

Original Research Article

Profile Distribution of Available Plant Nutrients in Western Hilly Tracts of Cuttack District, Odisha

ABSTRACT

Aims:An investigation was conducted to examine the distribution of available plant nutrients and the relationships between soil properties and available nutrient status in soil profiles in the Western Hilly Tracts of the Cuttack District, Odisha.

Place and Duration of Study:The research area, i.e. the Narasinghpur block, is located in the western part of the Cuttack district in Odisha and is characterized by lateritic uplands and mountainous terrain. Three soil profiles were exposed, ~~i.e. upland, medium land and low land were exposed, i.e. upland, medium land and low land~~ before the rainy season (February, 2020).

Methodology:For experiments, five layers demarcated at 20cm intervals up to a depth of 100cm were sampled, processed, and stored. Several parameters, including particle size, pH, EC, OC, and available Ca, Mg, S, Fe, Mn, Cu, and Zn, ~~among others, were analyzed~~ ~~were analyzed~~ and interpreted using standard protocols.

Results:Sand content ~~was observed to decrease~~ ~~decreased~~ with pedon depth, whereas clay content showed the opposite trend. With increasing soil depth in all pedons, soil pH increased while EC and soil organic carbon content declined. The available Ca, Mg, and S in surface soils varied from 4.11 to 6.56 [cmol (p⁺)/kg], 2.15 to 3.54 [cmol (p⁺)/kg] and 9.85 to 12.06 mg kg⁻¹, respectively. The corresponding subsurface ranges for these nutrients were 4.31 to 8.52 [cmol (p⁺)/kg], 2.41 to 4.52 [cmol (p⁺)/kg], and 6.95 to 11.41 mg kg⁻¹, respectively. The ~~range of available Fe, Mn, Cu, Zn, and B~~ ~~available Fe Mn, Cu, Zn, and B~~ ~~range~~ in surface soils were 127.85-278.81, 68.48-144.98, 0.64-0.9, 0.54-0.63 and 0.37-0.47 mg kg⁻¹, respectively. The subsurface ranges for these nutrients were 102.32-234.46, 53.21-118.28, 0.28-0.89, 0.17-0.50, and 0.29-0.91 mg kg⁻¹. The status of micronutrients in the present study region was as follows: Fe > Mn > Cu > Zn > B. With increasing soil depth, available Ca and Mg increased, but available S, Fe, Mn, Cu, Zn and B declined. Positive correlations between available Fe, Mn, Cu, and Zn with the soil organic carbon content of the soil and negative correlations with the soil pH were observed.

Conclusion: Plant nutrients in the research area varied with topography, although the differences ~~were not substantial between upland, medium land and lowland~~ ~~between upland, medium land and lowland~~ ~~was not substantial~~. However, accelerated decomposition of soil organic matter and agricultural residues likely led to higher micronutrient concentrations at the soil's surface ~~compared to~~ ~~than~~ subsurface.

Keywords:[Soil fertility, Micronutrients, pedon, soil profile, topography, Soil Organic Carbon]

1. INTRODUCTION

Micronutrients are elements that are required for plant growth in minute concentrations. Despite being required in ~~less~~ ~~fewer~~ quantities, micronutrients have the same functional importance as macronutrients and play critical roles in plant growth [1]. These elements include, Zinc (Zn), Iron (Fe), Copper (Cu), and Manganese (Mn), amongst others. ~~Majority of micronutrients, The majority of micronutrients,~~ are linked to plant enzymatic processes. Zn is known to increase the generation of

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growth hormones, starch, and seed development. Fe is crucial in chlorophyll formation, Cu in photosynthesis, and Mn is important in photosynthesis and metabolism [2]. Origin and sources of soil micronutrients are very diverse in nature. Parent materials, sewage sludge, municipal waste, farmyard manure, organic matter, and atmospheric depositions are their principal sources. Their principal sources are parent materials, sewage sludge, municipal waste, farmyard manure, organic matter, and atmospheric depositions [3]. Trace elements become trapped in the crystal lattice of minerals (such as clay) during the weathering process, making them unavailable. Trace elements are easily absorbed by clay mineral. Clay minerals easily absorb trace elements, but their displacement into the soil is complicated. Micronutrients in soil exist in a variety of various forms, including water-soluble, exchangeable, complex and chelated forms, as well as in the structure of primary and secondary minerals [4]. Numerous studies have demonstrated that the availability of micronutrients in the rhizosphere relies on soil pH, organic matter, clay content, and other physical, chemical, and biological factors [1]. According to [5], Fe and Mn are prevalent in silicate minerals including biotite and hornblende. Zinc may also replace some of the principal elements of silicate minerals, whereas Cu and Mn are frequently bound firmly by organic matter. Micronutrient availability is also altered by interactions between other soil nutrients. Interactions between other soil nutrients alter micronutrient availability. The soil formation process, lithology, parent material, and pedogenesis play a significant effect insignificantly affect the regional variation of nutrient availability. Thus, information on the status of micronutrients in the soil of a region is crucial for determining the nature and extent of their deficiency/toxicity in order to formulate agricultural strategies that will assist farmers in understanding the problems associated with soil nutrients and the amount of fertilizers to be added to the soil for cost-effective production. In order to better comprehend the behaviour of trace elements in the soil environment, the primary purpose of this study was to examine the status of available nutrients in soil profiles and their relationship with other soil properties.

2. MATERIALS AND METHODS

The study area was the Narasinghpur block of the Cuttack district, which is situated in the Mid-Central Table land agro-climatic zone of Odisha, India. The study region was split into three broad physiographic divisions based on slope and elevation, including gently sloping upland (337 feet above MSL, slope of 3-5%), very gently sloping medium land (307 feet above MSL, the slope of 1-3%), and virtually level low land (294 feet above MSL, slope of 0-1%). Using a GPS device, the landform of the research region was determined by traversing the area and collecting elevation data above Mean Sea Level (MSL) at various sites (Garmin make; model: GPSmap 76CSx). After a general traversal of the research region, three representative soil profiles were selected and exposed from three different topographic positions, including upland (20°37'16.5"N 84°55'37.5"E), medium land (20°31'23.8"N 85°01'43.3"E), and low land (20°27'36.8"N 85°02'55.4"E). Pedon 1, 2, and 3 related to the soil profiles of highland, medium land, and low land, respectively. Five layers delineated at 20cm intervals up to a depth of 100cm were sampled, processed, and stored for laboratory analysis. The soil samples were tested for texture using the Bouyoucos Hydrometer method [6], pH (1:2.5) and EC (1:2.5), organic carbon [7], exchangeable Ca & Mg [8], sulphur [9], DTPA extractable iron, manganese, copper, and zinc [10] and hot water extractable boron [11]. Pearson correlation analyses were conducted using [12].

3. RESULTS AND DISCUSSION

3.1 PHYSICO-CHEMICAL CHARACTERISTICS

3.1.1 Particle size distribution

Table 1 presented presents the various size distributions of the fine earth fraction of soil particles. The data showed that in Pedon 1, sand (%) ranged from 75 to 81, silt (%) ranged from 8.4 to 12.4, and clay (%) ranged from 9.6 to 14.6. In Pedon 2, the percentages of sand, silt, and clay sand, silt, and clay ranged from 65 to 76, 6.4 to 13.4, and 13.6 to 27.6, respectively. Sand percentages in Pedon 3 ranged from 62 to 68, silt percentages from 15.4 to 13.4, and clay percentages from 18.6 to 32.6. Sand content was observed to decrease decreased with pedon depth, whereas clay content showed the opposite pattern. It was due to the percolating water and the leaching of clay and colloidal

fractions of soil from the surface to the subsurface layers. Statistically significant negative correlation between sand and clay ($r = -0.947^{**}$) in Table 3 suggested that clay had been created through [the](#) transformation of sand to silt and ~~ferro~~neosynthesis of clay [13].

3.1.2 Soil reaction (pH)

The surface soil of Pedon 1 was found to be slightly acidic with a pH value of 6.27, which increased with soil depth to a value of 7.12 at a depth of 60-80 cm before decreasing to 7.09. The surface soils of Pedon 2 were moderately acidic with pH values of 5.76, whereas those of Pedon 3 were neutral with pH values of 6.73. The pH was found to be increasing with depth in both Pedon 2 and 3. (Table 1). The increase in soil pH with soil depth could be due to [the](#) leaching of basic cations from upper to lower horizons, primarily during periods of intense rainfall [14].

3.1.3 Electrical conductivity (EC)

The EC of all soil profiles remained below 1 dSm^{-1} , showing that they were non-saline [in nature](#) and suitable for all crop production. This low electrical conductivity could be related to soluble salt leaching and easy drainage during heavy rainfall [15].

3.1.4 Organic carbon (OC)

The surface layers of Pedon 1, 2, and 3 contained 0.59, 0.73, and 0.57 percent organic carbon, respectively (Table 1). ~~In all soil profiles, a consistent decline in organic carbon with increasing soil depth was observed.~~ [A consistent decline in organic carbon with increasing soil depth was observed in all soil profiles.](#) Higher organic carbon content in the surface layers of all three pedons may be linked to ~~the continuous accumulation and decay of crop residues~~ [crop residues' continuous accumulation and decay](#) [16].

Table 1. Distribution of particle size, soil pH, EC and organic carbon ~~with respect to depth~~ in representative pedons

Pedon Depth (cm)	Sand (%)	Silt (%)	Clay (%)	pH (1:2.5)	EC (dS m^{-1})	OC (%)
Pedon 1 (upland)						
0-20	81	8.4	10.6	6.27	0.15	0.59
20-40	79	11.4	9.6	6.73	0.13	0.41
40-60	78	9.4	12.6	6.77	0.11	0.27
60-80	76	9.4	14.6	7.12	0.09	0.24
80-100	75	12.4	12.6	7.09	0.05	0.14
Pedon 2 (medium land)						
0-20	76	9.4	14.6	5.76	0.18	0.73
20-40	73	13.4	13.6	6.02	0.07	0.49
40-60	70	6.4	23.6	6.54	0.06	0.29
60-80	66	7.4	26.6	7.04	0.03	0.22
80-100	65	7.4	27.6	6.78	0.02	0.21
Pedon 3 (lowland)						
0-20	68	13.4	18.6	6.73	0.19	0.57
20-40	65	13.4	21.6	6.98	0.17	0.41
40-60	63	10.4	26.6	7.33	0.06	0.24
60-80	62	5.4	32.6	7.25	0.02	0.22
80-100	63	7.4	29.6	7.58	0.01	0.18

3.2 Distribution of available secondary and micronutrients

3.2.1 Exchangeable Calcium and Magnesium

The surface layers of Pedon 1, 2, and 3 contained 4.11, 6.12, and 6.56 [cmol(p⁺)/kg] exchangeable Ca, respectively (Table 2). Distribution of Exchangeable Ca followed an increasing trend with depth in all pedons and was found to be highest in a depth of 60-80 cm, i.e. 7.85, 8.52 [cmol (p⁺)/kg] in pedons 1 and 2, respectively, while for pedon 3 highest value was observed in a depth of 80-100 cm. The surface layers of Pedon 1, 2, and 3 contained 2.15, 3.12, and 3.54 [cmol (p⁺)/kg] exchangeable Mg, respectively (Table 1). ~~Distribution of Exchangeable Mg. The distribution of Exchangeable Mg followed a similar trend as that of exchangeable Ca. In all soils, calcium and magnesium deficiency is not so high because of calcium and magnesium deficiency is not so high because of the~~ substantial quantity of Ca and Mg in the parent rock and minerals. Conscious farmers of the Cuttack district are applying agricultural liming materials frequently, which also act as a source of the nutrients. The surface soils contained a lower amount of exchangeable Ca and Mg than the sub-surface layers of a profile. This may be due to the removal of exch. Ca and Mg by the crop/vegetation from the surface horizons [17].

3.2.2 Available sulphur

In pedon 1, the uppermost layer (0-20 cm) contained the maximum concentration of sulphur (9.85 mg kg⁻¹), while the lowest concentration (7.89 mg kg⁻¹) was detected in the bottom layer (80-100 cm). In pedon 2, the upper layer (0-20 cm) contained the most available S (11.76 mg kg⁻¹), and the lower layer contained the least (6.95 mg kg⁻¹) (80-100 cm). In Pedon 3, the highest concentration of available S (12.06 mg kg⁻¹) was found in the surface layer (0-20 cm), while the lowest concentration (7.03 mg kg⁻¹) was found in the lower layer (80-100 cm) (Table 2). Surface layers included more available sulphur than subsurface layers, which could be attributed to higher organic matter content in surface layers than deeper layers, as well as variable land usage and parent material [18].

3.2.3 Available iron

The range of available Fe in surface and subsurface soils was 127.85-278.81 mg kg⁻¹ and 102.32-234.46 mg kg⁻¹, respectively. In pedon 1, the upper layer (0-20 cm) contained the maximum available iron (127.85 mg kg⁻¹), and the bottom layer contained the least (102.32 mg kg⁻¹). In Pedon 2, the surface layer (0-20 cm) contained the most of the available Fe (150.28 mg kg⁻¹), and the lower layer contained the least (105.68 mg kg⁻¹) (80-100 cm). In pedon 3, the surface horizon (0-20 cm) contained the maximum concentration of available Fe (278.81 mg kg⁻¹), and the lower horizons (80-100 cm) contained the lowest concentration (163.38 mg kg⁻¹) (Table 2). The decreasing trend of available Fe with increasing soil depth may be a result of result from the increased biological activity and organic carbon in the surface soils. This was further corroborated by the positive correlation (r=0.346**) between available Fe and organic carbon and the negative correlation (r=-0.447**) between available Fe and soil pH (Table 3) [19, 20].

3.2.4 Available manganese

The availability of manganese in surface and sub-surface soils varied between 68.48 and 144.98 mg kg⁻¹ and 53.21 and 118.28 mg kg⁻¹, respectively (Table 2). The decreasing trend of accessible Mn with soil depth may be a result of result from humic material deposition in the surface layers. The greater concentration of available Mn in surface soils was attributable to the chelating of organic compounds produced during the decomposition of crop residue and the addition of FYM [21]. These results were corroborated by a positive correlation of accessible Mn with organic carbon (r=0.356**) and a negative correlation with soil pH (r=-0.137**) (Table 3) [20].

3.2.5 Available copper

In Pedon 1, the surface (0-20 cm) and bottom layer (80-100 cm) contained the maximum (0.86 mg kg⁻¹) and minimum (0.31 mg kg⁻¹) concentrations of available copper, respectively. In Pedon 2, the surface layer (0-20 cm) contained the most available Cu (0.64 mg kg⁻¹), and the bottom layer contained the least (0.28 mg kg⁻¹) (80-100 cm). In Pedon 3, the surface (0-20 cm) contained the maximum available Cu (0.90 mg kg⁻¹) and the lowest (0.37 mg kg⁻¹) was found in the lowest horizon (80-100 cm) (Table 2). Due to its positive correlation (r=0.728**) with organic carbon and negative correlation (r=-0.313**) with soil pH, available Cu declined as soil depth increased (Table 3) [22].

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