Profile Distribution of Available Boron and secondary micro nutrients in rice-groundnut growing soils of Jajpur District, Odisha

ABSTRACT

An investigation was conducted to examine the distribution of available Boron, secondary micro nutrients and the relationships between boron with soil properties and other nutrients in the rice-groundnut growing soils of Jajpur district, Odisha. The clay content increased downward without following any definite trend. Soil pH of surface horizons was acidic and increased downward to neutral range. EC ranged between 0.02dSm^{-1} to 0.13 dS/m^{-1}. The soil organic carbon ranged from 0.17% to 0.63% with decreasing trend towards sub surface horizon. The exchangeable Ca, Mg and S content varied from 3.68 mg kg^{-1} to 6.76 mg kg^{-1}, 0.82 to 6.24 cmole (p^{+})/kg and 0.62 mg kg^{-1} to 14.19 mg kg^{-1} mg/kg respectively. Ca and Mg increased with increasing depth, whereas S showed the reverse trend. The DTPA- Fe,Mn,Cu,Zn and B content of pedon soil ranged from 60.68 mg kg^{-1} to 312.08 mg kg^{-1}, 6.48 mg kg^{-1} to 36.76 mg kg^{-1}, 0.62 mg kg^{-1} to 4.15 mg kg^{-1}, 0.42 mg kg^{-1} to 1.15 mg kg^{-1} and 0.05 mg kg^{-1} to 1.01 mg kg^{-1} mg/kg respectively. Fe, Mn and Zn increased from surface to sub surface but Cu and B showed the reverse trend. The availability of Boron is positively correlated with organic carbon, Exch. Mg, Fe, and Cu. Negatively correlated with pH, Exch. Ca, S, Mn, and Zn. Pedon soils were deficient with B, S, Zn and rich in Ca,Mg,Fe,Mn and Cu. Fe was in toxic level in table land zone of sukinda. The available B was found to be deficient throughout the district in up and medium land except in subsurface layers of low land. The availability of B is positively correlated with organic carbon, Exch. Mg, Fe and Cu factors but negatively correlated with pH, Exch. Ca, S, Mn, and Zn. In an agricultural district like Jajpur an important the key element B for rice-groundnut crop sequence should be applied to soil and leaf of rice, groundnut, and other crops grown in the district.

Keywords: ???

1. 1. INTRODUCTION

Rice-groundnut is an important cropping system of coastal Odisha occupying an area of 120.92 (000 ha) and Jajpur district 33000 ha alone. The yield is declining gradually which can be ascribed due to micronutrient deficiency particularly Boron in soil. Boron plays an important role in plant but required in small quantity (8). B application in rice-groundnut cropping system increased dry matter production (straw) up to 15.4 % and higher Harvest index (5) and also reducing chaffiness up to 35% in rice. It increases 15-20 nodules early maturity, pod weight and use efficiency of other nutrients increases resulting in higher yield. Application of B with lime in acid soil enhances the nodular properties of legumes (27). Soil is the principal source of Boron but Odisha soil is deficiency inwith B. The availability of Boron is influenced by several soil

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Comment [N2]: Reference should be in sequencial factors. The profile distribution of B in soil puts light on its status and relation with other parameters of soil tells its availability. Micronutrients are elements that are required for plant growth in minute quantity. Amelioration of problem soil like acid soil with liming materials also increase the groundnut yield (28) and rhizosperic activity (29). Despite being required in fewer quantities, B has the same functional importance as macronutrients and play critical roles in plant growth(6). Origin and sources of soil micronutrients are very diverse. The principal sources are parent materials, sewage sludge, municipal waste, farmyard manure, organic matter and atmospheric depositions (26). Clay minerals easily absorb trace elements, but their displacement into the soil is complicated. Boron in soil exist in various forms, including water-soluble, exchangeable, complex and chelated forms, as well as in the structure of primary and secondary minerals (23). 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 (6). Interactions between other soil nutrients alter boron availability. The soil formation process, lithology, parent material, and pedogenesis significantly affect in the regional variation of boron availability (2).Thus ,information on the status of boron in the soil of a region is crucial for determining the nature and extent of their deficiency/toxicity 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 (10). To better comprehend the availability of B in the soil environment, the primary purpose of this study was to examine the status of available B in soil profiles and their relationship with other soil properties (20).

2. MATERIALS AND METHODS

The study area was the Sukinda, Badachana, and Dasarathpur blocks of Jajpur district, Wwhich is situated in the Mid Central Table land and North Eastern Coastal plain 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 (350feet above MSL, the slope of 5-10 %),very gently sloping medium land (310feet above MSL, the slope of 0-5%), and virtually level low land (298 feet above MSL, the 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: GPS map 76CSx). After a general traversal of the research region, three representative soil profiles were selected and exposed from three different topographic positions, including upland ($21^{0}86^{'}779^{''}$N $86^{0}54^{'}707^{''}$ E), medium land ($20^{0}41^{'}114^{''}$N $86^{0}08^{'}215^{''}$E) and low land ($20^{0}51^{'}990^{''}$ N $86^{0}29^{'}145^{''}$ E). Pedon 1, 2, and 3 related to the soil profile of highland, medium land and low land respectively. Four layers delineated variable depth at different location were sampled. The soil samples were tested for texture using the Bouyoucos Hydrometer (21). pH (1:2.5) and EC (1:2.5). Organic carbon(11) , exchangeable Ca & Mg(22), sulphur (4), DTPA extractable iron, manganese, copper, and zinc(18) and hot water extractable boron (12). Pearson correlation analyses were conducted using methods (9).

3. RESULTS AND DISCUSSION

3.1.1 Particle size distribution

The fine earth fractions are the active part of soil .Table 1 presents the various size distributions of the fine earth fraction of soil particles. The data showed that in Pedon 1, sand (%) ranged from 57.2 to 59.2, silt (%) ranged from 4.0 to 5.0 and clay (%) ranged from 35.8 to 38.8. In Pedon 2, sand, silt and clay ranged from 60.2% to 68.2%, 7.0% to 9.0% and 24.8% to 30.8% respectively. Sand percentages in Pedon 3 ranged from 58.2% to 64.2%, silt ~~percentage~~ from 5.0% to 9.0%, and clay ~~percentages~~ from 28.8% to 35.8%. Sand content 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 suggested that clay had been created through the transformation of sand to silt and neosynthesis of clay (14).

The sand dominated this fraction. It ranged between 57.2 ~~(%)~~ to 68.2 %. The content of sand decreased towards sub surface horizons. It was more in Badachana soil (Pedon 2) and less in Sukinda soil (Pedon 1). The silt content was found increasing from surface to sub surface layers. The silt content was minimum compared to sand and clay. The clay content in 3 pedons varied from 24.8 % to 38.8 %. It increased with depth without any trend. The clay content was comparatively more in Sukinda soil (Pedon 1) than that of other pedons. Sukinda soil was relatively heavier than others. Textural classes were sandy clay loam to clay, Accordingly the texture changed from lighter on surface to heavier texture in below layers (24).

3.1.2 Soil reaction (pH)

The surface soil of Pedon 1 was found to be moderately acidic with a pH values of 5.69. The surface soil of Pedon 2 was found to be slightly acidic with a pH value of 5.84, which increased with soil depth to a value of 7.65 at a depth of 76-110 cm, whereas those of Pedon 3 were neutral with pH values of 6.3. The pH was found to be increasing with increase in depth ~~in~~ (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. The pH of different horizons ranged from 5.69 to 7.65. The pH value increased with increasing depth and become slightly alkaline except Sukinda (Pedon 1) which was acidic (23).

3.1.3 Electrical conductivity (EC)

The EC of all soil profiles remained below 1 dSm^{-1}, showing that they were non-saline and suitable for growing all types of crop. This low electrical conductivity could be related to soluble salt leaching and easy drainage during heavy rainfall (3).

3.1.4 Organic carbon (OC)

The surface layers of Pedon 1, 2, 3 contained 0.72%, 0.63%, and 0.59% ~~percent~~ organic carbon, respectively (Table 1). 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 crop residues continuous accumulation and application of organic manures (15).

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 3.68(cmol (p^+)/kg), 3.68(cmol (p^+)/kg), and 4.56 (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 42-82 cm ,76-110 cm, and 82-120 cm, i.e. 6.24(cmol (p^+)/kg), 6.4(cmol (p^+)/kg), and 6.76 (cmol (p^+)/kg) in pedons 1, 2, and 3 respectively. In three pedons Ca ranged between 3.68(cmol (p^+)/kg) to 6.76 cmol (p+)/kg soil. The lowest Ca available was in Sukinda (pedon 1) and Badachana blocks (pedon 2) surface horizon and highest in Dasarathapur (pedon 3). The surface layers of Pedon 1, 2, and 3 contained 0.8(cmol (p^+)/kg), 1.92(cmol (p^+)/kg) and 2.68 (cmol (p^+)/kg) exchangeable Mg, respectively (Table 1). The distribution of Exchangeable Mg followed a similar trend as that of exchangeable Ca. 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 Jajpur district apply agricultural liming materials, which also act as a source of 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 (16). Both Ca and Mg content of pedon soils increased with increasing depth of soil. Maximum quantity of Ca and Mg were observed in Dasarathpur (pedon 3) soils which might be due to washout deposit of these nutrients in low land from adjacent up and medium land. The value of Ca was more than Mg due to the fact that present rocks and minerals on earth crust contains more Ca than Mg.

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3.2.2 Available Sulphur

In pedon 1, the upper layer (0-12 cm) contained the most available S (2.47 mg kg^{-1}) and the lower layer contained the least (0.91 mg kg^{-1}) (at 42-82 cm) depth. In pedon 2 the uppermost layer (0-18 cm) contained the maximum sulphur (14.19 mg kg^{-1}). While the lowest concentration (2.67 mg kg^{-1}) was detected in the bottom layer (–76-110 cm). In pedon 3, the highest concentration of available S (3.08 mg kg^{-1}) was found in the surface layer (-0-22 cm) while the lowest concentration (0.62 mg kg^{-1}) was found in the lower layer (82-120 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 .

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Plant available S was decreasing towards lower horizon. Surface horizon of Badachana was showing high 14.19 mg kg^{-1} and lower horizon of Dasarathpur showing low S (0.62 mg kg^{-1}) (17).

3.2.3 Available Iron

The range of available Fe in surface and subsurface soils was 60.68 mg kg^{-1} to 242.16 mg kg^{-1} and 85.5 mg kg^{-1} to 312.08 mg kg^{-1} respectively. In pedon 1 the surface layer (0-12 cm) contained available Fe (242.16 mg kg^{-1}) and the lower layer contained the maximum (312.08 mg kg^{-1}) (at 42-82 cm) depth. In pedon 2, the upper layer (0-18 cm) contained the lowest available iron (115.84 mg kg^{-1}) and the bottom layer contained the maximum available Fe (124.2 mg kg-

^{1}) . In pedon 3, the surface horizon (0-22 cm) contained the minimum concentration of available Fe (60.68 mg kg^{-1}) and the lower horizons (82-120 cm) contained the minimum concentration (85.5 mg kg^{-1}) (Table-2). The increasing trend of available Fe from surface layers towards sub surface because of crop uptake, run off and leaching loses (7). The available Iron content in Sukinda soil found to be maximum (312.08 mg kg^{-1}) and Dasarathpur soil contained low available Fe (60.68 mg kg^{-1}), but all pedon soils were rich in Fe due to Fe bearing parent material from which soil had been derived.

3.2.4 Available manganese

The availability of manganese in surface and sub-surface soils varied between 6.48 to 26.08 mg kg^{-1} and 9.3 to 36.76 mg kg^{-1} respectively (Table 2). The content of Mn is sufficient in all pedons and the quantity increased towards sub surface layers which might be due to the presence of Mn bearing parent material and crop uptake of available Mn from surface layer (19).

3.2.5 Available copper

In Pedon 1 the surface layer (0-12 cm) contained the most available Cu (3.90 mg kg^{-1}) and the bottom layer contained the maximum Cu (4.17 mg kg^{-1}) ~~(~~at42-82 cm~~)~~ depth. In pedon 2, the surface (0-18 cm) and bottom layer (–76-110 cm) contained maximum (–2.06 mg kg^{-1}) and minimum (0.62 mg kg^{-1}) concentrations of available copper, respectively. In pedon 3, the surface (0-22 cm) contained the maximum available Cu (2.27 mg kg^{-1}) and the lowest (0.86 mg kg^{-1}) was found in the lowest horizon (82-120 cm) (Table 2).

-Sufficient quantity of Cu was found in all pedons. The value of Cu decreased from surface to sub surface layers except in Sukinda profile which might be due to rich Cu bearing parent material slow leaching and pH of horizon soils (7).

3.2.6 Available zinc

The DTPA Zn content in pedon 1, 2, 3 were 0.56 mg kg^{-1} to 0.75 mg kg^{-1}, 0.42 mg kg^{-1} to 0.89 mg kg^{-1} and 0.49 mg kg^{-1} to 1.15 mg kg^{-1}. The range of available zinc in surface and sub-surface soils were 0.42 mg kg^{-1} to 0.56 mg kg^{-1} and 0.75 mg kg^{-1} to 1.15 mg kg^{-1}, respectively. In most of the surface horizon soil, Zn was found to be deficient. It increased downwards which might be due to presence of Zn bearing minerals in below horizons and leaching effect. Crop uptake and losses might have reduced the content in the surface layers (1).

3.2.7 Available boron

The hot water extractable boron content in pedon 1, 2 and 3 were 0.12 mg kg^{-1} to 0.43 mg kg^{-1}, 0.05 mg kg^{-1} to 0.15 mg kg^{-1} and 0.27 mg kg^{-1} to 1.01 mg kg^{-1}. Boron availability in surface and sub surface soils were between 0.05 mg kg^{-1} to 0.27 mg kg^{-1} and 0.05 mg kg^{-1} to 1.01 mg kg^{-1} respectively. In Pedon 1, the sub surface layer (12-42 cm) contained the maximum concentration of available B (0.43 mg kg^{-1}) ,while the lowest concentration (0.12 mg kg^{-1}) was found in the surface horizon (0-12 cm). In pedon 2 the sub surface layer (18-54 cm) contained the maximum quantity of available boron (0.15 mg kg^{-1}) and the lowest (0.05 mg kg^{-1}) was observed in the surface layer (0-18 cm). In pedon 3, the sub surface (22-56 cm) contained the maximum concentration of available B (1.01 mg kg^{-1}), while the lowest concentration (-0.27 mg kg^{-1}) was observed in the surface layer (0-22 cm). Boron's greater buildup in the subsurface was aided by the leaching of boron in soluble form, which occurred in soils with a light texture and an acidic pH (10).The available B content of pedon soil increased up to second horizon then decreased downwards. B is highly soluble and leached from light texture surface soil and get deposited in second layer. In soils of Badachana and Sukinda available B was in deficient status. Where as in Dasarathpur soils sufficient level of B was found in sub surface horizons. It might be due to deposition of B in these layers.

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Correlation of B with other parameter of soil

Profile distribution of B was correlated with pH and other soil parameter presented in table -3. It was found that B was positively correlated with organic carbon, Exch. Mg, Fe, Cu, and negatively correlated with other parameters. Positive correlation indicated the availability of B will be increased by increasing the organic carbon. Negative correlation with clay and pH indicated that further increasing in clay and pH will decreased the availability B to the crop. The chelating effect of clay with B will decrease the availability of B to the crop plant. However multiple regression analysis showed the overall contribution of 13 parameters taken have 68.2 % contribution for availability of B. The highest correlation with EC followed by Zn, Fe, Exch. Mg, and organic carbon, all other parameters show negative regression. By increasing soil organic carbon, exch. Mg, available Fe, and Zn will positively helped in availability of B in soil for rice-groundnut cropping system (25).

Regression Equation

$$Y=3.264-0.006X_1-0.054X_2-0.025X_3-0.348X_4+7.644X_5+0.180X_6-0.069X_7+0.104X_8-0.042X_9+0.002X_{10}-0.012X_{11}-0.029X_{12}+0.830X_{13}$$

(X_1-(sand %), X_2-(silt %), X_3-(clay %), X_4- pH(1:2.5), X_5-EC (dS m^{-1}), X_6-OC (%), X_7-Exch.Ca (cmol(p+)/kg^-, X_8- Exch.Mg (cmol(p+)/kg^-, X_9-Avail S, X_{10}-Fe, X_{11}-Mn, X_{12}-Cu, X_{13}-Zn.)

4. CONCLUSION

Plant nutrients in the research area varied with topography, although the differences between upland, medium land and low land were not significant. Sand decreased with pedon depth, while clay increased. It's caused by translocation of clay and colloidal fraction from surface to sub surface horizon, percolating water and leaching. In all pedons, soil pH increased but EC and organic carbon declined with depth. Surface soils have less exchangeable Ca and Mg than subsurface layers. This may be due to crop/vegetation removing Ca and Mg from surface strata. Micronutrient status in the study region was Fe>Mn>Cu>Zn>B. Available Ca and Mg increased with soil depth, but S, Fe, Cu, Zn, and B decreased. Available Fe, Mn, Cu and Zn correlated positively with soil organic carbon and negatively with soil pH higher micronutrient levels on the surface than subsurface soils presumably resulted from the enhanced breakdown of soil organic matter and agricultural residues. Secondly, root distribution and rooting depth affect micronutrient concentrations because nutrients taken up by deeper roots are transported above ground and re-deposited on the soil surface. It can be concluded from the correlation statistics of

B with soil parameters that application of organic manure, Mg and Zn will enhance the availability of B to rice-groundnut cropping system of Jajpur district of Odisha. (13)

Table 1. Distribution of particle size, soil pH, EC and Organic carbon in representative pedons

Pedon Depth(cm)	Sand (%)	Silt (%)	Clay (%)	P^H (1:2.5)	EC (dS m^{-1})	OC (%)
Pedon 1 (Upland) Sukinda						
0-12	59.2	5.0	35.8	5.69	0.09	0.72
12-42	59.2	4.0	36.8	5.84	0.04	0.48
42-82	57.2	4.0	38.8	5.92	0.04	0.18
Pedon 2 (Mediumland) Badachana						
0-18	68.2	7.0	24.8	5.84	0.13	0.63
18-54	62.2	7.0	30.8	7.04	0.12	0.30
54-76	59.2	6.0	34.8	7.36	0.12	0.24
76-110	60.2	9.0	30.8	7.65	0.11	0.18
Pedon 3 (low land) Dasarathapur						
0-22	62.2	9.0	28.8	6.3	0.08	0.59
22-56	64.2	5.0	30.8	6.59	0.07	0.52
56-82	58.2	6.0	35.8	6.76	0.06	0.41
82-120	63.2	5.0	31.8	7.02	0.02	0.17

Table 2. Depth-wise distribution of available secondary and micronutrients in pedons

Pedon Depth(cm)	Exch.Ca (cmol(p^+)/kg	Exch.Mg (cmol(p^+)/kg	Avail S (mg kg^{-1})	Fe (mg kg^{-1})	Mn (mg kg^{-1})	Cu (mg kg^{-1})	Zn (mg kg^{-1})	B (mg kg^{-1})
Pedon 1 (Upland) Sukinda								
0-12	3.68	0.8	2.47	242.16	26.08	3.90	0.56	0.12
12-42	5.44	2.4	1.62	284.56	36.36	4.15	0.68	0.43
42-82	6.24	2.80	0.91	312.08	36.76	4.17	0.75	0.25
Pedon 2 (Mediumland) Badachana								
0-18	3.68	1.92	14.19	115.84	8.64	2.06	0.42	0.05
18-54	5.44	2.32	6.37	117.24	12.56	1.31	0.61	0.15
54-76	5.6	3.24	5.55	121.32	22.84	0.62	0.72	0.07
76-110	6.4	3.04	2.67	124.2	22.68	0.68	0.89	0.05
Pedon 3 (Low land) Dasarathapur								
0-22	4.56	2.68	3.08	60.68	6.48	2.27	0.49	0.27
22-56	5.64	3.06	1.03	68.68	7.4	1.99	0.64	1.01
56-82	6.68	3.12	0.88	74.20	8.2	0.98	1.02	0.96
82-120	6.76	2.84	0.62	85.50	9.3	0.86	1.15	0.43

Table 3. Correlations analysis between B vrs. all other characters

	Sand (%)	Silt (%)	Clay (%)	PH (1:2.5)	EC (dS m-1)	OC (%)	Exch.Ca (cmol(p+)/kg	Exch.Mg (cmol(p+)/kg	Avail S	Fe	Mn	Cu	Zn	B
Sand (%)	1													
Silt (%)	.431*	1												
Clay (%)	-.089	-.254	1											
PH (1:2.5)	.073	.168	.082	1										
EC (dS m-1)	.342	.627**	-.275	-.033	1									
OC (%)	.138	.030	-.559**	-.495*	.222	1								
Exch.Ca (cmol(p+)/kg	-.407	-.098	-.117	.233	-.375	-.493*	1							
Exch.Mg (cmol(p+)/kg	-.031	-.117	.169	.543**	-.425*	-.482*	.302	1						
Avail S	.421	.437*	-.627**	-.309	.700**	.499*	-.263	-.493*	1					
Fe	-.459*	-.334	.090	-.260	-.491*	.082	.259	-.086	-.325	1				
Mn	-.370	-.120	.177	-.282	.008	-.117	.215	-.403	-.028	.477*	1			
Cu	-.162	-.145	-.188	-.623**	.036	.489*	-.124	-.584**	.191	.547**	.650**	1		
Zn	-.109	-.167	.056	.472*	-.604**	-.422	.670**	.453*	-.398	.134	.021	-.325	1	
B	-.157	-.235	-.344	-.296	-.195	.453*	-.026	.105	-.009	.240	-.291	.101	-.002	1

**. Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2-tailed).

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