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Research Paper

Micronutrients Characterization of Soils of Basalt Parent Material in Ikom, Cross River State Nigeria for Sustainable Crop Production

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Micronutrients are essential elements that are used by plants in small quantities. For most micronutrients, crop uptake is less than 1.11 kg per hectare. In spite of this low requirement, critical plant functions are limited if micronutrients are unavailable, resulting in plant abnormalities reduced growth and lower yield. Therefore a Pedological study was conducted in soils derived from basalt parent material in Ikom, Cross River Nigeria to characterize the micronutrients of the soils for sustainable crop production. A total of 500 ha of land were surveyed using the rigid grid format and three mapping units were delineated based on similarities and differences observed in the morphological properties from the augured points. Profile pits were dug in the identified mapping units. The pits were sampled and taken to the laboratory for analyses. From the analytical results the characteristics of the soils ranged as follows: soil pH, 4.2 to 5.0, extractable Fe, 12.30 to 20.10 mg kg^{-1}, extractable Mn, 3.60 to 36.80 mg kg^{-1}, extractable Cu, 3.90 to 7.30 mg kg^{-1} and extractable Zn, 7.00 to 27.30 mg kg^{-1}. The implications of the analytical results were discussed. For sustainable crop production to be achieved in the mapping units studied, it is suggested that organic manure should be incorporated into the soils.

Key words: Micronutrients, characterization, sustainable, crop production

INTRODUCTION

Micronutrients are essential elements that are used by plants in small quantities. For most micronutrients crop uptake is less than 1.11 kg per hectare. In spite of this low requirement, critical plant functions are limited if micronutrients are unavailable, resulting in plant abnormalities, reduced growth and lower yield. Soil micronutrients are one of the most important environmental factors in plant ecology (Zhu and Yu, 1998). Influenced by soil parent material, climate, and vegetation, the content of trace elements in soil directly relates to the growth and development of vegetation and reflects the supply of mineral nutrition to plants by soil. Soil tests and plant tissue analyses have demonstrated that trace elements are an important limiting factor in crop growth. If any trace element is found to be excessive or deficient in soil, plant growth is affected and human and animal health are consequently impacted. Obasi, (2003), further opined that micronutrients deficiency in soils causes reduction in the yield of crops. It has been reported that worldwide, millions of hectares of farmland soil lack sufficient trace elements (micronutrients) (White and Zasoski, 1999). Ahukaemere *et al.* (2014) reported that intensive cropping practices, enhanced production of crops on marginal soils that contain low level of micronutrients and adoption of high yielding cultivars which have high micronutrients demand have led to increased demand for these nutrients. However, micronutrients are not applied regularly to the soil in conjunction with NPK fertilizer, yet about two to six times these elements are removed annually from the soil. Therefore, studies on the circulation and balance micronutrients in ecosystems have attracted increasing scientific interest (Rengel, 2007).

Research has demonstrated that the effective components of a nutrient are those that can be absorbed by plant and that the bioavailability of an element is related to its chemical state in the soil (Maiz *et al*., 2000). Accordingly, research on element availability has focused on the circulation of micronutrients and its main influencing factors in forests (Jiang, 2009) and farmland, as well as ecological succession processes, through bioavailability analysis of micronutrients in soil ecosystems (Zhang *et al*.,2006). Element bioavailability is influenced by many factors, such as pH value, redox conditions, texture, organic matter, soil mineral composition and temperature (Kabata-Pendias, 2004). Kabata-Pendias, (2004) summarized the availability of some elements including micronutrients under different soil conditions and stated that in oxidizing acid soils, many micronutrients, especially Cd and Zn, are very active and have strong bioavailability, whereas in reducing neutral or alkaline soils, element bioavailability is lower. Therefore, the bioavailability of micronutrients can be beneficial or harmful, it is not only dependent upon their total content but also upon their soil state and their ability to transfer from the solid phase of a soil into the soil solution (Zhao *et al*., 2010).

Characterization of soils is helpful in the appraisal of soil productivity (Onyekwere, 2017). Some works have been done on the morphological, physical and macronutrients characterization of soils derived from basalt parent material in Ikom, Cross River State Nigeria for sustainable crop production, but information on the micronutrients characterization of the soils is still lacking. Keeping in view the importance of micronutrients in sustainable crop production and also inadequate information available at present. Study on the micronutrients characterization of soils derived from basalt parent material in Ikom Cross River State Nigeria, was undertaken. This study will help to realize the full potential of the soil resources of the area. Based on this, there is need to study the micronutrients characteristics of soils derived from basalt parent material in Ikom Cross River Nigeria for sustainable crop production.

MATERIALS AND METHODS

The study area is Ikom, Cross River State, south south Nigeria. The area lies between latitude 5° 53' N and longitude 8° 46' to 48' E. The climate of the study area is characterized by distinct wet and dry seasons. The former, which lasts for about seven months starts immensely from April to October. The dry season stretches mainly from march through November. Peters and Ekwe-Ozor (1982) remarked that a condition of great uniformity is experienced in the area throughout the year. The area has a mean annual temperature between 22 and 32°C, the mean annual rainfall ranged from 2, 500 to 2,900 mm and the relative humidity varied from 60 to 74% (Table 1). The vegetation in the study area consists of tropical rain forest. The prevailing condition in the area has compelled people towards adapting farming systems that are comparatively advantageous and adapted to their environment. The soil is derived from the igneous formation (basalt).

Based on logistics and vast nature of the area, 500 hectares of land which were measured with the aid of Global Positioning System (GPS) Receiver Garmin Ltd Kansas, USA were surveyed. The overall micro-relief of the surveyed area consisted of slightly undulating to gently sloping terrain of not more than 4% gradient. A detailed soil survey using the rigid grid format was conducted. Transverses were cut along a properly aligned base line at 200 m intervals while auger borings were made at 25cm interval to a depth of 100 cm and morphological (colour, texture, structure, consistency and inclusions) descriptions were made, following which 3 different soil units were delineated and mapped. Three profiles pits each measuring (2 x 1 x 2) m or to any impermeable layer were dug in each delineated soil unit. The morphological characteristics of each of the soil profile pits were described, according to the guidelines for profile pit description outlined in soil survey manual (Soil Survey Staff, 2014). The Profile pits were cleaned and demarcated based on depths of genetic horizons, which were observed based on differences in morphology, starting from bottom to avoid contamination. Samples were taken to the laboratory for chemical analyses. All the soil samples collected from the profile pits were air dried; gently ground and sieved using a 2 mm sieve preparatory for laboratory analysis. Samples for total N and organic C were passed through a 0.5 mm sieve. For purpose of reporting, a representative profile pit was selected from the three profile pits delineated in each mapping unit of the study area (Table 2).

Soil analysis

Chemical properties

The chemical properties of the soils were determined according to standard laboratory procedures as contained in the method of soil analysis by International Soil Reference and Information Center and Food and Agricultural Organization (ISRIC and FAO, 2002). Soil pH (H_2O) was determined in 1:1 soil/ distilled water suspensions using a glass electrode. Micronutrients (Fe, Zn, Cu and Mn) in the soils were with 0. I N HCI solution

Table 1. Ten years (2005-2015) meteorological data of Ikom.

Year	Temperature (°C)		Rainfall (mm)		Relative humidity (%)		Sunshine Hours
	Minimum	Maximum	Days	Amount	1500	900	????
2005	22. 60	32.20	140	2760.20	61	70	4.6
2006	21.80	31.50	143	2720.60	60	72	4.7
2007	23.40	31.70	135	2650.60	63	74	4.4
2008	22.30	31.80	130	2490.40	62	71	4.7
2009	22.50	31.50	152	2690.90	61	70	4.8
2010	23.70	32.00	133	2700.00	60	71	4.8
2011	22.30	31.00	148	2900.00	60	70	4.7
2012	22.10	31.50	148	2800.50	60	70	4.5
2014	24.40	31.50	145	2550.00	61	70	4.7
2015	24.60	31.80	160	2600.00	62	71	4.7

Source: Cocoa Research Institute of Nigeria Ikom out Station Metrological Unit.

and the filtrates were determined with Atomic Absorption Spectrometer, at their respective resonance lines, using standard calibration method.

RESULTS AND DISCUSSION

Soil reaction

The soil reaction expressed as pH (H_2O) in all the mapping units were extremely too acidic, with a range of 4.2 to 5.0. The pH values increased with depth in all the mapping units studied with the Ap (ploughed for Agricultural activities) horizons having an average pH value of 4.2.The pH values of these soils indicated that they are included among the excessively leached acid latosols with low to medium humus found in areas of rainfall approximately 2,200 to over 5,000 mm per annum in hot lowland (Udoh *et al*., 2013). According to Okusami *et al*.(1997), the acidity nature of the mapping units studied is an indication of influence of pre-weathered parent material on the chemical properties of some soils within the tropics. There is need to incorporate organic materials in the soils, to reduce the soil acidity. According to Onyekwere *et al.* (2012), addition of organic fertilizer to soil reduces soil acidity because organic fertilizer has some liming effect on the soil.

Extractable micronutrients

The results of the micronutrients of the mapping units studied are presented in (Table 3).

Extractable Iron

The extractable iron content of the mapping units studied ranged from 12.30 to 20.10 mg kg^{-1}, and maintained no definite pattern of distribution down the depth. The values of Ap horizon ranged from 12.90 to 14.60 mg kg^{-1}, with a mean value of 13.93 mg kg^{-1}.

Extractable Manganese

The extractable manganese content for mapping units studied ranged from 3.60 to 36.80 mg kg^{-1}, apart from mapping unit 1 that decreased down the depth the other mapping units did not maintain any particular pattern of distributions with depth (Table 3). The values of Ap horizons ranged from 12.19 to 36 .80 mg kg^{-1}, with an average value of 21.53 mg kg^{-1}.

Extractable Cupper

The extractable cupper content of the mapping units studied ranged from 3.90 to 7.30 mg kg^{-1} and the values decreased with depth only in mapping unit 3 and maintain no definite pattern of distribution with depth in the other mapping units. The values of Ap horizon ranged from 5.70 to7.30 mg kg^{-1}, with an average value of 6.30 mg kg^{-1}.

Extractable Zinc

The extractable zinc content of mapping units studied

Table 2: Field morphological description of the mapping units studied.

Horizon	Depth (cm)	Matrix Colour (moist)	Texture	Structure	Consistency	(Moist)	Boundary	Other Feature
		Mapping	**Unit 1**					
Ap	0 -19	Reddish brown (5YR4/4)	C	2msbk	Fm		dw	c2rts
Bt1	19 – 35	Reddish brown (5YR5//4)	C	3msbk	Fm		gw	c1rts
Bt2	35 – 80	Red (5YR4/6)	C	3msbk	Fm		gw	c2rts
Btv1	80 – 116	Yellowish brown (5YR4/6)	C	3msbk	Vfm		gw	f2rts,c2 Fe
Btv2	116 -155	Yellowish brown (5YR4/6)	C	3msbk	Vfm		-	f2rts,c2e
		Mapping	**Unit 2**					
Ap	0 – 20	Dark reddish brown (5YR3/4)	C	2msbk	Vfm		dw	c2rts
AB	20 – 45	Reddish brown (5YR4/3)	C	2msbk	Fm		dw	c1rts
Bt1	45 – 80	Reddish brown (2.5YR4/4)	C	2msbk	Fm		gw	m2rts
Bt2	80 – 135	Dark reddish gray (5YR4/2)	**C**	3msbk	fm			f2rts
		Mapping	**Unit 3**					
Ap	0 - 18	Dark reddish Brown (2.5YR3/3)	SCL	2msbk	Fm		cw	c2rts
AB	18 - 62	Red (2,5YR4/6)	SCL	3msbk	Fm		dw	c2rts
Bt1	62 – 100	Red (2.5YR4/8)	SC	3msbk	Fm		dw	m2rts
Bt2	100 130	Red (2.5YR4/8)	SC	3msbk	Vfm			f1rts

Boundary: a = abrupt, b = broken, c = clear, d =diffuses, s = smooth, w = wavy, g = gradual, I = irregular. When a dash (-) is present the property is not recorded. Structure: sbk = sub angular blockly, m = medium, l = weak, 2 = moderate, 3 = strong. Consistency: vfm = very firm, fm = firm. Texture: s = sand, SCL = sandy clay loam, Sl = sandy loam, LS = loamy sandy. Other Features: rts = roots, m = many, c = common, f = few, 1= fine, 2 = medium, 3 = coarse, Fe-mm = Fe = iron nodules (plintite).

Table3. Micronutrients and soil pH of the mapping units studied.

Horizon	Depth (cm)	Fe	Mn	Cu	Zn	pH (H_20)
Mapping		**unit 1**				
Ap	0 -19	14.30	36.80	7.30	27. 30	4.2
Bt1	19 – 35	12.90	19.40	7.01	21. 40	4.3
Bt2	35 – 80	20.10	23.70	6.90	20.80	4.5
Btv1	80 – 116	18.30	23.70	7.10	20.00	4.5
Btv2	116 -155	15.10	25.80	6.80	19.70	4.6
Mapping		**unit 2**				
Ap	0 – 20	12.90	12.19	5.90	19.60	4.2
AB	20 – 45	14.30	3.6	4.40	15. 40	4.4
Bt1	45 – 80	14.30	8.60	4.40	13.300	4.5
Bt2	80 – 135	12.90	8.60	5.70	10.60	4.6
Mapping		**unit 3**				
Ap	0 – 18	14.60	15.60	5.70	17.30	4.2
AB	18 - 62	14.30	14.30	4.80	7.90	4.5
Bt1	62 – 100	13.80	11.00	4.60	8.30	4.6
Bt2	100 130	12.30	9.80	3.90	7.00	5.0

ranged from 7.00 to 27.30 mg kg^{-1}, the values increased with depth only in mapping unit 1. The values of Ap horizon ranged from 17.30 to 27.30 mg kg^{-1}, with an average value of 21.40 mg kg^{-1}. All the mapping units studied had high Fe content as the values exceeded 4.6 mg kg^{-1} regarded as high critical limit of extractable Fe in soils (Samuel *et al*., 2003), but had Fe^{2+} below 50 to 100 mg kg^{-1} considered as the range in which some crops like rice starts to show toxicity symptoms especially in soils with low fertility status (Van Mansvoort *et al*., 1984). Apart from mapping unit 1, the Ap horizon of other mapping units studied had extractable Mn values between the threshold range of 10 – 25 mg kg^{-1} a range at which Mn toxicity manifests in soils (Umar *et al.,* 2001). This result is in conformity with the findings of Ndukwe *et al*., (2011). There is need to incorporate organic fertilizer in the soils to reduce the effect of Mn toxicity on crops.All the soils studied had high extractable Cu content as all the values exceeded 0. 20 mg kg^{-1} regarded as critical limit of extractable Cu in soils (Samuel *et al.,* 2003). The mapping units studied are well endowed with extractable zinc content at the Ap horizon, having values that exceeded 2.00 mg kg^{-1}, the moderate value of extractable zinc required in soils (Kparmwang *et al*., 2000).

Conclusion

From the research conducted it can be concluded that all the Mapping units studied are extremely too acidic, had high values of extractable Fe, Mn, Zn and Cu. For sustainable crop production to be achieved in the study area there is need to apply organic manure in order to reduce soil acidity and check Mn toxicity.

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