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Effect of Agroforestry on Zn Distribution in Selected Ricesoilsin Ishiagu, Ebonyi State, Nigeria

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ABSTRACT
Agroforestry is an agricultural practice that combines the presence of trees in lands used for farming. These trees presents so many benefits to the soil such as litter addition, decomposition, nutrient release, nutrient pumping, and erosion control etc. Rice (*oryza sativa* L.) is a crop fed by more than half of the world's population and is grown in more than a hundred countries especially in Asia. Zinc is one of the most important micronutrient essential for growing rice, it acts as an essential component of many enzymes and is involved in many biochemical process in the growth of plants. Analysis of different soils for the distribution of zinc on upland and lowland rice cultivated soils with agroforestry and also open field soils with rice cultivation (non agroforestry), shows that zinc distribution meets acceptable critical levels given as 10mg/Kg. The highest and lowest mean values obtained is given as 65.24mg/kg in lvLP and 22.31 mg/Kg in lvOP respectively. These suggests that agroforestry in rice cultivation has no negative effect on the distribution of zinc but rather enhances the soil properties. Hence, agroforestry practices in rice land is encouraged.

KEYWORDS: Rice, Zinc, Agroforestry, Distribution, Soils

I. INTRODUCTION

An agricultural practice that allows presence of trees in farming systems is an ancient practicethat began to gain institutional attention during the 1970s and 1980s, with the beginning of studies on "agroforestry systems". One of the principal definitions employed in this context was that proposed by Lundgrenand Raintree in 1982: "Agroforestry is a collective name for land use systems and technologies where woody perennials (trees, shrubs, palms, bamboos, etc.) are deliberately used on the same land-management units as agricultural crops and/or animals, in some form of spatial arrangement or temporal sequence. In agroforestry systems there are both ecological and economical interactions between the different components"(Nair, 1989).

Rice(Oryza sativa L.)isoneofthemajorstaples,feedingmorethanhalfoftheworldpopulation.Itisgrowninmorethan100countries,predominantlyinAsia.Riceprovides21%ofenergyand15%ofproteinrequirementsofhumanpopulationsglobally (Macleane*tal*., 2002;Depar*etal*., 2011).To feed ever-rising world population, which is estimatedtobe10billionbytheendofthiscentury(Lal,2009), an increase in rice production per unit area is direlyneeded(VonGrebmer*etal*., 2008).

Zinc is an important micronutrient essential for plant growth especially for rice grown under submerged condition.Zinc deficiency is the most common micronutrient deficiency of rice in Arkansas, where, according to DeLong, Slaton, Herron, and Lafex (2018) 58% of the soil-sampled land area tests very low or low in Zn and is at risk to Zn deficiency. Zinc deficiency is prevalent worldwide in temperate and tropical climates (Fageria *et al.*, 2003; Slaton *et al.*, 2005). Zinc act as an essential component of many enzymes and controls several biochemical processes in the plants required for growth (IRRI, 2000). About 30% of the world's human population has diets deficient in zinc. Zinc deficiency in humans affects physical growth, the functioning ofthe immune system, reproductive healthand neurobehavioural development. Therefore, the zinc content of staple foods, such as rice is of major importance (Alloway 2008).

With the numerous benefits of trees, an important element is the positive effect of trees on soil properties and consequently benefits for crops. The extent to which the total concentration of a trace element, such as zinc, in a soil is available for uptake by plants or movement down the soil profile depends on a range of soil properties.The Zn requirement of crops is largely met from soluble portions released through chemical transformations of native soil Zn (Shuman, 1991). In addition Zn may be supplied to plants from soluble forms in synthetic or organic sources, as well as anthropogenic atmospheric inputs

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(Iyengar *et al.*, 1981; Johnson and Petras, 1998). For a better understanding, total soil Zn can be broadly described in five mechanistic fractions which can be quantified using sequential or batch fractionation schemes (Zerbe *et al.*, 1999; Hseu, 2006; Fedotov and Spivakov, 2008; Saffari *et al.*, 2009).

Generally these are: (1) water soluble Zn in the soil solution, (2) readily exchangeable Zn in electrostatic reaction with soil particles, (3) complexed organic Zn, chelated or adsorbed to organic ligands, (4) inorganic Zn associated with secondary minerals such as carbonates or insoluble metal oxides and (5) residual Zn held in primary minerals (Sposito *et al*, 1982; Alloway, 2003; Saffari *et al.*, 2009). These fractions provide broad information on the biological, geological and chemical processes which have occurred in a soil and are useful for predicting the availability of Zn for plant uptake. The extent to which each fraction is present and the transformations in equilibrium between fractions is influenced by **soil properties** such as pH, cation exchange capacity, presence of metal oxides and soil organic matter. It has been widely reported that the residual Zn and oxide bound Zn are the more stable fractions while the exchangeable Zn and water soluble Zn fractions are rather more soluble (Saffari *et al.*, 2009).

The range of total zinc concentrations in soils reported in the literature tends to show an overall mean total concentration of around 55 mg Zn kg-1. Kiekens (1995) reported a typical range of zinc in soils of 10-300 mg kg-1 with a mean of 50 mg Zn kg-1.This study examined the effect of agroforestry in the distribution of zinc in rice soils located in Ishiagu.

II. MATERIALS AND METHOD

Location

The study area is Ishiagu, Ivo L.G.A of Ebonyi state which lies approximately between latitudes **6°02'07"N** 5^{o} 40' and longitudes **6°32'40"E**., Southeastern Nigeria. The study was carried out on three experimental plots,namely, the low land agroforestry rice field, the upland agroforestryrice field and the open rice field (non agroforestry).

Field Work

A survey was carried out with the aid of location map of the study area to identify major upland and lowland rice zone in Ishiagu and each of the rice zones was mapped out. A combination of target and random sampling techniques was used. The target sampling technique was used to identify the major rice areas. Random sampling technique was used to identify the two rice land use types (LUTs). The rice land use types include; lowland and upland rice production.In each of the land use types three pedons was sunk, making a total of 6 pedons per zone. Samples were collected from pedons according to horizon differentiation. Samples were carefully labeled and sent for soil analysis.

Laboratory Soil Analysis

Zinc (Zn) Analysis

Pre-extraction of cation with dithionite – citrate carbonate according to the methods of (Hesser 1977) as follows: two and half grams (2.5g) of each air dried sample were weighed into a beaker and the same quantity of sodium dithionite was added. This was prepared by adding 88.23g of sodium citrate to 21.02g of citric acid in two liter flask and made to mark with distilled water to give exactly 0.15M, sodium citrate and 0.5M citric acid are essential for this extraction. The beaker was shaken over night in a shaker and later filtered with whatman filter paper. 25 ml of the extracts was pipette into a 200ml beaker and 5ml of 30% H_2O_2 was added after the beaker was covered with watch glass. The sample was then allowed to cool. At this stage 10ml of HNO_3 – H_2SO_4 acid mixture was added in a fume chamber with the sample, again digested for $3^1/_2$ hours until the extract becomes clear. The extract was allowed to cool and diluted with distilled water and made to 100ml in a volumetric flask. Concentrations of zinc were determined thereafter using Perkin Elmer model 2280/2380 Atomic Absorption Spectrophotometer.

Statistical Analysis

Coefficient of Variation (CV) was used to estimate the degree of variability existing among soil properties inthe study site. Coefficient of variation (C.V.) ranked as follows; Low variation ≤15%, Moderate variation >15≤35%, High variation >35% was used as outlined by Wilding, (1985). Comparisons were drawn from the results of the laboratory analysis of the pedons in the upland and low land rice zones. Analysis of variance (ANOVA) was used to analyse the variability of cation ratios across the two rice zones using 3x3 factorial RCBD and mean separation performed using LSD (Wahua, 1999) to evaluate the cation ratios of the rice soils in Ishiagu.

Results and Discussion

The Zinc distribution of Ishiagu was as shown in Table 1. There was a decrease in Zn

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distribution down the profile in Ishiaguagroforestryupland pedons 1 and 2 (IvUP1 and IvUP2) while there was an increase in pedon 3 (IvUP3). In the agroforestrylowlands of Ishiagu soils, there wasa decrease in pedons 2 and 3 (IvLP2 and IvLP3) while there was an increase down the profile in agroforestry lowland pedon 1 (IvLP1). For the open field (non agroforestry) Ishiagu soils, IvOP1 was found to be relatively uniform, IvOP2 decreased down the profile and IvOP3 increased down the profile.

Means were 41.24, 27.05 and 44.96 mg/kg at the agroforestryuplands and pedons IvUP1, IvUP2 and IvUP3 respectively. At]the agroforestry lowlands, means were 48.94,65.24 and 63.20 mg/kg at the three respective pedons of IvLP1, and IvLP3 respectively. While at the non agroforestry open field means were 22.31, 45.70 and 44.92 mg/kg at,IvOP2 and IvOP3 respectively.Coefficient of variation (CV) was high (CV>35%) in IvUP1 and IvUP3 while IvOP3, IvOP1, IvUP2, IvLP2, IvOP3, IvOP1 pedons in the mapping unit all varied moderately (CV>15≤35%); with IvOP2 only having low variability (CV<15%).

Table1: Zn Distributionin Ishiagu(Ivo LGA)Agroforestry riceSoils(mg/kg)

Horizons	Pedon 1	Pedon 2	Pedon 3
Uplands Soils (IvUP)			
1	78.10	30.75	35.40
2	45.12	35.60	29.20
3	23.50	24.35	70.42
4	18.22	17.50	44.80
Mean	41.24	27.05	44.96
CV	65.93	29.06	49.93
Rank	***	**	***
Lowland Soils (IvLP)			
1	48.34	86.30	72.20
2	44.15	66.20	41.68
3	39.72	49.34	73.52
4	63.55	59.10	65.40
Mean	48.94	65.24	63.20
CV	21.17	23.99	23.62
Rank	**	**	**
Open field Soils (IvOP)			
1	22.52	52.30	22.50
2	40.34	43.60	13.99
3	22.51	45.70	28.50
4	22.31	45.70	32.92
Mean	26.9	46.83	24.48
CV	33.25	8.80	33.46
Rank	**	***	

* = Low variability, ** = moderate variability and *** = high variability

Accrding to Kiekens (1995) critical level of Zn is given to be 10 mg/kg and toxicity level at above 300mg/kg suggesting that all soils investigated were within acceptable Zn range in the three land use types under study in Ishiagu, Ebonyi state. The distribution of Zn in Ishiagu soils ranged between 22.31 mg/kg in IvOP to 65.24 mg/kg in IvLP.

Bundela (2007) reported potential of agroforestry system in soil and water conservation through performing as vegetation barriers for soil erosion processes, and helping in retaining annual rainfall in the field for increasing soil moisture and improving other soil properties.

III. CONCLUSION

Based on available result Zinc distribution is within acceptable range. It is evident that Zn distribution in agroforestry soils upland and lowland is more than the open land. It shows that the presence of trees has a positive impact on the zinc distribution. Presence of trees on the field are the important component of the sustainable land use systems (agroforestry), which improves soil nutrient status by various processes, such as litter addition, decomposition, nutrient release, atmospheric N2 fixation, nutrient pumping, etc. The loss of nutrient via soil erosion is also checked by tree species. The improved soil through agroforestry systems helps to meet increased food requirement and serve as an evergreen revolution. Further studies is needed to ascertain the detailed contribution of trees to the presence of zinc in the soil.

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