International Journal of Plant & Soil Science

34(23): 1681-1686, 2022; Article no.IJPSS.94094
ISSN: 2320-7035

Vertical Distribution of Available Nutrients in Boudh Block of Boudh District Catena

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJPSS/2022/v34i232591

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/94094

Short Research Article

Received 20 September 2022
Accepted 28 November 2022
Published 08 December 2022

ABSTRACT

An investigation was conducted to analyse the distribution of available plant nutrients and to examine the relationships between soil properties and available nutrient status in soil profiles of Eastern India. Three soil profiles were exposed under three different topographic positions. In all the pedons, soil reaction (pH) was increasing and EC was very nominal because there is no accumulation of dissolved salts in the soil pedons. The status of available N was decreasing with soil depth and phosphorus (P) was increased with depth of soil, Organic carbon (OC) was unevenly distributed with the depth of soil, sulphur was also unevenly distributed with depth of soil which is comparable with the (OC). There is similar trend between pH and P.

Keywords: Available nutrients; pedon; soil profile; topography.

1. INTRODUCTION

Understanding the vertical distribution of plant nutrients in soils is important since the roots of the majority of crops extend beyond the surface layers and obtain some of the nutrients they need from there. The soil fertility and crop production are greatly influenced by the features

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of the soil profile as they are conditioned by the many processes and elements of soil development. Understanding the prevalent soil formation (soil genesis) causes and processes is very necessary in order to evaluate soil characteristics; this requires a detailed and scientific research of soil profiles [1-3]. Without the careful use of macro and micro nutrient fertilisers to address the current shortages, crop production cannot be increased further. Therefore, it is crucial to have a thorough understanding of how plant nutrients are distributed vertically in soil in order to recommend the right fertiliser schedule for various crops and ensure maximum production. The availability and distribution of plant nutrients, both in surface soils and subsurface soils, are significantly impacted by topographic variations [4]. In order to explore the vertical distribution of plant nutrients in various topographic locations, this research was carried out in a well-formed catena (toposequence) located in Eastern India with varied topographic positions.

2. MATERIALS AND METHODS

The selected study area was located in Boudh block of boudh district. Based on slope and elevation, the study area has been divided into three major physiographic units such as upland 108m above mean sea level (N 20^{o}49'04.7" E 84^{o}15'43.1"), Medium land 157m above sea level (N 20^{o}44'42.1" E 84^{o}13'28.2") and low land 114m above mean sea level (N 20^{o}48'56.7" E84^{o} 15'55.5") total three profiles are excavated. Soil depth of pedons 1, 2,3 were found to be 87, 67 and 97 cm respectively. Soil samples from different genetic horizons were collected, processed and preserved for laboratory studies. The soil samples were analysed for textural class by Bouyoucos Hydrometer method, pH (1:2) and EC (1:2), organic carbon [5], available nitrogen [6], phosphorus [7], potassium [8] and sulphur [9].

3. RESULTS AND DISCUSSION

3.1 Physical and Chemical Characteristics

Particle size distribution: In pedon 1, a gradual increase in clay content was observed from surface to the depth of 87 cm, which can be attributed to the presences of eluvation process (fundamental pedogenic process). In pedon 2, there is a equal distribution of clay content. In pedon 3, gradual increases up to 39 cm (Table 1), and there is decreased in clay content with equal distribution on up to 97 cm this says there is absents of eluvation process [10].

3.2 Soil Reaction

The surface soil of pedon 1 was found to be acidic with a pH value of 5.08 which increased with soil depth up to a value of 6.54 almost near to neutral at the lower most horizon 87 cm. The surface soils of pedon 2 were found to be slightly acidic with a pH value of 6.31 which increased with soil depth up to a value of 6.76 almost neutral at lower most horizon 67 cm. The surface soils of pedon 3 were found to be strongly acidic with 4.74 pH value and gradually increased with depth with 6.05 pH value. The increases in soil pH with increasing soil depth could be attributed to leaching of basic cation from upper horizons towards the lower horizons mostly during intensive rainfall. Specially in lower land area i.e., pedon 3 due to heavy leaching of bases dues to leaching and rains [11,12]. Electronic conductivity (EC) almost nominal in all Pedons this indicates that there is no accumulation of dissolved salts in the pedons (Table 1).

3.3 Organic Carbon Content

There is uneven distribution of organic carbon in pedon 1, 2 and 3. In pedon 3 there is high content of 3.45 g kg^{-1} followed we can observe from the results there is uneven distribution of OC content this implies there is uneven distribution of decomposition of crop residues in every year in the surface horizons (Khanday *et al.,* 2018) and [10] observations are mentioned in Table 1.

4. DISTRIBUTION OF AVAILABLE NUTRIENTS

4.1 Available Nitrogen

In pedon 1, the highest amount of available nitrogen (N) (201.6 kg ha^{-1}) was found in the surface horizon (0-13 cm) and the lowest (100.8 kg ha^{-1}) in the third and fourth layer (28-44 and 44-64 cm) and there is slight increase in final layer 112.0 kg ha^{-1}. In pedon 2, the highest amount of available N was found in the surface (0-26 cm) and middle layer (26-39 cm), 257.6, 246 kg ha^{-1}, respectively. In pedon 3, highest amount of available N was found in upper layer (0-13cm) 190.4 kg ha^{-1}, lowest amount recorded in lower layer (77-97 cm) 100.8 kg ha^{-1}. Nitrogen was positively correlated with (EC), (r = 0.747**)

Table 1. Depth wise distribution of particle size, soil pH and Organic carbon in representative pedons of Boudh block

Horizon Depth (cm)	Sand (%)	Slit (%)	Clay (%)	pH	EC (dSm^{-1})	Organic Carbon ($g\ kg^{-1}$)
Pedon 1. (Upland)						
0-13	72.5	17.5	10	5.08	0.607	0.75
13-28	72.5	17.5	10	5.31	0.189	0.75
28-44	72.5	17.5	10	5.15	0.117	2.85
44-64	67.5	12.5	20	5.67	0.160	0.15
64-87	59	16	25	6.54	0.235	0.30
Pedon 2. (Medium land)						
0 - 26	69	11	20	6.31	0.286	1.20
26 - 39	59	21	20	6.16	0.963	2.40
39 - 67	59	21	20	6.76	0.619	2.25
Pedon 3. (Lowland)						
0 - 13	74	16	10	4.74	0.146	3.45
13 - 26	69	16	15	5.34	0.116	1.05
26 - 39	69	6	25	5.55	0.108	0.30
39 - 51	64	16	20	5.83	0.149	3.00
51 - 64	69	11	20	6.16	0.152	4.50
64 - 77	69	11	20	6.14	0.147	2.70
77 - 97	69	11	20	6.05	0.113	3.00

(Table 3). Available N tended to decrease with soil depth, which might be due to the confinement of falling of plant residues and debris to rhizosphere of plants [13,10and2] (Table 2).

4.2 Available Phosphorous

In pedon 1, the highest amount of available phosphorus (P) was recorded in lower layer (44-64 cm) 105.69 kg ha^{-1}. Low amount was recorded in upper layer (0-13 cm) 29.03 kg ha^{-1}. This shows the clear relation with soil pH as the upper layer of soil was 5.08 acidic pH available P was low, in contrast the soil pH was 6.54 in lower layer shows high availability of the available P. In pedon 2, the highest amount of available P was recorded in lowest layer (39-67cm) 121.50 kg ha^{-1}. Low amount of soil available P recorded in upper layer (0-26 cm) 96.31 kg ha^{-1}, over all P available is high in all layers this is due to neutral range of pH (Table 1.). In pedon 3, the highest amount of available P was recorded in lower layer (26-39 cm) 121.99 kg ha^{-1}. Low amount of available P was recorded in upper layer (0-13 cm) 52.13 kg ha^{-1}. This is positively correlated with exchangeable calcium (Ca) (r = 0.518*) and with pH (r = 0.647**) (Table 3.) The availability is of high and low available P was closely related to soil pH [14, 15, and 16] (Table 1).

4.3 Available Potassium

In pedon 1, the lowest amount of available potassium (K) (248.3 kg ha^{-1}) was found in the surface horizon (0-13 cm) and the highest amount available K (114.6 kg ha^{-1}) found in the lower horizon (64-87 cm). In pedon 2, highest amount of available K (444.6 kg ha^{-1}) found in the upper horizon (0-26 cm), lowest amount of available K (361.8 kg ha^{-1}) found in lower horizon (26-39 cm). In pedon 3, highest amount of available K (204.4 kg ha^{-1}) found in 51-64 cm, lowest amount of available K (100.70 kg ha^{-1}) found in lower horizon (77-97 cm). Potassium was positively correlated with pH (r = 0.704**), EC (r = 0.515*) and exchangeable Ca (r = 0.657**) (Table 3.). In overall observation found that availability of K is correlated with clay percentage (Table 1) [17,10 and 18].

4.4 Available Sulphur

In pedon 1, highest amount of available sulphur (S) (79.43 kg ha^{-1}) found in 28-44 cm horizon, lowest amount of available S (62.00 kg ha^{-1}) found in upper horizon 0-13 cm. In pedon 2. highest amount available S (103.22 kg ha^{-1}) found in 26-39 cm; lowest amount of available S (89.15 kg ha^{-1}) found in upper horizon 0-26 cm. In pedon 3, highest amount of available S (185.00 kg ha^{-1}) found in upper horizon (0-13 cm), low available S (104.56 kg ha^{-1}) found in 39-51 cm horizon. S was positively correlated to OC (r = 0.535*) (Table 3). There is uneven distribution of S in profile this quite related to the OC content (Table 1 and Table 2).

Table 2. Depth wise distribution of available nutrients in representative pedons of Boudh block

Horizon depth (cm)	N	P	K	S	Ca	Mg
	kg ha^{-1}				meq 100g^{-1}	
Pedon – 1 (Upland)						
0-13	201.60	29.03	114.60	62.00	430.00	290.00
13-28	112.00	47.91	122.40	66.36	230.00	110.00
28-44	100.80	98.34	131.00	79.43	660.00	660.00
44-64	100.80	105.69	211.80	76.41	710.00	80.00
64-87	112.00	103.11	248.30	68.03	1020.00	250.00
Pedon -2 (Medium land)						
0 - 26	257.60	96.31	444.60	89.15	760.00	160.00
26 - 39	246.40	115.08	361.80	103.22	910.00	180.00
39 - 67	257.60	121.50	377.10	95.85	1290.00	200.00
Pedon – 3 (Lowland)						
0 - 13	190.40	52.13	177.40	185.00	240.00	50.00
13 - 26	134.40	98.83	152.70	156.85	800.00	70.00
26 - 39	145.60	121.99	191.80	109.26	430.00	40.00
39 - 51	123.20	116.67	194.20	104.56	460.00	40.00
51 - 64	112.00	108.05	204.40	125.68	450.00	120.00
64 - 77	123.20	92.08	167.10	130.04	150.00	650.00
77 - 97	100.80	100.70	182.30	124.00	450.00	50.00

Table 3. Correlation between soil properties

	Sand (%)	Clay (%)	Slit (%)	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})	S (kg ha^{-1})	Ca m.eq 100g^{-1}	Mg m.eq 100g^{-1}	pH	E.C	OC content (g kg^{-1})
% Sand	1											
% Clay	-0.675**	1										
% Slit	-0.355	-0.448	1									
N (kg ha^{-1})	-0.302	-0.005	0.372	1								
P (kg ha^{-1})	-0.647**	0.785**	-0.210	-0.033	1							
K (kg ha^{-1})	-0.625**	0.496	0.129	0.737	0.478	1						
S (kg ha^{-1})	0.222	-0.057	-0.196	0.016	0.061	-0.100	1					
Ca m.eq 100g^{-1}	-0.759**	0.364	0.457	0.430	0.518*	0.657**	-0.284	1				
Mg m.eq 100g^{-1}	0.102	-0.208	0.139	-0.102	-0.083	-0.158	-0.228	-0.055	1			
pH	-0.789**	0.773**	-0.023	0.236	0.647**	0.704**	-0.223	0.576*	0.027	1		
E.C	-0.529*	0.006	0.632	0.747**	-0.014	0.515*	-0.281	0.488	0.036	0.288	1	
OC content (g kg^{-1})	0.082	-0.133	0.070	-0.023	0.129	-0.015	0.535*	-0.236	0.139	0.058	-0.051	1

** = 5 % significances; ** = 1 % Significances*

4.5 Exchangeable Calcium and Magnesium

In pedon 1, highest amount of exchangeable Ca (1020 meq 100 g^{-1}) found in lower layer (64-87cm) and exchangeable (Mg) (660 meq 100 g^{-1}) found in third horizon (28-44 cm). In pedon 2, highest amount of exchangeable Ca (1290 meq 100 g^{-1}) found in lower horizon (39-67 cm) and exchangeable Mg (200 meq 100 g^{-1}) found in same lower horizon (39-27 cm). In pedon 3, highest amount of exchangeable Ca (800 meq 100 g^{-1}) found in horizon (13-26 cm) found in horizon 13-26 cm and exchangeable Mg (650 meq 100 g^{-1}) found in horizon 64-77 cm (Table 2). Exchangeable Ca was positively correlated with pH (r = 0.576*) (Table 3) [11].

5. CONCLUSION

In overall observation in the present study, it is observed that there is uneven distribution of organic carbon content which indicates that there is uneven distribution of organic matter residues similar trend was observed in available S. Soil reaction (pH) as the depth increases the pH also increases this type of trend influences the available P content in the profiles. EC was very nominal this is because there is no accumulation of dissolved salts in profiles. Clay content also increases with the depth this indicates the presents of illuviation process this increases also facilities the increase in soil available potassium content in the soil profiles. In over finding in lower layers there is enough available K this is very useful for plantations crops when plants developed a full matured root system. In case of available N this enough balance availability is there. In case of available P, it is completely depths on the soil reaction (pH) this indicates that there must need of application of lime which should be done after proper laboratory analysis.

ACKNOWLEDGEMENT

The authors are thankful to the Senior Scientist and Head of KVK Boudh for providing the necessary facilities and technical support to undertake the field survey.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/94094