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Full Length Research Paper

Status and distribution of available micronutrients along a toposequence at Gubi Bauchi North Eastern Nigeria

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Abstract

A study was carried out to determine the status and distribution of extractable zinc (Zn), cupper (Cu), iron (Fe) and Manganese (Mn) along a toposequence at Gubi, Bauchi Nigeria. Four profile pits were dug along the toposequence at the upper slope, middle slope, lower slope and valley bottom positions and soil samples taken from identified horizons were subjected to laboratory analysis. The results show that the mean values were 0.26, 0.36, 44.75 and 47.50mg/kg for Zn, Cu, Fe and Mn respectively. Zn and Cu were generally "low" to "medium" in all the horizons of the pedons, and also below the critical limits for arable crop production. The crops will benefit from supplementary application of these micronutrients for maximum productivity. Fe and Mn values were "high" and above the critical limits for arable crop production in all the horizons of the pedons. The soils will not require supplementary application of Fe and Mn.

Keywords: Extractable micronutrients, critical limits, supplementary application, crop productivity.

INTRODUCTION

Soil fertility is an important factor which determines the growth and productivity of plants. It is determined by the presence or absence of macro or micronutrients. Iron (Fe), Manganese (Mn), Copper (Cu) and Zinc (Zn) are essential micronutrients for plant growth. Through their involvement in various enzymes and other physiologically active molecules these micronutrients are important for gene expression, biosynthesis of proteins, nucleic acids, growth substances, chlorophyll and secondary metabolites, metabolism of carbohydrates and lipids, stress tolerance etc (Rengel, 2003; Gao et al., 2008).

The quest for a sustainable food security in Nigeria through the use of information on nutrient status of soils has become imperative. The distribution of available micronutrients within soil profiles has been considered useful for a better understanding of soil's capacity to sustain an adequate amount or supply of these nutrients to plants so as to meet the increasing demand for sustainable food sufficiency. Several researchers have advocated the need for assessing the micronutrients status of soils Chaudari et al. (2012) and Nigeria in particular Ibrahim et al. (2011) and Mustapha et al. (2011). The study was therefore conducted to assess the distribution of extractable Fe, Mn, Cu, and Zn in soil profiles along a toposequence at Gubi, Bauchi state North-Eastern Nigeria.

MATERIALS AND METHODS

Site Description

The study was conducted at Gubi, Bauchi in the Northern Guinea Savannah Zone of Nigeria (10^o 22' N and 9^o 47 'E) and 609m above sea level .The area is made up of charnochite, bauchite lithology formed on older granite suite of Paleozoic age. It is made up of basement complex rocks with granite forming the bulk of the parent

material. The soils are mostly shallow to deep and fairly flat although the plains are dotted with inselbergs (Carter 1964). The area has two distinct seasons, the rainy season which starts in May and ends in October and the dry season from November to April with mean daily temperature of 26°c. (Kowal and Knabe 1972).The dominant vegetation is mostly tree, shubs and grasses. The common tree species include *Parkia clappertonia, Butryospernum parkii,Tamarindus indica* and the common grasses are *imperata cylidrica, Digitaria abyssinia* and common shrubs include *Psiadia punctulata, Tarchonantus camphoratus* etc.

Site selection and soil analysis

Four pedons were dug along a toposequence representing upper slope, middle slope, lower slope and valley bottom positions referred to as pedons 1, 2, 3 and 4 respectively. Soil samples were collected from each identified horizon of the four pedons and subjected to laboratory analysis.

Particle size distribution was determined using the hydrometer method as described by Bouyoucos (1957). Soil pH was determined in 1:1 soil water suspension with a glass electrode pH meter. Organic carbon was determined by the wet oxidation method Walkley and Black (1934). Cation exchange Capacity (CEC) was determined by sodium acetate (NaOAc) saturation and neutral ammonium acetate. The extractable micronutrients: Zn, Cu, Fe and Mn were extracted using 0.1M HCl solution Osiname et al. (1973) and determined on an atomic absorption spectrophotometer at appropriate wavelength.

For the micronutrients ratings the limits given by Esu (1991) were adopted as follows:

	Low	*Medium*	*High*
Zn	<0.8	0.81 – 2.0	>2
Cu	<0.2	0.2 – 2.0	>2
Fe	<2.5	2.5 – 5	>5
Mn	<1.0	1.1 – 5.0	>5.

Source: Esu (1991)

RESULTS

The results of laboratory analysis of soil samples for the study are shown in Tables 1 and 2.

DISCUSSION

Status and distribution of available Zinc (Zn)

The DTPA extractable Zinc in all the pedons and horizons ranged from 0.17 to 0.75 mg/kg with a mean value of 0.26mg/kg. Based on the critical values of Esu (1991) all the soil samples fall in the category of 'low' Zn status and would require Zn fertilization for a better arable crop production. In general in most of the pedons Zn decreased with depth while it is irregularly distributed in others. Singh and Shukla (1985), Bassirani et al. (2011), reported similar results, this also conforms to the findings of Mustapha et al. (2011) in soils in Gombe, Nigeria.

Status and Distribution of Copper (Cu)

Table 2 shows that Cu in the soils ranged from 0.08 to 0.93 mg/kg, based on the Esu (1991), micronutrients fertility ratings it falls in the "low" to 'medium' categories, (with an average of 0.36 mg/kg) in all the horizons of the pedons. Pedon 4 Bt2 had the lowest Cu status (0.08mg/kg) and the highest extractable Cu content in the AB horizon (0.93mg/kg). Generally the surface horizons (Ap) had the highest Cu content while it is irregularly distributed in all the horizons of the four pedons. These results are similar to those obtained by Mustapha and Singh (2003) for soils in Galambi, Bauchi State in the same agro – ecological zone of Nigeria (mean = 0.21mg/kg) and Mustapha et al., (2010) when they studied soils of Yamaltu – Deba Local Government Area of Gombe State (mean = 0.21mg/kg). Notably Cu in the upper horizons of all the pedons fall within the medium micronutrients ratings of Esu (1991) and could therefore require supplementary Cu applications for sustainable arable crop production. This also agrees with findings of Mustapha et al. (2011) when they studied soils of Akko Local Government area of Gombe State in the same agro – ecological zone.

Iron (Fe) status

Table 2 shows that Fe content ranged from 25.86 to 86.11 mg/kg in all the horizons of the pedons rating it in the "high" category of Esu (1991) micronutrients fertility ratings in all the horizons of the four pedons and are above the ones reported by Mustapha et al. (2010) for soils in Gombe State (18.40 – 21.9mg/kg) and Mustapha and Singh (2003) for soils in Bauchi State (12.40 – 45.10mg/kg). The high Fe content in soil (above the critical value of 2.5 mg/kg for crop production) means that Fe deficiency is not likely for crops grown on these soils. Geurten (1986) found out that Fe deficiency is very unlikely as iron is known to be soluble under relatively reducing conditions Chestworth (1991). However the presence of Fe in high concentrations in soils could lead to its precipitation and accumulation and upon complex chemical reactions lead to the formation of phlintite (laterite). This upon alternate wetting and drying could irreversibly form hard indurated material (petrophlintite or ironstone) which could restrict root penetration and

Table 1. Soil Particle Size Distribution, Texture, PH, Organic Carbon

Pedon No	Depth	Sand	Silt	Clay	Texture	pH	Org. Carbon
	(cm)		%			1:1	g/kg
Pedon 1							
Ap	0 - 28	62.96	26.54	10.48	sl	5.35	7.45
Bt1	28 - 99	52.96	14.56	32.48	scl	4.84	2.19
Bt2	99 - 131	48.96	20.56	30.48	scl	4.78	1.53
Pedon 2							
Ap	0 - 18	60.96	10.56	20.48	sl	4.48	4.17
Bt1	18 - 56	50.96	16.56	32.48	scl	4.79	3.07
Bt2	56 - 121	48.96	20.56	32.48	cl	4.95	4.17
Pedon 3							
Ap	0 - 21	68.93	20.56	10.48	sl	5.06	11.4
AB	21 - 51	68.96	14.56	16.48	sl	4.99	2.85
Bt1	51 - 99	62.96	18.56	16.48	sl	4.74	2.19
Bt2	99 - 141	54.96	16.56	28.48	l	5.17	2.19
Pedon 4							
Ap	0 - 16	70.96	16.56	12.48	sl	5.16	18.42
AB	16 - 46	66.96	16.56	16.48	sl	5.18	2.19
Bt1	46 - 96	58.96	16.56	24.48	scl	5.03	26.53
Bt2	96- 150	62.96	12.56	24.48	scl	4.94	2.19

Table 2. Profile Distribution of Extractable Micronutrient

Pedon No	Depth	Zn	Cu	Fe	Mn
	(cm)			mg/kg	
Pedon 1					
Ap	0 - 28	0.21	0.43	38.69	52.16
Bt1	28 - 99	0.17	0.26	42.93	66.01
Bt2	99 - 131	0.31	0.43	36.11	52.75
Pedon 2					
Ap	0 - 18	0.23	0.52	25.86	39.99
Bt1	18 - 56	0.27	0.36	63.75	43.16
Bt2	56 - 121	0.18	0.21	74.29	40.87
Pedon 3					
Ap	0 - 21	0.24	0.81	31.30	52.06
AB	21 - 51	0.18	0.36	35.25	83.50
Bt1	51 - 99	0.34	0.55	86.11	72.12
Bt2	99 - 151	0.21	0.26	40.25	34.43
Pedon 4					
Ap	0 - 16	0.36	0.53	28.16	18.18
AB	16 - 46	0.75	0.93	57.26	60.60
Bt1	46 - 96	0.2	0.17	43.77	57.23
Bt2	96- 150	0.17	0.08	62.09	48.26
Mean		**0.26**	**0.36**	**44.75**	**47.5**

drainage. This observation is similar to that of Mustapha et al. (2010).

Manganese (Mn) status

Manganese (Mn) in the soils (table 2) ranged from 18.18 to 83.50 mg/kg (mean = 47.5 mg/kg), according to the rating of Esu (1991) it is rated 'High' in all the horizons of the pedons. This implies that soils content of Mn is above the critical available range of 3 to 5 mg/kg reported by Lindsday and Norveil (1978) and 1 – 5mg/kg reported by Esu (1991). The surface horizons had lower Mn content than sub- surface horizons and it increased with depth but the pattern is not rigidly followed. Pedon 3 AB horizon had the highest Mn content of 83.50mg/kg and pedon 4 Ap had the least Mn content of 18.18mg/kg. These figures suggest that Mn content of the soils is high and cannot be a limiting factor to successful crop production in the area. Kparmwang (1996) reported similar findings in similar Nigerian soils.

CONCLUSION

The profile distributions of Zn, Cu, Fe and Mn in the area of study suggests that supplementary application of Zn and Cu will be required for sustainable arable crop production in the soils studied, while Fe and Mn are not likely to be deficient in such soils. So it is recommended that for successful arable crop production Zn and Cu be applied to the soils in the study area.

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