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Hydrochloric Acid (0.1M) and DTPA-extractable and Total Zinc in Charnockite Soil Profile of Ekiti State, Nigeria

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ABSTRACT

A study was conducted to determine the content and distribution of total 0.1M HCl and diethylene triamine penta acetic acid (DTPA) extractable zinc (Zn) in the genetic horizons of six (6) profiles formed from Chanockite parent rock in Ekiti State. The content of Total Zn for all the soils varied from 28 to 84mg/kg. Most of the soils had the highest concentration of total Zn in the surface horizons. There was a strong association between total Zn and organic carbon. Available Zn determined with 0.1M HCL extractable was higher than DTPA-extractable Zn. The values from the two extractants show that available Zn is clearly deficient. There would be need for Zn application to the soils for successful and profitable crop production.

Introduction

Soil micronutrient study was neglected in both soil science and crop production in Nigeria and Africa as whole and even other developing countries (Pam, 1990). Recently, micronutrients studies have received some attention from scientists. Kang and Osiname(1972) reported that the deficiency symptoms were not apparently shown in the past because depleted micronutrients were replenished from the soil organic matter during the long fallow periods that followed cultivation.

The distribution of available micronutrients within soil profiles has been considered useful for a better understanding of soil capacity to sustain an adequate supply of these nutrients to plant and their downward movement in soil. In crop production, information regarding the total and extractable Zinc in the lower depths is of utmost importance in assessing the amount of the element held in reserve or immediately available to the plants.

Generally, studies on zinc have been related to ecological zones with most of the investigation done on soils of the savanna zone (Lombin,1983). There is little or no much research work on Zinc distribution within soil profiles in the charnockitic soils of Ekiti State, Nigeria. There are also indications that Zinc deficiency may develop as agriculture becomes more intensive. Zinc occurs in basic ferromagnesian minerals such as olivine and biotite through isomorphous substitution of Zn^{2+} for Fe^{2+} and Mg^{2+} . According to Udo and Fagbami(1979), rocks of igneous origin contain more Zinc than their sedimentary counterparts with Zn being more concentrated in basalt than granite.

The charnockitic soils of Ekiti are a vast arable land with agricultural value. With agricultural intensification of the charnockite soils, deficiencies of not only the macronutrients but that of micronutrients as well may develop. This therefore necessitates attention on the micronutrient status of the soil of the area. This study was therefore conducted to determine variation in content and profile distribution of zinc on charnockitic soils of Ekiti State.

Materials and Methods

Six profile pits were dug at Ado, Ikere, Ijan, Osin –Itapa, Ijesa- Isu and Ire- Ekiti. Each pedon was cited in mid-slope of the general terrain of its location. The morphological properties of the profiles were described in the field using criteria of the soil survey. Manual of soil survey staff (2003) and the guidelines for soil profile description (FAO, 1990). Samples from the diagnostic horizon in each profile were taken, air dried, gently ground and sieve for laboratory analysis.

The P^H of the soil was determined in 1:2 soil:water mixture using digital P^H meter, Organic Carbon was determined by Walkey and Black dichromate wet Oxidation method (Allison, 1978) and organic matter calculated as organic carbon x 1.724%. Free oxides of Fe were extracted with diothionite Citrate Mixture buffered with Na with bicarbonate (DCB) (Merha and Jackson, 1969). Total Zn was determined by $HClO_3$ –HF-H_2SO_4 –HNO_3 digestion method (Udu and Ogunwale, 1978). The DTPA-extratable Zinc was determined by extracting 20g of the soil with 40mls of 0.005M diethylenetriamine penta acetic acid (DTPA) according to the procedure described by Lindsay and Norvell (1978). The dilute acid extractable Zn was determined by extracting 5g of soil with 50mls of 0.1 N(HCL-Zn) as described by Maclean and Langille (1976). Zinc in the extracts was measured on Perkin Elmer atomic absorption spectrophotometer, model 303.

Statistical Analysis

Simple correlation analysis was performed to test relationship between total and extractable zinc and some soil properties.

Table 1: gives the location of the pedons and classification of their soils using (soil survey staff, 2003) and FAO (1990), revised legend of the soil map of the world.

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Total Zinc

The soil profiles differed widely in total Zn content (table 2). The values ranged from 28 to 84mg/kg. Soils from Ire, Ado and Osin-itapa had higher values which decreased down the profile; however, the content was higher at Ire, Ado and Osin-itapa. The range of values obtained is comparable with others. For some western Nigerian soils Osiname et.al.; 1973 obtained a range of 15-84 mg/kg and the mean value of 34mg/kg. The values of total Zn are lower to those reported by Udo and Fagbami (1979) in basaltic soils (52-183mg/kg) and also values reported by Kpamwang et. al; (1995) 30 -265mg/kg also in basaltic soils. The values of total zinc in the soil are relatively high which indicate that Zinc exists in these charnockitic soils largely in unavailable form. Total zinc is generally regularly distributed in most of the profiles. The higher content of total zinc in the surface horizon in most of the soil profile maybe due to the associations of zinc with soil organic carbon. Earlier finding by other researchers have indicated that soil layers rich in organic carbon such as upper soil horizons have higher zinc concentrations (Audbert and Pinta, 1977). In addition, since most of the sample site was cropped to soy beans and this soils were characterized by heavy accumulation of leave litters on the soil surface. This might reduce the direct impart of raindrops on the soil surface and thus reduce the leaching of zinc down the profile. The total Zn distribution was highest at the surface layer corresponding to the position with the highest organic carbon.

Table 1: Classification of soils derived from charnockite in Ekiti State.

Profile site	USDA classification		FAO/UNESCO classification
Ado	Grossarenic	plinthic	Ferric Lixisol
Ikere	kandiudalf		Ferric Lixisol
Ijan	Grossarenic	plinthic	Ferric Lixisol
Osin-Itapa	kandiudalf		Ferric Lixisol
Ijesa-Isu	Grossarenic	plinthic	Haplic Lixisol
Ire	kandiudalf		Plinthic Lixisol
	Plinthic kandiudalf		
	Typic kandiudalf		
	Plinthic kandiudalf		

Source: Shittu, O.S., 2008

Extractable Zinc

The quantities of 0.1N HCl and DTPA-extractable Zn are given in (table 2). The quantity of extractable with 0.1N HCl range from 0.53 to 2.65mg/kg with a mean of 1.03mg/kg while values for DPTA are 0.05 to 1.43mg/kg and 0.60mg/kg.

There was no regular pattern of distribution of extractable Zn even though it tended to accumulate in the surface soils in Ijan, Osin-itapa and Ijesa-isu while it increased with depth in others. In a number of profiles, the values of HCl-extractable Zn remain approximately constant with depth. Zn values were higher with 0.1N HCl than DTPA except in Ado and Ire surface soil. Across the horizon, HCl-extractable Zn was higher than DTPA-extractable zinc. Thus, higher extraction by HCl may be attributed to the dissolution of some Zn bearing minerals by HCl. The values of HCl-extractable Zn are generally lower than those reported by Udo and Fagbami (1979). For soils on basaltic (range, 1.20 to 2.75mg/kg). They are also generally lower by values reported by Lombin(1983). For soils of the Nigerian savannah as a whole (0.54 to 4.54mg/kg). The values of HCl-extractable zinc mostly fall within the critical available range of 1.0 to 7.0mg/kg. (Cox and Kamprath, 1972) and 1.0 to 5.0mg/kg (Sims and Johnson, 2001). This indicate a situation of borderline deficiency, and if the upper values of this limit are anything to go by as the case might be with sandy soils such as those used in this study, then the soils are probably deficient. HCl extractable Zn and therefore, available Zn. Itapa,Ijesa-isu, Ijan, a trend of distribution that suggests greater contribution from soil organic matter than mineral colloids

Table 2: Profile Distribution of Total and Extractable Zn in Soils formed from Charnockite rocks of Ekiti State

	Depth(cm)	Total Zn mg/kg	HCl-Zn mg/kg	DTPA-Zn mg/kg
Ado	0-11	84	0.53	0.68
	12-21	68	1.06	0.16
	21-62	42	0.53	0.19
	62-118	33	1.09	0.61
	118-150	29	0.53	0.52
Ikere	0-23	19	0.53	0.42
	23-64	24	1.04	1.24
	64-92	33	2.12	1.05
	92-140	15	1.06	0.49
Ijan	0-20	28	1.58	1.43
	20-35	36	0.53	0.08
	35-60	36	0.53	0.59
	60-90	38	1.50	0.52
	90-120	32	0.53	0.49
Osin-Itapa	0-23	84	2.12	0.49
	23-50	42	1.06	0.25
	50-80	29	0.93	0.05
	80-130	17	0.53	0.12
	0-20	28	1.58	1.40
Ijesa-Isu	20-33	34	1.06	0.65
	33-110	29	1.58	0.54
	110-150	36	0.53	0.57
	0-20	82	0.53	0.76
Ire	20-43	68	0.53	0.54
	43-70	60	0.53	0.59
	70-120	30	2.65	0.57

Table 3: The mean and ranges of Extractable Zn in 6 profiles

Parent Mineral Rock	Towns	Profile Means HCl-Zn	DTPA-Zn	Profile Ranges HCl-Zn	DTPA-Zn
Charnockite	Ado	0.74	0.43	0.53-1.06	0.16-0.61
	Ikere	1.19	0.80	0.53-2.12	0.42-1.24
	Ijan	1.42	0.74	0.53-1.58	0.49-1.43
	Osin-Itapa	1.03	0.23	0.53-2.12	0.05-0.49
	Ijesa-Isu	1.19	0.79	0.53-1.58	0.57-1.40
	Ire	1.06	0.62	0.33-2.65	0.54-0.76

The DTPA extractable Zn is in most cases lower than HCl extractable Zn. This probably suggests a lower efficacy of DTPA when compared to HCl as extractant for Zn. Most mean values of DTPA extractable Zn are below the critical available level (0.8mg/kg soil)(Lindsay and Norvel, 1978) in the soils. Thus, more or less confirms the fact the soils are deficient in available Zn. It has also been noted that although there is variability in the distribution of extractable available zinc in soil profile, extractable available Zn accumulate in the top soil.(Folliet and Lindsay, 1970). Consequently, removal of top soil through grading or erosion can increase the likelihood of Zn deficiency in crops (Grunnes et.al; 1961). Generally, in all the horizon, the content of available Zinc obtained from this study, fell below the critical level of 3.3mg/kg for HCl extractable Zn as reported by Pam(1990), who worked on soils of similar areas of the basement complex rock of south western Nigeria.

The relationship between extractable Zinc and some soil properties were examined by the use of simple correlation analysis. Table 4 shows the correlation coefficient of the relationships of extractable Zn and total Zn with some soil properties. HCl extractable Zn was not correlated with any of the soil properties while DTPA extractable Zinc was correlated with organic carbon, P^H and clay. Total Zn was significantly correlated with HCl and DTPA-extractable Zn but the two forms of extractable Zn has no correlation with each other.

Table 4: Charnockite Coefficient relating Total and Extractable Zn to some soil properties

	TotalZn	DTPA-Zn	HclZn
DTPA-Zn	0.48**		
Hcl-Zn	-0.33**	0.44	
Org C	0.76**	0.21**	-0.06
pH	-0.16	0.26**	0.04
Clay	0.31**	-0.43**	-0.09
Fe_2O_3	0.30**	0.06	-0.9

*significant at 5% Confidence Level
** significant at 1% Confidence Level

The relationship of total Zn with some soil properties showed that total Zn strongly correlated with organic Carbon(r =0.76**) but had weaker correlations with clay and free $Fe_2 O_3$. Hence, the factor which largely controls total Zn content is the soil Organic carbon. This association of total Zn with clay and $Fe_2 O_3$ was also reported by white (1957), Karin and seed berry (1976).

Conclusion

Soils developed on charnorkite in Ekiti state contain relatively high total Zn but low available forms. The situation is such that the soils are clearly deficient in available Zn. Total and extractable forms of Zn are related to some soil properties indicating that they are to some extent tied to multiple sources which will contribute to or affect their availability. Dilute acid (HCl) generally extracted more Zn from soil than DTPA. Based on the critical limit of 3.3mg/kg (Pam, 1990), most of the soil sample falls in the category of low Zn status fertilization for better crop production. In general, in most of the profiles, the available Zn decreased with depth and follows the trend of organic carbon accumulation. Also the significant relationship between Zn and soil properties shows the importance of this soil properties (clay, P^H , organic carbon) in the availability of Zn. The importance of organic matter in the supply of Zn was also observed in this study. Farmers in the study area are advised to apply organic matter to their farm to supply Zn nutrient

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