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Influence of soil parent materials on the distribution of Boron, Copper and Zinc in Selected Soils in South Western Nigeria

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Abstract

Understanding the influence of soil parent materials on the distribution and availability of soil micronutrients is essential for proper soil micronutrient management techniques. The soil profile distribution of total and extractable boron (B), copper (Cu), and zinc (Zn) in four western Nigeria formed on various parent materials such as alluvium, shale, schists, and sandstone was determined. Total and available B, Cu and Zn concentrations were analysed and measured in mg/kg using standard procedures. The total concentration of B ranges from 28.80 to 70.24, Cu from 38.45 to 85.25, and Zn from 42.30 to 63.23. The soil formed on schists had more total Zn, Cu and B than those from alluvium, shale and sandstone. The available B, Cu and Zn ranged from 0.001 to 0.008, 0.003 to 0.014 and 0.003 to 0.010 respectively. The mean concentration of total B, Cu and Zn are respectively 49.08, 67.94 and 54.15 in soils with alluvium parent material; 50.05, 73.94 and 54.86 in soils with shale parent material; 58.73, 74.31 and 54.42 in soils with schist parent materials; 45.69, 43.15 and 48.93 in soils with sandstone parent materials. The results showed that soils from schists parent materials had the highest concentration for B and Cu while soils from sandstone had the highest Zn total concentration. In alluvium, shale, schists and sandstone parent materials B had mean available concentrations of 0.003, 0.005, 0.004 and 0.002 respectively, Cu had 0.008, 0.005, 0.007 and 0.009 respectively while Zn had 0.008, 0.008, 0.011 and 0.009 respectively. The results showed that B is more available in soils with shale parent material while Cu and Zn are more available in soils with sandstone parent materials. The available forms of the studied micronutrients in this study were below the critical levels and which could reduce crops quantitative and qualitative yields. Therefore, application of well formulated organic and inorganic fertilizers may be required to improve their status in the soil.

Introduction

Inherent soil chemical and physical properties, fertility, species biodiversity, distribution and status of both micro and macro nutrients are largely dependent on the soil parent materials (Moore *et al.*, 2022). Elements such as iron, zinc, copper, boron, manganese, molybdenum and chlorine are referred to as micronutrients not because they are not important but because they are essential elements required in very small amounts for growth and development of crops (Oluwadare *et al*., 2013). Important plants metabolic activities are affected or reduced if these nutrients are not available in required concentrations for plants uptake and this would lead to plant growth dysfunctionality and impairment of enzymatic activities in which these nutrients play important roles thereby causing reduction in both crop qualitative and quantitative yield as well as poor soil fertility status which determines crop productivity (John *et al.,* 2018).

The variability of the soil parent materials in term of mineral and chemical compositions invariably influences the distribution and the status

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in term of the availability for plants' uptake of these important micronutrients (Moore *et al.*, 2022). The distribution of the available micronutrients assessment has been the major concern of most researchers and recent researches had provided information showing increase in their deficiency and toxicity (Ahukaemere *et al*., 2017). The original geologic substrate, the subsequent geochemical and the pedogenic regimes give total levels of micronutrients in soils and provide the required information on variations of soil micronutrients with soil parent materials (Ahukaemere *et al*., 2017). This will enable soil scientists to provide proper management measures and required fertiliser formulations that would enhance the availability of soil micronutrients thereby promoting optimum crop yield (Ahukaemere, *et al*., 2017). Many reports had been given on the distribution of the available micronutrients within soil profile system along a land scape of soils from basement complex and that of sedimentary rocks (Oyinlola and Chude, 2010). Updated information on the status of micronutrients concentrations is required in soils with different parent materials as this would guide us on the requirements for fertilizer formulation requirements of such soils. This study therefore aimed to evaluate the status and distribution of available B, Cu and Zn in soil profiles from alluvium, shale, schists and sandstone parent materials.

Materials and Methods

Site Description

The study was carried in southwestern Nigeria. Table 1 provides a description of the study sites.

Field Work

Profiles reflecting alluvium, shale, schist and sand stone parent materials were selected at different locations. The profile pits reflecting the different parent materials were dug at different locations as described in Table 1. The soil samples were taken separately at different profile depths: 0–15, 15–30, 30–60, 60–90, 90–120 and 120–150 cm. The sampled soils, were air-dried, ground and sieved through a 2 mm sieve and used for laboratory chemical analyses.

Laboratory Analyses

Only AnalaR grade reagents and chemicals were used in the analysis for physical and chemical parameters of the soil samples.

Chemical and Physical Properties of Soils Studied

The physical and chemical characteristics of the soil samples that were determined include particle texture, soil pH, organic carbon, CEC, exchangeable acidity, base saturation and total and available forms of Zn, Cu and B in mg/kg. Organic Carbon, total nitrogen, pH, cation exchange capacity (C.E.C.) and exchangeable acidity were determined on the < 2.0 mm soil fractions, using procedures described in the International Institute of Tropical Agriculture (IITA) Manual Series, No.1 (Sha'Ato *et al.*, 2000).

Determination of Total Cu and Zn

About 10 g of soil sample was ground to pass through a 72 mesh sieve. Soil sample of 5 g was accurately weighed into a 250 ml flask. 10 ml of hydrogen peroxide (H_2O_2) was added and the solution was evaporated to near dryness at 90^0C.

Table 1: Site Description of the study areas in southwest Nigeria

Parent Material	Location	Coordinate	Vegetation
Alluvium	Omi-Adio, Oyo State	7.3900^0N, 3.7537^0E	Derived savannah
Shale	Ifo, Ogun State	6.8192^0N, 3.1930^0E	Rain forest
Schists	Obsfemi Awolowo University, Research Farm, Osun State	7.5221^0N, 4.5263^0E	Rain forest
Sand stone	Ikenne, Ogun State	6.8650^0N, 3.7143^0E	Rain forest

This treatment was repeated until the sample no longer produce effervescences on addition of H_2O_2. Three (3) drops of concentrated tetraoxosulphate (IV) acid (conc. H_2SO_4) and 10 ml of hydrogen fluoride (HF) was added and the sample was placed on a heater. The temperature of the heater was slowly raised to 100^0C and the solution evaporated to dryness. Concentrated trioxonitrate (V) acid ($HN0_3$) of 15 ml, 2 ml of conc. H_2SO_4 and 5 ml of hydrogen tetrachlorate ($HClO_4$) were added and heating of the flask was continued until strong fumes of sulphur (VI) acid (SO_3) were produced. The flask was cooled, and 25 ml of distilled water was added, rinsing down the sides of the container and placing the residue to complete the extraction of the Cu and Zn. The solution was transferred quantitatively to a 50 ml volumetric flask and the volume was marked up with distilled water. Total Cu and Zn in the solution were determined on atomic absorption spectrophotometer (Sha'Ato *et al.*, 2000).

Determination of Total B

A gram of soil sample, sieved through 72 mesh, was accurately weighed into a beaker and moistened with a few drops of water. A 5 ml of 48% HF and 0.5 ml of 60% $HClO_4$ were added. The beaker was nearly covered with a glass lid and heated on a heater at 100^0C and evaporated to dryness. After cooling, 5 ml of 6 M hydeogen chloride (HCl) and 30ml of distilled water were added. The beaker was then placed on a heater and the contents were gently boiled for 5 minutes. The solution was evaporated to dryness and the acid digestion was repeated. When the residue was completely dissolved, the solution in the beaker was transferred to a 50 ml volumetric flask, cooled and diluted and then colour was determined using the same method as described in available B (Sha'Ato *et al.*, 2000).

Available Cu and Zn

A 0.1 M HCl, 0.05 M ethylenediamine-tetraacetic acid, disodium salt (Na_2 EDTA) in neutral 1 M ammonium acetate (NH4OAc) was used for the determination of available Cu and Zn. Duplicate 5.0 g sub-samples of air-dried soil (< 2.0 mm diameter) at different profile depths (horizons) were transferred into 100 cm^3 plastic bottles and extracted with 50cm^3 of extractant (0.1 M HCl, 0.05 M EDTA) as described by Udo and Ogunwale (1986). The amounts of micronutrients extracted were determined by flame atomic absorption spectrophotometry using a Perkin-Elmer AAS Model 2380 instrument fitted with Hamammatsu Hollow Cathode Lamps. For every determination, reagent blanks were prepared in order to be assured of the analytical data.

Available B

A 10 g of soil was accurately weighed into a centrifuge tube and 20 ml of boiling water was added. The tube was corked and shaken for 25 minutes. 1 g of $CaCl_2$ was then added and the tube was shaken for 5 more minutes. The soil suspension was filtered into a plastic bottle Udo and Ogunwale (1986).

Results and Discussions

Physical and chemical properties of the soils with alluvium, shale, schists and sand stone parent materials at different depths of the profile pit

Table 2 shows the particle size distribution and some chemical properties of the soils from the considered parent materials. The minimum values of the clay, silt and sand in g kg^{-1} are respectively 60, 60 and 436 while the maximum values are 550, 170, and 831. This distribution majorly gives the soil along the profile pits of the various parent materials a sandy clay loam texture which indicated the high tendency of the top soil to be proned to leaching because of the high presence of macro-pores caused by the dominating sand fraction. This property according to Oluwadare *et al.* (2013) could negatively affect the growth of crops due to low water and nutrient retention capacity of the soil which enhances leaching of soil nutrients. Also, the intense and continuous use coupled with the sandy nature of the soil, lead to the leaching and removal of cations such as Ca^{2+}, Mg^{2+} and K^+ resulting in the soil acidity and probably give the reason for the averagely acidic pH of the top soils (6.5, 6.2 and 6.1) for alluvium, shale and sand stone parent materials and the low CEC of the top soils (1.46, 1.34, and 1.48) cmol/kg for alluvium, shale and sand stone parent materials except that of the schist parent materials having a pH of 7.3 and appreciable CEC (2.48 mol/kg) as

Table 2: Physical and Chemical Properties of the soils with alluvium, shale, schists and stone parent materials

Depth (cm)	pH	OC	OM	Clay	Silt	Sand	Exh Acidity	Ca	K	Mg	Na	CEC
					ALLUVIUM (Adio Series)							
0– 15	6.5	3.11	5.4	12.0	14.0	75.6	0.6	0.9	0.06	0.32	0.58	1.46
15 – 30	6.3	0.96	1.65	13.0	15.0	64.9	0.40	0.20	0.15	0.15	0.24	1.14
30 – 60	6.0	0.68	1.17	20.0	17.0	84.7	0.20	0.20	0.17	0.17	0.67	1.31
60 – 90	6.4	0.39	0.69	22.0	13.0	43.6	0.80	0.15	0.24	0.24	0.18	1.42
90– 120	6.2	0.39	0.69	24.0	11.0	64.3	0.40	0.15	0.32	0.32	0.19	1.12
120 – 180	7.4	0.39	0.69	30.0	15.0	69.6	0.50	0.20	0.53	0.53	0.58	1.99
					SHALE (Egua Series)							
0 – 15	6.2	3.15	6.14	19.0	17.0	80.4	0.40	0.40	0.18	0.05	0.81	1.34
15 – 30	5.6	2.39	4.14	18.0	15.0	81.9	0.40	0.60	0.10	0.21	0.91	1.22
30 – 60	5.3	1.32	2.28	47.0	13.0	76.8	0.40	0.63	0.23	0.23	0.24	1.13
60 – 90	5.3	1.12	1.24	55.0	15.0	64.6	0.40	0.33	0.04	0.18	0.18	1.13
90-120	6.0	0.59	1.03	32.0	9.0	52.4	0.60	0.25	0.05	0.18	0.18	1.06
120 -180	6.8	0.39	0.69	45.0	21.0	56.3	0.80	0.68	0.05	0.17	0.18	1.83
					SCHISTS (Egbeda Series)							
0 – 15	7.3	2.11	3.78	10.0	16.0	92.7	0.40	4.10	0.32	0.42	0.24	2.48
15 – 30	6.9	1.36	2.35	36.0	10.0	81.2	0.25	1.76	0.35	0.48	0.22	2.46
30- 60	6.9	0.88	1.51	38.0	10.0	80.4	0.60	1.28	0.41	0.54	0.23	2.06
60- 90	6.8	0.88	1.51	34.0	12.0	83.1	0.40	1.20	0.36	0.18	0.22	1.86
90- 120	6.6	0.52	0.89	32.0	12.0	82.7	0.40	1.04	0.28	0.38	0.22	1.32
120- 180	6.1	0.39	0.69	24.0	14.0	76.7	0.60	0.96	0.40	0.37	0.23	1.56
					SAND STONE (Alagba Series)							
0– 15	6.1	0.56	0.96	30.0	6.0	72.3	0.40	0.40	0.16	0.32	0.20	1.48
15 – 30	6.9	0.48	0.83	44.0	6.0	70.8	0.40	0.45	0.09	0.25	0.18	1.37
30 – 60	6.0	0.48	0.83	32.0	6.0	74.5	0.40	0.53	0.15	0.32	0.17	1.57
60 – 90	7.6	0.39	0.69	36.0	16.0	85.3	0.20	0.53	0.13	0.32	0.18	1.36
90- 120	7.6	0.19	0.34	16.0	16.0	59.7	0.60	0.40	0.14	0.21	0.14	1.43
120 – 180	6.1	0.19	0.34	6.0	8.0	72.3	0.26	0.25	0.25	0.13	0.18	0.94

OC-Organic Carbon, OM-Organic Matter, EA-Exchangeable Acidity shown in Table 2. This results corroborates the findings of Oluwadare *et al.* (2013) who observed a low CEC and pH with the soil of sandy clay loam textural class. The trend of the CEC observed in this work indicates that the soils are dominated by kaolinite clay mineral and this invariably suggests a low specific surface area for the adsorption capacity of micronutrients. This observation is in line with the findings of Agbenin *et al*., (2009) who recorded accumulation of trace elements in the leaves of amaranthus (*Amaranthus caudatus)* and lettuce (*Lactuca sativa*) above permissible level probably because of low-activity clay mineral like kaolinite.

Total concentration and available form of B

The total and available of form B are given in Table 3. The mean values of total B, in the alluvium, shale, schist and the sand stone parent materials in mg/kg as shown in Table 4 are 49.08, 50.05, 58.73 and 45.69; Cu had mean values of 67.94, 73.94, 74.31 and 43.15; while Zn had mean values of 54.15, 54.86, 54.42 and 48.93 respectively. Although B is predominant in igneous rocks most especially in the granites, the mean total concentration of B in this work was appreciably high when compared with the worldwide concentration which is between 2 - 270 mg/kg with a mean concentration of 20 mg/kg as reported by Agbenin, (2020). The trend in the concentratrion of B down the profile can be attributed to the clay argelluviation or argellic horizon and the appreciable level of the pH down the horizon as the retention and adsorption of B are both clay and pH dependent (Agbenin, 2020). Although, the range of the concentration of the total B, Cu and Zn given in this work may be said to be low, they do not deviate from their lithogenic existence in soils (Barghouthi *et al.,* 2012). The inconsistence in the patterns of variation of the total concentrations of B, Cu and Zn with the profile depths justifies down-profile increase in the concentrations of B, Cu and Zn was definitely indicated. With Cu, and particularly Zn, the increase is perfectly in agreement with clay distributions in the profile and the trend agreed with the findings of (Rufus *et al*., 2012) who observed similar trend and related it to the ability of micronutrients especially Cu and Zn to be associated and translocated with clay in soils.

Total Concentration of Cu

The total and available of form Cu are provided in Table 3. The mean values of total Cu in the alluvium, shale, schist and the sand stone parent materials in mg/kg as shown in Table 4 are 67.94, 73.94, 74.31 and 43.15. These values are appreciably high when compared with the global range of total concentration of Cu with varies from 2 to 250 mg/kg with mean value of 30 mg/kg as reported by Agbenin (2020). The inconsistent pattern of the distribution of Cu down the profiles is perfectly in agreement with the argillic horizon and the trend corroborates the findings of Rufus *et al.,* (2012). The high level of Cu above the mean of 25 mg/kg in the earth crust proves the enrichment of Cu in the soil as a result of the anthropogenic activities and probably less intense of cultivation. This view is in agreement with the report of Agbenin (2020) who reported a mean range of 5 to 13 mg/kg under continuous cultivation.

Total Concentration of Zn

The total and available of form Zn are as shown in Table 3. The mean values of total Zn, in the alluvium, shale, schist and the sand stone parent materials in mg/kg as shown in table 4 are 54.15, 54.86, 54.42 and 48.93 respectively. Although the range of the mean of the total concentration of Zn obtained in this study is below the average total concentration of about 90 mg/kg, it does not deviate from the total range of 40 to 70 mg/kg in most savanna soils of Nigeria and the total concentration range of 28 to 58 mg/kg from soils under long-term cultivation as reported by Agbenin (2020). The irregular distribution of Zn in the profile could be attributed to the argillic horizon. This view is in line with the findings of Rufus *et al*., (2012) who observed similar trend and related it to the ability of micronutrients especially Cu and Zn to be associated and translocated with clay in soils.

Table 3: Total and available forms of B, Cu and Zn

Depth (cm)	Total Forms			Available Forms		
	B	Cu	Zn	B	Cu	Zn
	(mg/kg)			(mg/kg)		
ALLUVIUM						
0 – 15	52.50	80.30	61.25	0.061	0.063	0.041
15 – 30	54.00	72.12	59.56	0.070	0.054	0.032
30 - 60	30.20	64.21	56.28	0.070	0.139	0.020
60 - 90	28.80	67.21	52.60	0.092	0.127	0.016
90 – 120	60.80	58.24	48.67	0.065	0.063	0.037
120 – 150	68.20	65.56	46.56	0.109	0.085	0.061
SHALE						
0 –15	51.67	75.62	62.10	0.065	0.076	0.015
15 –30	53.25	81.60	58.30	0.075	0.076	0.022
30 –60	56.35	68.42	53.10	0.075	0.095	0.030
60 –90	25.60	76.35	60.20	0.072	0.015	0.042
90 –120	54.80	77.40	50.20	0.052	0.064	0.052
120 –150	58.60	64.30	45.25	0.075	0.629	0.034
SHISTS						
0 – 15	53.20	85.25	63.23	0.092	0.096	0.060
15 – 30	58.10	79.40	62.30	0.101	0.109	0.060
30 – 60	52.40	75.10	56.30	0.110	0.108	0.008
60 – 90	56.00	72.40	54.20	0.061	0.086	0.053
90 – 120	62.45	68.40	48.24	0.117	0.108	0.044
SAND STONE						
0 – 15	48.40	46.30	50.20	0.109	0.076	0.049
15 – 30	50.36	42.40	48.25	0.096	0.32	0.041
30 – 60	45.40	38.45	47.25	0.092	0.054	0.028
60 – 90	42.00	40.20	48.60	0.075	0.054	0.025
90 – 120	42.00	45.56	49.20	0.075	0.054	0.027
120 – 150	46.00	46.00	50.10	0.078	0.086	0.038

Available B in mg/kg

As shown in Table 5, the available B ranged from 0.001 to 0.008. The mean values of the available B, in the alluvia, shale, schist and the sandstone parent materials as shown in Table 5 are 0.003, 0.005, 0.004 and 0.002. These concentrations are generally low compared to the critical levels of 0.3 mg/kg in sandy soils, 0.5 mg/kg in loamy soils and 0.8 mg/kg in clay soils (Agbenin, 2020). The low concentration of the available B could be traced to the appreciable increase in the pH and the coarse textural class and relatively low clay content of the studied soils formed from the considered parent materials in this study. This view could be corroborated with the findings of Agbenin (2020) who confirmed the solubility, the retention and invariably, the availability of micronutrient metals and non-metals such as B and Mo to increase with decrease in the soil pH and to decrease with coarse-texture soil with low clay content. The results also conform to the range of values obtained by Kparmwang and Malgwi, (1997). There is a less tendency of uptake of B above safe limit because of the range of level of CEC (0.94 -

2.48 cmol/kg) which suggests that the clay mineral of the soil is that of kaolinite which is characterized with low surface area for adsorption of micronutrients as discussed by Agbenin, (2020). The available B of the soils are very low and could reduce crop growth. Brady and Weil (2002) claimed the low B contents in soils to be the consequences of low B content in the soil parent material, Loss through leaching which could be caused by argilluviation of the clay mineral and increase pH. These factors, all of which are seen in this work could also be responsible for the low level of B in this work.

Available Cu and Zn in mg/kg

As shown in Table 5, the available Cu and Zn ranged from 0.001 to 0.014 and 0.001 to 0.016 respectively. The mean values of the available Cu in the alluvium, shale, schist and the sandstone parent materials as shown in table 5 are 0.008, 0.005, 0.007 and 0.009 while that of Zn are 0.008, 0.008, 0.011 and 0.009 respectively. The range of values reported in this work for both Cu and Zn are below their required concentrations of 6.8 mg/kg Cu (Agbenin, 2020) and about 5.5 mg/kg Zn (Noulas *et al.,* 2018). The extractable Zinc in this work was in line with the report of Agbenin (2020) who stated the extractable Zn, consisting of exchangeable and soluble Zn concentration to be generally ranged between 0.1 and 2.0 mg/kg. The range of CEC, 0.94 - 2.48 cmol/kg in this work as shown in Table 2, suggests that the dominating clay mineral in the argillic horizon of the soil profiles in this report could be more of kaolinite which is characterized with low surface area and high coarse soil texture and invariably low adsorption site and less availability of soil micronutrients such as Cu and Zn as reported in this work and as corroborated by Agbenin, (2020). Low soil organic matter (SOM) content of the soils, 0.34 - 6.14 mg/kg, as shown in Table 2, could also be responsible for the low concentrations of the available micronutrients, most especially Cu and Zn as shown in this work. This thought is in line with the report of Siddiqui *et al.*, (2015), who reported SOM as a key factor promoting the soil enrichment and the uptake of micronutrients by higher plants. Unlike macronutrients cations, increase in pH decreases sorption and availability of micronutrients (Barrow and Hertmink, 2023). The range of availability of Zn and Cu in this study could also be traced to the averagely increased in pH level.

Table 4: Range of total concentration of B, Cu and Zn (mg/kg) in the analysed soil samples

	B	Cu	Zn
	Alluvium		
Mean:	49.08	67.94	54.15
Minimum:	28.80	58.24	46.56
Maximum:	68.20	80.30	61.25
	Shale		
Mean:	50.05	73.94	54.86
Minimum:	25.60	64.30	45.25
Maximum:	58.60	81.60	62.10
	Schist		
Mean:	58.73	74.31	54.42
Minimum:	52.40	65.30	42.30
Maximum:	70.24	85.30	61.23
	Sand stone		
Mean:	45.69	43.15	48.93
Minimum:	42.00	38.45	47.25
Maximum:	48.40	46.30	50.20

Table 5: Range of available concentration of B, Cu and Zn (mg/kg) in the analysed soil samples

	B	Cu	Zn
	Alluvium		
Mean:	0.003	0.008	0.008
Minimum:	0.001	0.003	0.003
Maximum:	0.006	0.014	0.010
	Shale		
Mean:	0.004	0.005	0.008
Minimum:	0.002	0.007	0.003
Maximum:	0.006	0.002	0.016
	Schists		
Mean:	0.004	0.007	0.011
Minimum:	0.001	0.003	0.001
Maximum:	0.008	0.013	0.016
	Sand stone		
Mean:	0.0018	0.009	0.009
Minimum:	0.001	0.001	0.002
Maximum:	0.004	0.012	0.01

Table 6: Correlation Coefficient between total and available B, Cu, and Zn and some soil properties

	Total B	Available B	Total Cu	Available Cu	Total Zn	Available Zn
OC	0.06ns	0.24ns	0.17ns	0.38ns	-	0.15ns
pH	0.34ns	0.98**	0.38ns	0.65**	0.67**	0.72**
Clay	0.41*	0.38ns	0.50*	0.21ns	0.41*	-0.042ns

OC-Organic Carbon, ** Significant at 1% confidence level; *Significant at 5% confidence level; ns not significant

Correlation studies between total and extractable B, Cu, Zn and some soil properties

Although not significant, there were positive correlation among OC, total and available B, Cu and Zn as shown in Table 6. This shows that increase in OC will increase both the total and available concentration of B, Cu and Zn. This view corroborated the findings of Dhaliwal *et al*. (2019) who observed the addition of organic matter to have had an improved effect on OC leading to improved status of soil micronutrients over time. There were strong positive and significant correlation among the available B, Cu, Zn and the total Zn with the soil pH. This shows that these micronutrients are all pH dependent and are more available at a less alkaline soil pH. The clay content of the soil is also positively and significantly correlated with the total B, Cu and Zn this is due to the nutrient holding capacity of clay soil as discussed by Agbenin, (2020)

Conclusion

Results obtained from this study has shown that, the micronutrients studied namely, B, Cu and Zn were found to be clearly deficient in both surface and pedon soils. This means that there is low content of B, Cu and Zn both in total and available forms in the parent materials of the soils. For successful and profitable crop production, there would be need to supply B, Cu and Zn from fertilizers especially for high B, Cu and Zn requiring crops.

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