantly.

3. Results and Discussion

The major soil textural class was Clay Loam for all landforms except Loam in Upper Piedmont (Table 1). The % sand, silt and clay did not differ significantly ($p<0.05$) among different landforms. Highest amount of sand (40.5%), silt (45%) and clay (35.6%) were found at Upper Piedmont, Lower Piedmont and Young Alluvial Plain, respectively. Relatively high clay content in Young Alluvial Plain and Old Alluvial Plain reflects the long term geomorphic processes of erosion in the upper topographic position and deposition in the lower topographic position (Collins and Foster, 2008).

The soils were acidic in reaction with pH ranging from lowest 5.2 (Young Alluvial Plain) to highest 5.7 (Foot Hills) (Table 2). Except foot hills (medium acidic) other landforms falls in strongly acidic category (pH<5.5), but the pH did not differ significantly at 5% level of confidence. Leaching of basic cations due to high precipitation causes soil acidity (Brady and Weil, 2004). Higher amount of hydrogen ions in the soil solution shows a higher rate of electrical conductivity. Hence, low soil pH due to large number of hydrogen ions in the soil may encourage soil electrical conductivity. Soil pH is negatively related with soil electrical conductivity in the form of power function and not in linear relationship because there are several other factors such as soil mineral, porosity, soil texture, soil moisture and soil temperature also affect electrical conductivity in the soil (USDA, 2011; Mohd-Aizat *et al.*, 2014). The soil electrical conductivity was in normal range (<1 dS m^{-1}) and was highest (0.22 dS m^{-1}) in case of Young Alluvial Plain, which was at par with old Young Alluvial Plain (0.16) and significantly higher than other landforms at $p<0.05$. Lowest EC (0.09 dS m^{-1}) was found in case of Foot Hills with pH 5.7. Significantly higher ($p<0.05$) soil OC was found in Young Alluvial Plain (0.97%) followed by Lower Piedmont (0.90%), Old Alluvial Plain (0.84%), Upper Piedmont (0.83%) and Foot Hills (0.72%). The organic carbon content in different landforms falls in medium to high range (0.50-0.97%). Soil organic matter and consequently soil OC is one of the most important attributes of a soil because it affects nutrient cycling, soil structure and water availability. Maintaining or increasing soil OC content is an important measure of the sustainability of a cropping system. Soil OC is the main source of energy for soil microbes and therefore, the amount of soil OC will influence the availability of essential plant nutrients through mineralization and immobilization (Emmanuel *et al.*, 2018). Soil is generally considered to comprise 5% of soil organic matter while almost 95% of soil Nitrogen is closely associated with soil organic matter (Pribyl, 2010). The available N in different landforms varies between lowest 186 kg ha^{-1} (Foot hills) to highest 269 kg ha^{-1} (Young Alluvial Plain). Available N in Upper Piedmont (253 kg ha^{-1}) and Young Alluvial Plain are significantly higher than other landforms and at medium range of availability (240-480 kg ha^{-1}). Others are in the lower range of N availability (<240 kg ha^{-1}). Transport and accumulation of organic matter and nutrients might be the cause of higher OC and available N in the Young Alluvial Plain (Collins and Foster, 2008). Significantly higher available P_2O_5 was found at Old Alluvial plain (59.6 kg ha^{-1}), which was at par with Upper Piedmont (54.0 kg ha^{-1}) followed by Young Alluvial Plain (49.3 kg ha^{-1}), Foot Hills (49.1 kg ha^{-1}) and Lower Piedmont (45.1 kg ha^{-1}). The available P_2O_5 level falls within the medium range. This could be due to low decomposition of organic materials and slow release of mineral nutrients (Brady and Weil, 2004). Available K_2O was found in lower range (< 200 kg ha^{-1}) of availability in all landforms. Significantly higher available K_2O was found in Old Alluvial Plain (138.2 kg ha^{-1}) and lowest 138.2 kg ha^{-1} at Foot Hills. Low level of K in soils might be due to the crop removal and low retention capacity for K owing to low activity clays.

Soil testing for iron is not usually recommended. Most test methods do not discern between forms of iron, and therefore have little meaning for plant nutrition. Iron deficiencies are uncommon on acid soils. However, significantly higher Fe was found in Young Alluvial Plain (126 ppm) and lowest at Foot hills (82 ppm). High level of Fe content resulted from high degree of weathering of ferruginous materials under heavy rainfall (Bandyopadhyay *et al.*, 2018). Mn values above 1.5 ppm using the DTPA extraction method are sufficient. Mn deficiencies generally occur only in soils with pH 7.0 or above. Mn toxicity may occur in acid soils. Significantly higher Mn was found in Young Alluvial Plain (25.2 ppm) and lowest at Upper Piedmont (13.6 ppm). Zinc values above 1.0 ppm using the DTPA extraction method are sufficient. Zn deficiencies sometimes are associated with high soil P concentrations, soils high in fine clay and silt, or soils with high pH. In our study area all the landforms have Zn concentration below sufficiency level ranging from 0.5 ppm (Young Alluvial Plain) to 0.85 ppm (Upper Piedmont). Copper values above 0.6 ppm using the DTPA extraction method are sufficient. Copper deficiencies are usually uncommon. Significantly higher Cu content was found at Lower Piedmont (2.52 ppm) and Young Alluvial Plain (2.51 ppm). Other three landforms contain Cu below 2 ppm level. Zinc deficiency in the soils of North Eastern states were reported in previous study (Bandyopadhyay *et al.*, 2018) and reason for wide spread deficiency might be due to loss in leaching and runoff (Bhuyan *et al.*, 2014).

4. Conclusions

Study clearly reveals that soils are acidic in reaction and low to medium in N; low in K and medium in P under different landform of study area. In case of micronutrient Zn deficiency is the limiting factor across all the landforms. Hence, there is need to develop landform specific appropriate nutrient management strategies and suitable cropping system to alleviate the limitations due to acidity and depletion of primary nutrients NPK and micronutrients especially Zn.

5. References

Ali RR and FS Moghanm (2013).Variation of soil properties over the landforms around Idkulake, Egypt. *The Egyptian J. Remote Sensing and Space Sci.*, 16 (1): 91-101.

Amundsen R, Harden JW and MJ Singer (1994). Factors of Soil Formation: A Fiftieth Anniversary Perspective. *Soil Sci. Soc. Am. J.* (Spec. Publ.), 33: 31-64.

Baishya A, Gogoi B, Bora AS, Hazarika J, Borah M, Das AK and P Sutradhar (2017). Soil fertility and onfarm crop response to NPK and Zn fertilization in rice-rice cropping sequence of Lower Brahmaputra Valley Zone of Assam. *Agricultural Science Digest-A Research Journal*, 37(2): 87-93.

Bandyopadhyay S, Ray P, Padua S, Ramachandran S, Jena RK, Roy PD, Dutta DP, Singh SK and SK Ray (2018). Priority Zoning of Available Micronutrients in the Soils of Agro-ecological Sub-regions of North-East India Using Geo-spatial Techniques. *Agricultural Research*, 7(2): 200-214.

Bhuyan N, Barua NG, Borah DK, Bhattacharyya D and A Basumatari (2014). Georeferenced micronutrient status in soils of Lakhimpur district of Assam. *Journal of the Indian Society of Soil Science*, 62(2): 102-107.

Brady NC and RR Weil (2004).The nature and properties of soil. Prentice Publishers, New Delhi, India.

Bray RH and LT Kurtz (1945). Determination of total, organic and available forms of phosphorus in soils. *Soil Sci.*59: 39-45.

Brubaker SC, Jones AJ, Lewis DT and K Frank (1993). Soil properties associated with landscape position. *Soil Sci. Soc. Am. J.* 57: 235-239.

Chen ZS, Hsieh CF, Jiang FY, Hsieh TH and IF Sun (1997).Relations of soil properties to topography and vegetation in a subtropical rain forest in southern Taiwan. *Plant Ecol.*, 132: 229-241.

Collins CD and BL Foster (2008). The role of topography and soil characteristics in the relationship between species richness and primary productivity in a Kansas grassland. *Transactions of the Kansas Academy of Science,* 1903: 105-117.

Emmanuel A, Hitler L, Udochukwu AO, Ayoola AO, Tizhe TF, Isa AP, Danjuma BH and IDzarma (2018). Assessment of Organic Carbon and Available Nitrogen in the Soil of Some Selected Farmlands Located at ModibboAdama University of Technology, Adamawa State, Nigeria. *J. Environ. Anal. Chem.,* 5(2): 239. doi:10.4172/2380-2391.1000239.

Hook PB and IC Burke (2000). Biogeochemistry in a shortgrass landscape: control by topography, soil texture, and microclimate. *Ecol.* 81: 2686-2703.

Jackson ML (1973). *Soil Chemical Analysis*, Prentice Hall of India Pvt. Ltd., New Delhi.

Johnson CE, Méndez JJR and GB Lawrence (2000).Forest soil chemistry and terrain attributes in a catskills watershed. *Soil Sci. Soc. Am. J.* 64: 1808-1814.

Lindsay WL and WA Norvell (1978). Development of DTPA soil test for zinc, iron, manganese and copper. *Soil Sci. Soc. Am. J.* 42: 421-427.

McKenzie NJ and PJ Ryan (1999).Spatial prediction of soil properties using environmental correlation. *Geoderma*, 89: 67-94.

Mohd-Aizat A, Mohamad-Roslan MK, Wan NorAzminSulaiman, Daljit Singh Karam (2014). The relationship between soil pH and selected soil properties in 48 years logged-over forest. *Int. J. Env. Sci.*, 4(6): 1130-1140.

Piper CS (1966).Soil and Plant Analysis. Hans Publisher, Bombay.

Pribyl DW (2010). A critical review of the conventional SOC to SOM conversion factor. *Geoderma,* 156: 75-83.

Shao HB, Guo QJ, Chu LY, Su ZL, Cheng JF and JH Zhang (2007).Understanding molecular mechanism of higher plant plasticity under abiotic stress. *Biointerfaces*, 54: 37-45.

Subbiah BV and GL Asija (1956).A rapid procedure for the estimation of available nitrogen in soils. *Curr. Sci.,* 25: 259-260.

United States Department of Agriculture (USDA) (2011). Soil Quality Indicator: Soil Electrical Conductivity; Natural Resources Conservation Services: United State.

Walkley A and IA Black (1934). An examination of the Degtjareff method for determining soil organic matter, and a proposed modification of the chromic acid titration method. *Soil Sci.,* 37(1): 29-38.

Zhou Y and HB Shao (2008). The responding relationship between plants and environment is the essential principle for agricultural sustainable development on the globe. *CR Biol.*, 331: 321-328.

Table 1. Landforms and soil texture

Sl No.	Parameter	Landforms					LSD (p<0.05)
		Upper Piedmont	Lower Piedmont	Foot Hills	Old Alluvial Plain	Young Alluvial Plain	
1	Sand (%)	40.5	24.8	38.1	34.1	23.7	NS
2	Silt (%)	32.3	45.0	33.7	34.7	40.7	NS
3	Clay (%)	27.2	30.3	28.2	31.3	35.6	NS
4	Soil type	Loam	Clay Loam	Clay loam	Clay Loam	Clay Loam	--

Table 2. Landforms and soil chemical properties

Sl No.	Parameter	Landforms					LSD (p<0.05)
		Upper Piedmont	Lower Piedmont	Foot Hills	Old Alluvial Plain	Young Alluvial Plain	
1	Water pH	5.3	5.5	5.7	5.3	5.2	NS
2	EC (dS m^{-1})	0.09 ^{b}	0.12 ^{b}	0.09^{b}	0.16 ^{ab}	0.22 ^{a}	0.02
3	Organic C (%)	0.83 ^{c}	0.90 ^{b}	0.72^{d}	0.84 ^{c}	0.97 ^{a}	0.02
4	Available N (kg ha^{-1})	253 ^{a}	210^{b}	186^{b}	211 ^{b}	269 ^{a}	29.1
5	Available P_2O_5 (kg ha^{-1})	54.0 ^{ab}	45.1 ^{b}	49.1^{b}	59.6 ^{a}	49.3 ^{b}	8.1
6	Available K_2O (kg ha^{-1})	83.2 ^{d}	118.8 ^{b}	99.7^{c}	138.2 ^{a}	113.1 ^{b}	6.8
7	Fe (ppm)	112 ^{b}	103 ^{b}	82^{c}	108 ^{b}	126 ^{a}	11.9
8	Mn (ppm)	13.6 ^{c}	15.4 ^{c}	16.1^{c}	20.3 ^{b}	25.2 ^{a}	2.7
9	Zn (ppm)	0.85 ^{a}	0.83 ^{a}	0.52^{bc}	0.58 ^{b}	0.50 ^{c}	6.81
10	Cu (ppm)	1.87 ^{b}	2.52 ^{a}	1.76^{b}	1.45 ^{c}	2.51 ^{a}	0.28

The values followed by different lowercase letters are significantly different according to Duncan's Multiple Range Test *at P =0.05*.